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Do we have a problem: The effects of individual- and team-level problem construction on team creativity

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Content

Abstract

In this experimental study, we examined the effects of problem construction – one of the creative problem-solving processes held to influence creativity – in teams and the resulting creativity of team output. Fifty-six participants formed 28 two-member teams, and were individually induced to adopt either goal- or constraint-oriented focus in problem construction. Contrary to earlier research indicating that the promotional nature of goals and the preventive nature of constraints influence different dimensions of creativity, teams consisting of members with goal-oriented focus did not differ from teams that are comprised of members with constraint-oriented focus. Further, although research on team cognition has emphasised sharedness of member cognition and its benefits, our findings indicate that differences in team member cognition may not always have negative effects. That is, when two team members adopted goal- and constraint-oriented focus respectively, the originality of their solution to an ill-defined problem was enhanced. The process hypothesised to resolve the differences in team member cognition also did not have any impact on the creativity of the solutions. Implications of these findings and avenues for further research are discussed.

Introduction

The contexts in which organisations operate are becoming increasingly complex and dynamic in nature. It has been maintained that innovation greatly enables organisations to create a competitive advantage in volatile environments as it allows generating, accepting, and implementing new ideas, products, or services (Bilton & Cummings, 2010; Zhou & Shalley, 2011). Extant literature on innovation supports the idea that organisations with greater innovativeness perform better: for instance, innovative organisations can successfully respond to customer needs and competitor actions and accordingly develop new capabilities (Calantone, Cavusgil, & Zhao, 2002).

Creativity is a closely linked yet distinctive concept from innovation. Whereas innovation pertains to the implementation of new ideas toward improving procedures, products, or services, creativity refers to the stage of generating those new ideas (Anderson, Potocnik, & Zhou, 2014). In this sense, creativity can be viewed as the first stage of innovation (Hülsheger, Anderson, & Salgado, 2009). Although debates surrounding the nature and definition of creativity still exist (e.g., Kaufman, 2003), most researchers agree that creativity encompasses two definitional components: novelty and appropriateness (Hennessey & Amabile, 2010). That is, creativity involves the generation of novel ideas or products that are different in important ways from what preceded them, and are of value and useful for the situation at hand (Hennessey & Amabile, 2010; Fleenor & Taylor, 2004).

The same forces underlying the need for creativity and innovation in organisations – increasing globalisation, competition and technological sophistication – are driving organisations to shift their design of work from individual jobs to team structures (Kozlowski & Ilgen, 2006). The problems organisations face require high levels of adaptability and diversity in skills and expertise, which a single individual does not possess (Kozlowski & Bell, 2008; Kozlowski, Gully, Nason, & Smith, 1999). Thus, teamwork has been argued to be necessary to achieve creativity and innovation in organisations because teams can bring together a broader pool of skills and talents (Jones, 2009; Wuchty, Jones, & Uzzi, 2007). On the other hand, empirical research has shown that this faith in creative potential of teams may be misplaced. Investigations on brainstorming groups typically show that the performance of individuals in brainstorming is superior to that of groups both in terms of the quantity and the quality of the ideas generated (Diehl & Stroebe, 1987; Mullen, Johnson, & Salas, 1991; Paulus & Dzindolet, 1993). This pattern of results has been hypothesised to be due to several factors that give rise to process losses in groups, including evaluation apprehension, free-riding, and production blocking (Paulus & Dzindolet, 1993). However, some researchers have postulated that groups can perform better on brainstorming tasks under certain circumstances. For example, when idea sharing in groups is enabled and encouraged, brainstorming groups can be more productive than individuals (Paulus & Yang, 2000).

Even though academic research on creativity is proliferating, much of the prior work on creativity has been focused on the individual-level creativity (Reiter-Palmon, Wigert, & de Vreede, 2011). Within this approach, the role of individual differences such as cognitive ability and personality, as well as mood states have been emphasised in explaining individuals' performances on creativity tasks (e.g., Feist, 1998; Amabile, Barsade, Mueller, & Staw, 2005). On the other hand, research investigating the direct role of teams in producing creative ideas or products is still in its early stages. This gap in research needs to be addressed, considering that the team structures occupy a core position in today's organisations, and that the very reason teams are used is because they are believed to be more creative than individuals.

Studies on team-level creativity to date have mainly focused on team input variables such as member composition and characteristics, and social process variables including team climate, cohesion, and conflict in fostering team creativity (see Hülsheger et al., 2009 for a review). Although cognitive processes associated with creative problem-solving have been widely examined at the individual level, an in-depth investigation of the effect of team cognitive factors on team-level creativity has been relatively under-studied (Santos, Uitdewilligen, & Passos, 2015). Recent development in team dynamics literature suggests that some team characteristics are emergent: they originate from individual characteristics, however, are amplified and modified as team members interact with one another (Kozlowski & Klein, 2000). This suggests that team characteristics do not merely serve as a background or social context to the individual, but rather are a collective phenomenon separable from mere aggregation of individual characteristics, and hence play a crucial role in team performance. Thus, team-level creativity may be a different phenomenon from individual creativity, and findings on cognition associated with creative problem-solving at the individual level may not be directly applicable to the team level. Our aim in the present study is to investigate the cognitive processes of creative problem-solving in teams.

Literature review and research question

Creative problem-solving processes

One area in cognitive processes of team creativity that has received much attention is that of idea generation, and in particular, brainstorming. Idea generation refers to the process of producing alternative solutions to a problem, and hence is the most salient process typically associated with creativity (Reiter-Palmon, Herman, & Yammarino, 2008). However, research has suggested that creative problem-solving processes consist of several stages, and idea generation is only one of them.

The attempts to formalise general procedures in creative problem-solving have started early on. One of the first such models was proposed by Wallas (1926). Based on some documented recounts of sudden inspiration and enlightenment in creative acts, Wallas (1926) formalised the classic four-stage model of creative problem-solving. First, the problem-solver consciously works to define and analyse the problem in the *preparation* stage. In the subsequent *incubation* stage, the problem-solver relaxes and takes a break from the problem, however, the unconscious mind continues to work to make associations and combine ideas. The third stage, called *illumination*, occurs when the problem-solver becomes aware of a meaningful and promising idea. Finally, the validity of the idea can be tested in the *verification* stage.

The four-stage model has served as the foundation of a variant of later creative process models, and there have been efforts since to extend and enhance this basic model (Lubart, 2001). For example, Sapp (1992) suggested that a phase of frustration may occur between the incubation and the illumination stage, and it is an important juncture at which problem-solvers decide whether or not to start the problem-solving process over towards a new direction. On the other hand, Wallas' (1926) conception of the creative process has been criticised as evidence on the co-occurrence and recursion of different stages have been found (e.g., Eindhoven & Vinacke, 1952).

More recently, creativity scholars have attempted to move beyond the superficial stage-based descriptions and to explore the nature of creative problem-solving based on cognitive processes. For example, Mumford, Mobley, Uhlman, Reiter-Palmon and Doares (1991) specified a general set of core creative processes based on information-processing demands. Problem-solvers first engage in *problem construction* process in order to define the problem to be solved. This conceptualisation of the problem helps problem-solvers identifying crucial elements of the problem. During the ensuing *information encoding* process, problem-solvers retrieve information from their memory system or acquire new knowledge. Once information has been obtained, it is organised into a set of categories pertinent to the problem at hand through the *category search* process. In solving complex problems, information encoding and category search efforts often occur in tandem such that a piece of information activates certain categories and these categories guide further encoding (Mumford et al., 1991). This iterative pattern of information search leads problem-solvers to the *category specification* process whereby they identify the set of categories that fits best to the problem. Only after a set of relevant categories has been identified can problem-solvers *combine and reorganise* it to generate new problem solutions. Subsequently, problem-solvers *evaluate* the utility of the potential solutions, *implement* chosen solutions, and *monitor* the conditions and success of the solutions. Mumford and colleagues' (1991) creative process model incorporates the dynamic nature of creative problem-solving efforts and allows for multiple processes to recur in cycle. Moreover, the proposed processes have been shown to explain significant variance in creative performance on marketing and managerial tasks (Mumford, Supinski, Baughman, Costanza, & Threlfall, 1997).

Although many other cognitive process models of creative problem-solving have been proposed, and they differ in terms of the number and the precise nature of the processes (see Lubart, 2001 for a review), several core processes cut across these models: problem construction, information encoding, idea generation, idea evaluation and selection, and implementation and monitoring (Reiter-Palmon et al., 2008). As stated, whereas idea generation processes have received much attention at the team level, research on other processes of creative problem-solving has lagged behind (Reiter-Palmon et al., 2011). In the present paper, we aim to study creative problem-solving efforts in teams, with a particular focus on one of the neglected areas in team literature: problem construction.

Problem construction and creativity

Not all problems require creative solutions: problems that require creativity differ from more routine problems in some important ways. Creative problem-solving is more likely to occur in response to ill-defined or poorly structured problems or situations (Mumford, Baughman, Threlfall, Supinski, & Costanza, 1996). Ill-defined problems are characterised by multiple possible goals, multiple possible information and resources that can be used, and multiple possible solutions (Dillion, 1982; Mumford et al., 1991). Thus, problem-solvers must begin creative problem-solving processes by imposing structure on the problem – by defining the nature of the problem and identifying the resources and rules to be used to solve the problem (Mumford et al., 1991). *Problem construction* refers to this process of defining the goals and parameters of the problem-solving effort (Mumford, Reiter-Palmon, & Redmond, 1994; Reiter-Palmon et al., 2008).

Problem construction processes have been postulated to play a crucial role in the success of creative problem solving efforts, because the effective application of the subsequent processes is contingent upon the context and direction provided by problem construction activities (Mumford et al., 1991). Problem construction prescribes the kinds of knowledge and information problem solvers need to solve the problem. Empirical work on the problem construction process strongly supports the link between the process and creativity. For example, art students who engaged in problem construction, as measured by both the time they took to select the scene and objects to paint, and the uniqueness of the objects selected, produced more original and aesthetically valuable paintings (Getzels & Csikszentmihalyi, 1975; 1976). Okuda, Runco, and Berger (1991) using a sample of children also found that problem construction processes were the best predictor of creative accomplishments. Reiter-Palmon, Mumford, O'Conner Boes, and Runco (1997) demonstrated that participants who were asked to actively engage in problem construction by restating and redefining the problem in multiple ways produced more creative solutions to a series of real-life problems compared with those who were not instructed to do so.

Mumford and colleagues (1994) have proposed a theoretical model of problem construction specifying the factors that influence the process, which revolves around the cognitive processing of problem representations. *Problem representations* can be described as ad hoc cognitive structures that capture the central features of problem-solving efforts (Holyoak, 1984). Problem representations often contain four types of information that are necessary to solve problems effectively: (a) the *goals* of the problem-solving effort; (b) the key pieces of *information* needed; (c) the key *procedures* to be employed; and (d) any *restrictions or constraints* placed on the problem solution (Holyoak, 1984). Gick and Holyoak (1980; 1983) suggested that prior problem-solving experience serves as an important mental model problem-solvers rely on in abstracting key features of ill-defined problems, and problem representations are generated based on the past experience.

According to Mumford and colleagues' (1994) model, problem construction begins with problem-solvers' *perception of environmental cues* or stimuli. Due to limitations in attentional resources, cues that are in some ways more meaningful and salient are more likely to be perceived (Gick & Holyoak, 1980). Problem-solvers then engage in a recursive memory search, and problem representations that are most strongly associated with those cues perceived to be the most salient are activated (*activation of problem representations*). Although all activated problem representations hold relevance to the perceived cues or the problem, some representations may reflect the nature of the problem better than others (Wigert, 2011). Hence, problem-solvers go through the *representation screening* stage by which they identify the most relevant problem representations that would allow them to generate an appropriate problem-solving strategy. It is important to note that, when faced with a novel problem, problem-solvers often are not able to select a problem representation that is directly analogous to the problem at hand. Instead, either a problem representation can be applied in a flexible manner or multiple problem representations can be activated and selected, and subsequently, combined to generate a new applicable problem representation (Mumford et al., 1994).

Research question

Even though we have some understanding of how individual problem-solvers construct ill-defined problems, research on creative problem-solving in teams in general, and problem construction process in particular, is much more limited (Reiter-Palmon & Robinson, 2009). Generally, a team is defined as two or more individuals who are interdependent on each other in striving to achieve some common outcomes (Kozlowski & Ilgen, 2006). In group dynamics literature, teams often are distinguished from groups, however, in many cases the two terms are interchangeably used (Paulus, Nakui, Putman, & Brown, 2006). A team is a unified system with emergent characteristics that cannot be fully understood by only examining the individuals who compose the team (Lewin, 1951). Thus, findings from investigations on how individuals engage in creative problem-solving may inform what may be expected in teams, however, the dynamics of team processes will add extra layers that likely influence creative problem-solving at the team level (Harms, Kennel, & Reiter-Palmon, 2017).

Considering that problem construction phase is contingent upon problem-solvers' past experience, the activation of multiple different problem representations may be more pronounced in teams, since individual team members are likely to possess different experiences as well as knowledge, skills, personalities and values (Reiter-Palmon et al., 2008). Moreover, these differences in problem representations may be more prominent when the team consists of diverse members. Individual team members often are not aware that other members frame the problem in a different way (Cronin & Weingart, 2007), and this can lead to disagreements about the best solution to the given problem (Reiter-Palmon & Robinson, 2009). In this sense, the degree of heterogeneity in team members' problem representations may have an impact on the resulting team creativity. On the other hand, teams can address the presence of multiple perspectives and problem representations, and the level of heterogeneity in individual problem representations may have different effects on team creativity if the team can somehow discuss and address it. Therefore, our research question is: *"How does the degree of heterogeneity in individual-level problem representations and the team-level problem construction process influence the team's creativity?"*

Research model and hypotheses

Overview of the present study

The present study aimed to examine the effect of heterogeneity in individual-level problem representations and the team-level problem construction processes on the creativity of team problem solutions in a laboratory setting. We used two of the four aforementioned problem representation elements (i.e., goals and constraints) to manipulate participants' problem representation structures, since these elements have been shown to heavily influence how problem-solvers search for and select adequate problem representations (Mumford et al., 1994). Participants received a fictional marketing problem to solve, and were randomly assigned to one of two individual-level conditions. Before engaging in the problem-solving effort, half of the participants were instructed to generate goals of the problem-solving effort, whereas the other half were instructed to generate possible constraints of the given problem. More specifically, goals were described as something that should or can be achieved by solving the given problem and, inversely, constraints were described as something that should be avoided or overcome when solving the given problem (Wigert, 2011). After the individual generation of goals or constraints, participants were assigned to two-member groups, where they received instructions regarding team-level problem construction processes. Groups in the Team Problem Construction (TPC) conditions received written instructions to discuss with their teammate the goals and/or constraints that they had generated individually, before solving the problem together. On the other hand, those in the No-Team Problem Construction (NTPC) conditions received no such instruction and were prompted to solve the problem together right away. Thus, the experimental conditions took on a 3 (both members generate goals; both members generate constraints; one member generates goals and the other generates constraints) x 2 (TPC vs. NTPC) design (see Table 1 in the Method section below for detailed layout of the study design). The groups' solutions to the problem were rated based on their originality, quality, and complexity.

Hypotheses

It has been postulated that the representation screening stage is central in problem construction. In order to avoid overtaxing their limited cognitive resources, problem-solvers strive to simplify the activated problem representations (Cronin & Weingart, 2007). The representation screening stage involves identifying the problem representations that best fit the problem situation, which in turn allows problem-solvers to establish an appropriate strategy that will guide their problem-solving efforts. Mapping the most befitting problem representations onto salient features of the problem situation at hand is heavily influenced by the four problem representation elements (i.e., goals, constraints, key information, key procedures), because these elements can provide a context or a mental model against which problem-solvers evaluate the appropriateness of problem representations (Mumford et al., 1994; Herman, 2008). For example, problem-solvers may select a problem representation with goals that are similar to those of previous successful problem-solving episodes. On the other hand, a problem representation containing too many constraints may urge problem-solvers to discard the representation. Hence, in the present study, we decided to manipulate participants' cognitive processes of problem construction by manipulating the saliency of the goals and constraints elements of problem representation structure. Previous research has reported that these two elements are effective in influencing participants' cognitive processes during the problem construction stage (Wigert, 2011; Herman, 2008).

Literature on the goal and constraint elements of problem representations suggest that focusing on goals and constraints during problem construction may prompt problem-solvers to adopt fundamentally different ways of thinking in achieving a creative outcome (Herman, 2008). Focusing on goals of the problem-solving effort (i.e., what should or can be achieved by solving a problem) can redirect problem-solvers' criteria of the representational screening stage towards specific objectives they want to achieve, and therefore, the problem-solvers are less likely to select problem representations solely based on previous experience (Mumford et al., 1994; Redmond, Mumford, & Teach, 1993; Reiter-Palmon et al., 1997). This shifts the focus of problem construction away from commonly associated relationships, and thus can prompt problem-solvers to conceptualise problems in a novel way. On the other hand, when problem-solvers focus on the constraints elements (i.e., what should be avoided or overcome when solving a problem), problem cues are likely to be blocked rather than triggered (Holyoak, 1984). Constraints shift the criteria of problem-solvers' representational screening stage towards the selection of problem representations that correspond with the most salient restrictions of the problem at hand (Mumford et al., 1994). Hence, problem-solvers are more likely to focus on discarding less appropriate problem representations, and identifying and retaining the most useful and viable representations. Mumford and colleagues (1996) pointed out that this dismissal of problem representations based on constraints may lead problem-solvers to eliminate potentially novel ways of framing a problem.

In short, focusing on goal elements during the problem construction process helps problem-solvers establish new and original problem representations, whereas focusing on constraints may guide them to adopt fewer, yet higher-quality representations. The problem representations selected in turn shape how problem-relevant information is interpreted and evaluated when problem-solvers strive to move from the problem situation to the desired endpoint (Cronin & Weingart, 2007). Thus, the amount, originality, and quality of the problem representations structured during the representational screening stage will likely have an impact on the final product of those problem-solving efforts. That is, novel problem representations are likely to allow for a problem to be addressed by more novel solutions, and high-quality solutions are likely to ensue from high-quality problem representations. By the same token, when the number of problem representations generated is limited, the complexity of solutions (i.e., the quantity of independent ideas present within a solution) is likely to be reduced. Therefore, we first hypothesise that there will be discrepancies in the solutions produced by groups in the present study, depending on whether their members are prompted to focus on the goals or constraints elements in the problem construction process.

Hypothesis 1a: Teams consisting of members both prompted to focus on goals will generate a more original team solution than those teams consisting of members both prompted to focus on constraints.

Hypothesis 1b: Teams consisting of members both prompted to focus on goals will generate a more complex team solution than those teams consisting of members both prompted to focus on constraints.

Hypothesis 1c: Teams consisting of members both prompted to focus on constraints will generate a higher-quality team solution than those teams consisting of members both prompted to focus on goals.

The set of hypotheses presented above predicts differential effects of goals- and constraints-focus on problem solutions in groups whose members are induced to adopt the same focus in the problem construction process (what we call *homogeneous group*). We expect that the two foci will have different impacts on problem solutions when group members are prompted to focus on the problem representation elements that are different from each other (i.e., one member focuses on goals while the other focuses on constraints; *heterogeneous group*). Our next hypothesis concerns the comparison between the problem solutions generated by homogeneous and heterogeneous groups.

An abundance of research on group creativity has emphasised the importance of members' cognitive diversity in creative problem-solving. Research on job-relevant diversity, or the heterogeneity of team members regarding task-related attributes including functional roles, educational background as well as skills and expertise, has repeatedly documented that more functionally diverse teams are more creative (Hülsheger et al., 2009). One of the largest and most significant studies of team creativity and innovation conducted on a total of 1,222 research teams discovered that functional diversity accounted for 10 per cent of the variance in team creativity and innovation (Andrews, 1979; Payne, 1990; West, 2002). It has been suggested that the ability to generate diverse categories of problem solutions to a single problem is crucial in creative problem-solving. That is, when no set conclusion or answer is attached to the given problem, the novelty and originality of creative productions hinges on individuals' ability to generate and explore many possible solutions that can be combined in an unexpected fashion (Guilford, 1956; McCrae, 1987). Functional diversity in team composition can be conducive to team creativity because members' exposure to a variety of divergent perspectives can stimulate them to engage in informational conflict, integrate new ideas, and pursue previously unexplored directions (Perry-Smith, 2006; Milliken & Martins, 1996; Simons, Pelled, & Smith, 1999). Moreover, the presence of diverse perspectives on how to manage the problem may prevent team members from prematurely reaching consensus on the problem that needs careful consideration (van Knippenberg, De Dreu, & Homan, 2004).

However, the advantages of members' cognitive diversity on team creativity have not been consistently found. In some multi-functional teams, members fail to optimally utilise the unique knowledge and skills of others (e.g., Milliken & Martins, 1996; Dahlin, Weingart, & Hinds, 2005; Williams & O'Reilly, 1998). Further, the presence of divergent perspectives in teams may even jeopardise the teams' task execution (Weingart, Todorova, & Cronin, 2010). One explanation for these mixed findings is that information sharing could be problematic in teams when members possess idiosyncratic knowledge and experience. That is, team members often are not aware that other members frame the team's problem in a different way, and tend to focus on sharing common knowledge (Cronin & Weingart, 2007; Stasser, 1999). Even when the differences in member preferences and knowledge surface, the members may not be willing to share information (Lovelace, Shapiro, & Weingart, 2001).

Cronin and Weingart (2007) asserted that when problem representations are incongruent between team members, information sharing and processing can be degraded. Problem representations represent cognitive frameworks by which problem-solvers interpret and evaluate problem-relevant information. In other words, problem-solvers determine which information is relevant to the problem situation, and how useful a certain piece of information is based on their problem representations (Daft & Weick, 1984; Ohlsson, 1992). These frameworks are unlikely to be changed each time the problem-solvers encounter new information (Hayes & Simon, 1974). Rather, the incoming information that does not fit with the receiver's problem representations is likely to be distorted, or regarded as useless (Cronin & Weingart, 2007). The impeded flow of information within a team in the context of problem construction is particularly problematic, because it can hinder the process of creating the team's joint problem representation whereby members integrate their individual problem representations with those of others to map the ways they can solve the given problem together as a team. If individual team members fundamentally differ as to what the problem is and how it should be solved, the members are likely to opt actions starkly different from what their teammates would choose (Weingart et al., 2010).

It has been suggested that the incongruity between members' problem representations is particularly detrimental to team problem-solving efforts when the representations are incompatible to one another (Cronin & Weingart, 2007). We expect that the promotional nature of goals-focus and the preventive nature of constraints-focus would be indeed incompatible with one another, and that the detrimental effect of divergence in member problem representations on team performance will be found in heterogeneous groups in this study. Specifically, we hypothesise that heterogeneity in members' problem representation structure can impede information sharing and processing, which may undermine the originality, quality, and complexity of the joint problem representation within the team. This in turn may have a detrimental effect on the team's solution.

Hypothesis 2a: Heterogeneous teams will generate a less original team solution than homogeneous teams.
Hypothesis 2b: Heterogeneous teams will generate a lower-quality team solution than homogeneous teams.
Hypothesis 2c: Heterogeneous teams will generate a less complex team solution than homogeneous teams.

Several researchers have argued that the contribution functional and informational diversity makes on team creativity is dependent on the quality of group processes (e.g., West, 2002). In recent years, researchers have suggested that team reflexivity is one of the most important factors that determine the quality of group processes (Schippers, Den Hartog, Koopman, & Wienk, 2003). Team reflexivity refers to "the extent to which group members overtly reflect upon, and communicate about the group's objectives, strategies, and processes, and adapt them to current or anticipated circumstances" (West, Garrod, & Carletta, 1997, p. 296). Research shows that team creativity as well as overall performance is facilitated when members discuss and reflect upon team goals and procedures, especially when the team works on complex and non-routine tasks (West, 1996; De Dreu, 2002).

More often than not, team members are not aware that other members conceptualise the given problem differently (Cronin & Weingart, 2007; Reiter-Palmon et al., 2008). As previously discussed, if incongruities in individual problem representations are not addressed, group processes as a whole can be negatively impacted (Pieterse, van Knippenberg, & van Ginkel, 2011). On the other hand, when members surface these incongruities and discuss how they, as a team, will define the problem at hand, the members will be more likely to resolve the differences and successfully create a joint problem representation by expanding their representation to accommodate the perspectives of others (Weingart et al., 2010).

The literature on team mental models sheds light on how the process of members' representation accommodation can contribute to team performance. Mental models are in essence the cognitive representations of knowledge regarding the pattern of interaction with the environment (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Resick, Dickson, Mitchelson, Allison, & Clark, 2010). A team's mental model (TMM) refers to an organised understanding and a mental representation of the knowledge team members share concerning relevant task and team aspects and the environment in which they operate (Klimoski & Mohammed, 1994). Members of those teams high on TMM are "on the same page" with regards to what to expect from other members and what the team needs, and this allows the members to coordinate actions and adapt behaviours to changing task demands (Cannon-Bowers, Salas, & Converse, 1993; Mohammed, Ferzandi, & Hamilton, 2010). Therefore, several researchers have achieved a common theoretical assumption that high level of TMM is a precursor to effective team processes and performance (Klimoski & Mohammed, 1994; Kraiger & Wenzel, 1997; Rentsch & Hall, 1994). When team members possess shared understanding of work goals, procedures, strategies, and performance requirements that include problem interpretation issues, they can anticipate and identify what other members require to accomplish their task (Santos et al., 2015). This in turn facilitates coordination in teams, and leads to enhanced overall team performance (Mohammed et al., 2010).

Considering that the importance of a problem construction process hinges on its ability to specify the kinds of knowledge and information that needs to be retrieved or acquired to solve the problem at hand (Mumford et al., 1991), team members' shared understanding of other members' problem representations can facilitate information search and sharing at the team level. In other words, when members agree upon how to interpret and define the problem, they can attend to key information needed to solve the defined problem, and can communicate about the problem in a similar manner (Mohammed & Ringseis, 2001; Reiter-Palmon et al., 2008). This cognitive consensus on problem representation can be achieved when group members make an effort to attend to others' diverging perspectives by engaging in reflexive group processes. Thus, we believe that when team members in this study are instructed to engage in a team problem construction (TPC) process by discussing their goal- and/or constraint-focused individual problem representations with each other, information sharing and processing between them will be enhanced, and the process of creating a shared team-level problem representation will be facilitated. In particular, we predict that the enhanced flow of information enabled by the TPC process will allow heterogeneous groups to capitalise on the members' divergent problem representation structures. That is, heterogeneous groups engaging in the TPC process will be able to draw a team problem representation from a broader pool of potential solution categories, with fewer impediments to communication and coordination between members. When heterogeneous group members can successfully combine their two opposing problem construction foci, we expect that they will be able to generate a highly original team solution to a problem. On the other hand, when both members focus on the same problem representation element (i.e., either goals or constraints), the problem representations shared in homogeneous groups will be of limited range, and the conceptual scope explored in creating a team problem representation may be narrower than in heterogeneous groups. Thus, we hypothesise the solutions generated by homogeneous groups will be less original than those of heterogeneous groups engaging in the TPC process.

Hypothesis 3a: Heterogeneous teams that engage in team problem construction processes will generate a more original team solution than heterogeneous teams that do not engage in the team problem construction processes.

Hypothesis 3b: Heterogeneous teams that engage in team problem construction processes will generate a more original team solution than homogeneous teams that engage in the team problem construction processes.

Hypothesis 3c: Heterogeneous teams that engage in team problem construction processes will generate a more original team solution than homogeneous teams that do not engage in the team problem construction processes.

Furthermore, heterogeneous groups that engage in the TPC process may outperform the groups in other conditions on other dimensions of creativity. Several empirical studies we have located indicate that when individuals are prompted to adopt both goals- and constraints-focus during the problem construction process, their solutions may be positively influenced by the combined effect of the two foci. Herman (2008) found that when participants were asked to generate both goals and constraints of a problem prior to solving the problem, the quality of the solutions they produced was enhanced. On the other hand, Butler, Scherer, and Reiter-Palmon (2003) demonstrated that when they provided participants with two objectives that are of promotional and preventive nature, the fluency (i.e., the number of solutions generated), flexibility (i.e., the number of categories within the solutions), and effectiveness (i.e., the number of subsets of problems addressed by the solutions) were improved. Therefore, we further hypothesise that heterogeneous groups that engage in the TPC process will produce more complex, and higher-quality solutions than the groups in other conditions.

Hypothesis 4a: Heterogeneous teams that engage in team problem construction processes will generate a higher-quality team solution than heterogeneous teams that do not engage in the team problem construction processes.

Hypothesis 4b: Heterogeneous teams that engage in team problem construction processes will generate a higher-quality team solution than homogeneous teams that engage in the team problem construction processes.

Hypothesis 4c: Heterogeneous teams that engage in team problem construction processes will generate a higher-quality team solution than homogeneous teams that do not engage in the team problem construction processes.

Hypothesis 5a: Heterogeneous teams that engage in team problem construction processes will generate a more complex team solution than heterogeneous teams that do not engage in the team problem construction processes.

Hypothesis 5b: Heterogeneous teams that engage in team problem construction processes will generate a more complex team solution than homogeneous teams that engage in the team problem construction processes.

Hypothesis 5c: Heterogeneous teams that engage in team problem construction processes will generate a more complex team solution than homogeneous teams that do not engage in the team problem construction processes.

Method

Participants

A total of 58 individuals completed the experiment in the present study. One participant, and subsequently the group the participant belonged to, was excluded from further analyses for correctly guessing the purpose of the experiment. The remaining sample consisted of 56 individuals (53.6% female), aged between 20 and 51 years (M = 26.44, SD = 5.17). Within the sample, 82.1% of the participants were students, 67.4% of which were enrolled at BI Norwegian Business School. The experimental procedure employed in the present study required participants to solve a fictional marketing problem. 42.9% of the sample reported that they had had either educational or work-related marketing experience. The requirement set to participate in the study was an intermediate level of proficiency in English. Participants were recruited online via the School’s research recruitment system (SONA), and they were promised a chance to win a lottery worth 500 Norwegian Kroner.

Design

The present study employed a 3 (Heterogeneity in individual-level problem representation structure; Homogeneous-Goals and Goals, Homogeneous-Constraints and Constraints, and Heterogeneous-Goals and Constraints) x 2 (Team Problem Construction vs. No-Team Problem Construction) between-subjects experimental design. Participants formed 28 two-member groups and were randomly assigned to one of the six conditions. Heterogeneity in individual-level problem representation structure was manipulated by instructions prompting participants to generate either goals or constraints of a problem prior to solving the problem. In groups conditioned to be *heterogeneous* in terms of their members' individual-level problem representations, one member was instructed to generate goals of the problem-solving effort, whereas the other member was instructed to generate constraints of the problem. On the other hand, in groups conditioned to be *homogeneous* in terms of their members' individual-level problem representations, the two members received the same instruction: they were either instructed to generate goals of the problem-solving effort (*HoGG* conditions) or to generate constraints of the problem (*HoCC* conditions). Team-level problem construction processes were also induced by instructions. Participants in the Team Problem Construction (TPC) conditions received a written instruction to discuss with their teammate the goals and/or constraints that they had generated individually, before solving the problem together. On the other hand, those in the No-Team Problem Construction (NTPC) conditions received no such instruction and were prompted to solve the problem together right away. See Table 1 for detailed layout of the study design.

Table 1. *Primary Study Conditions*

		Heterogeneity in individual-level problem representation structures		
		Homogeneous		Heterogeneous
		Goals and Goals	Constraints and Constraints	Goals and Constraints
Team-level problem construction	Team Problem Construction	*HoGG-TPC* (*n* = 3)	*HoCC-TPC* (*n* = 3)	*He-TPC* (*n* = 11)
	No-Team Problem Construction	*HoGG-NTPC* (*n* = 3)	*HoCC-NTPC* (*n* = 2)	*He-NTPC* (*n* = 6)

Procedure

Participants were invited into the laboratory and were then randomly assigned to two-member groups that were seated in a cubicle. Each participant was given a booklet containing all the materials and stimuli to be used during the experiment. Participants were told that the study was about the cognitive processes involved in team creative problem-solving, and were given instructions on the procedures of the experiment. Specifically, participants were informed that they will be working on tasks both individually and in groups, and that they were not to turn the pages in the booklet unless otherwise instructed by experimenters. After the instructions have been provided, participants read and signed informed consent forms.

For the first half of the experiment, participants were asked to work individually and to not interact with their teammates. All the participants were first presented with the definition of creativity alongside an outline of the tasks they will be asked to complete throughout the experiment (see Appendix A). Participants were given 45 seconds to read through the information. Participants were then presented with an example problem called "Flexitime Problem", for which they were given seven minutes to work on. Adapted from Wigert's (2011) manipulation task material, the Flexitime Problem asked participants to imagine themselves as a manager of a division in charge of devising a flexitime work schedule for its employees. The same example problem was given to all participants, however, the instructions and examples were tailored to the experimental conditions (see Appendix B and C). Participants in the goals condition were instructed that in order to solve problems without one correct solution, they would need to clarify the goals of the problem-solving effort, and were given four example goals of the Flexitime Problem (e.g., "Improve employee work-life balance to increase satisfaction."). Similarly, participants in the constraints condition were instructed to clarify the possible constraints of the problem, and were shown four example constraints (e.g., "The agency may want certain employees dependent on each other to work during the same hours."). All the participants then were asked to list other possible goals or constraints that they could think of, depending on the condition they were in.

After working on the example problem, participants were given the actual ill-defined problem to solve – the "Marketing Problem". The Marketing Problem entailed a scenario in which the participants as a project manager intern have to devise a plan to create hype around a fictional product – a three-dimensional holographic television. Participants were also presented with a description of the product regarding its specifications as well as its retail price (see Appendix F). Both the Marketing Problem and the product description were adapted from Redmond and colleagues' (1993) and Herman's (2008) experiment materials. The same problem and product description was given to all participants, however, the instructions on what to do before attempting to solve the problem differed across conditions. These instructions coincided with the instructions exemplified in the Flexitime Problem. Participants who had been prompted to think of goals of the Flexitime Problem were asked to think of and list the goals of the Marketing Problem (i.e., what can be achieved by solving the problem; see Appendix D), whereas those been prompted to think of constraints of the Flexitime Problem were instructed to consider and list the constraints of the Marketing Problem (i.e., the obstacles that must be overcome when solving the problem; see Appendix E). All participants were given seven minutes to read the problem and the product description and to generate goals or constraints.

Following the individual generation of goals and constraints related to the Marketing Problem, participants were instructed to work with their teammate on producing the solution to the Marketing Problem. One of the team members received an answer sheet on which to provide the team's plan on how to create hype around the new product for potential customers. The sheet contained instructions that would prompt participants to be as thorough as possible in providing the team's solution, as well as induce the team problem construction manipulation. Participants in the NTPC condition were simply instructed to work on providing the team's solution and were notified they will be given twenty minutes for the task (see Appendix G). On the other hand, participants in the TPC condition received an additional written instruction on their answer sheets which asked them to discuss the goals and/or constraints of the Marketing Problem with their teammates for five minutes, and then to produce the team's solution for the next twenty minutes. Specifically, participants in the HoGG-TPC condition were instructed to discuss important goals of the Problem, while those in the HoCC-TPC condition were asked to discuss important constraints of the Problem. Participants in the He-TPC condition were instructed to discuss both goals and constraints of the Problem (see Appendix H).

After submitting their problem solution, participants were asked to return to their cubicles and answer individually a questionnaire about demographic information as well as covariate measures. Following Wigert (2011), a manipulation check question was also included in the questionnaire (see Appendix I). Upon completion of the questionnaire, participants were thanked and debriefed.

Measures

Dependent variables

Creativity of solutions to the Marketing Problem was assessed based on Wigert's (2011) scoring scheme. The two researchers independently evaluated the solutions generated by each group based on originality, quality, and complexity, as suggested by prior work (Chalupa, 1988). Inter-rater agreement (IRA) and reliability (IRR) was assessed using an r_{WG} analysis and an intraclass correlation (ICC), both of which indexing the extent to which ratings from the two raters can be aggregated. For the purposes of the present study, averaged measures ICCs were used, and a traditional reliability cut-off value of .70 was applied. Although r_{WG} values of .70 have also been frequently used as the cut-off point denoting high versus low inter-rater agreement, it should be noted that r_{WG} values in the present study are likely to be attenuated given the number of raters (Lindell, Brandt, & Whitney, 1999). Therefore, we adopted a more inclusive set of guidelines for interpreting agreement as suggested by LeBreton and Senter (2008), which suggests that r_{WG} values above .51 and .71 be interpreted as moderate and strong agreement, respectively.

Solution originality was operationalised based on the novelty, imagination, and structure of the solution (see Appendix J). *Novelty* was defined as the degree to which the solution represented a unique approach relative to other solutions, whereas *imagination* referred to the extent to which the solution offered an imaginative or humorous approach. *Structure*, for the purposes of the present study, was conceptualised as the degree to which the solution was free from the assumptions presented in the problem (i.e., "use your knowledge on the Internet and technology to devise a plan"). Two raters evaluated the originality of the solutions on a 5-points Likert scale (1 = very unoriginal; 5 = very original), and the ratings were averaged to produce a single originality score for each solution. The IRA of the originality ratings was moderate with an r_{WG} of .57, and the IRR was good with an ICC (2,2) of .72, F (27, 27) = 3.54, $p < .01$.

Solution quality ratings were operationalised based on the completeness and effectiveness of each solution (see Appendix K). Specifically, *completeness* was defined as the extent to which the solution was elaborate or thorough and addressed multiple issues presented in the Marketing Problem (i.e., selecting potential customer base, and devising a plan to create hype for those customers). *Effectiveness* referred to the extent to which the solution was viable or appropriate, and was conceptualised as the degree to which the solution will be able to solve the issues presented in the problem. The researchers independently rated the quality of each solution on a 5-points Likert scale (1 = very low quality; 5 = very high quality), and the ratings were averaged to produce a single quality score for each solution. The IRA of the quality ratings was moderate with an r_{WG} of .63, and the IRR was good with an ICC (2,2) of .81, F (27, 27) = 5.28, $p < .001$.

Solution complexity ratings were based on the quantity of independent ideas in the solution. An idea was considered independent if the proposed action was not presented elsewhere in the solution. The researchers counted the number of independent ideas presented in each solution, and the number of ideas reported by each rater was averaged to produce a single complexity score for each solution. The IRA of the quality ratings was moderate with an r_{WG} of .62, and the IRR was good with an ICC (2,2) of .90, F (27, 27) = 9.69, $p < .001$.

Manipulation check

After having completed the Marketing Problem, participants were presented with a question to validate our individual-level problem construction manipulation (see Appendix I). Following Wigert (2011), the question assessed whether participants can correctly identify the individual-level problem construction instruction they had been given. Specifically, the question ("*I was instructed to list X before solving the Marketing Problem. Which of the following is X?*") asked participants to choose an appropriate answer among four multiple choice options provided (*Goals*; *Constraints*; *Both goals and constraints*; and *Nothing*), and was answered by all participants individually.

Covariates

After having submitted their group solutions to the Marketing Problem, participants were asked to individually complete a post-experimental questionnaire assessing a set of covariate measures. Covariates measured by the questionnaire included: task- and relationship conflict within the team, participants' English proficiency level, and team decision quality. However, only the covariates that achieved meaningful ($p < .10$) correlations with the dependent variables have been retained in further analyses (See Table 2 in the Results section below).

Problem construction time (1-item) assessed how much time participants believed to have spent on constructing the Marketing Problem, prior to solving the Problem. Problem construction is considered primarily an automatic process where schematic knowledge structures are unconsciously activated based on the associations between environmental cues and previous experience (Reiter-Palmon et al., 1997). However, the more ill-defined a problem is, the more conscious processing is needed to define and structure the problem. It has been theorised that when individuals engage in problem construction in an effortful manner, the originality and quality of their solutions will be enhanced (Mumford et al., 1994). The question assessing the construct was adapted from Reiter-Palmon and colleagues' (1997) research, and asked participants how much time they spent thinking of goals or constraints of the Marketing Problem (see Appendix I), which required the participants to rate the item on a 7-point Likert scale (1 = none at all; 7 = a great amount of time).

Team history (1-item) assessed the degree to which the participants assigned together in the same group were familiar with working with each other. We anticipate that the effects of team problem construction (TPC) processes will manifest by allowing the team members to understand and accommodate the problem representations of one another's in creating a team-level problem representation. In other words, the TPC processes will help teams establish a TMM on how to interpret and define the given problem. Literature suggests that the formation of a TMM in teams depends at least in part upon members' awareness of communication patterns, preferences, and habits (Mohammed et al., 2010), which we believe groups with high levels of team history are likely to possess. If participants assigned in the same team already possess a functional TMM, the effects of the TPC processes may be attenuated. Team history was measured by a question asking how often the participants have worked with their teammate prior to the experiment (see Appendix I). Participants rated the item on a 7-point Likert scale (1 = never; 7 = always).

Results

Manipulation check

Following Wigert (2011), the effectiveness of our manipulation was assessed by a question determining whether the participants understood and were able to correctly identify the individual-level problem construction instructions that they had been provided with. Specifically, the question ("*I was instructed to list X before solving the Marketing Problem. Which of the following is X?*") asked participants to choose an appropriate answer among four multiple choice options provided (*Goals*; *Constraints*; *Both goals and constraints*; and *Nothing*). In response to the question, 91.1% of the participants correctly identified what they had been asked to list before solving the Marketing Problem. To be more specific, 83.3% of the participants in HoGG-TPC, 83.3% of the participants in HoGG-NTPC, 90.9% of the participants in He-TPC, and 83.3% of the participants in HoCC-TPC conditions correctly identified the instructions. All of the participants in HoCC-NTPC and He-NTPC conditions managed to correctly identify the instructions. A total of five participants, two of which belonging to a same group, failed to choose an appropriate answer. A follow-up interview with the participants, however, revealed that the manipulation check question may have been conducive to misinterpretation. One participant belonging to a group in the He-TPC condition had chosen "*Both goals and constraints*" as the answer to the manipulation check question, and informed the researchers that she had interpreted the question as to be asking to identify the instructions given to her group (i.e., TPC instructions prompting her to discuss important *goals and constraints* of the problem with her teammate), rather than the instructions given to her individually (i.e., individual-level problem representation manipulation instruction prompting her to list the goals of the Marketing Problem). When asked by the researchers verbally, all five participants were able to identify the instructions they had been given. More specifically, they understood that goals are promotional in nature, or something that should be achieved, whereas constraints are preventive in nature, or something that should be avoided or overcome. In light of these reports, we decided to include those groups whose members failed to choose an appropriate answer to the manipulation check question in the data analysis.

Data treatment and analysis

Individual team members' responses to the two covariates (i.e., problem construction time and team history) were aggregated to the team level to match the level of the outcome variables (i.e., solution creativity scores). An r_{WG} analysis was used to assess the extent to which the aggregation can be justified (LeBreton & Senter, 2008). IRA was strong with an average r_{WG} of .77 for *problem construction time*. For *team history*, IRA was also strong with an average r_{WG} of .73. Based on these values suggesting that there is a sufficient agreement between the two teammates, the individual responses for these covariates were averaged to the team level.

Given the total number of observations (n = 28), data were checked for normality and homoscedasticity prior to every analysis. Non-parametric tests were employed when both these assumptions were not satisfied. Significance level <.05 was set for all the analyses unless otherwise indicated.

Descriptive statistics

Prior to examining the primary hypotheses, the relations among our study variables were reviewed. Table 2 presents the means and standard deviations, as well as the correlations between the dependent variables and the covariates. As can be seen, a strong positive relationship between solution originality and quality ratings (r = .73, p < .01) was obtained, indicating that solutions that were more original were also judged to be of higher quality. This pattern of result may be attributable to the raters' inability to distinguish between originality and quality of the solutions, or the overlap in stimuli that were rated. It can also be due to the innate correlation between the two constructs (Reiter-Palmon et al., 1997). On the other hand, solution complexity ratings were positively yet moderately related to originality (r = .47, p < .05) and quality (r = .44, p < .05) scores, supporting the idea that complexity as a dimension of creative thinking is relatively independent from originality and quality (Chalupa, 1988). The covariate variable team history was moderately correlated with solution originality (r = .51, p < .01); the correlations between team history and the other two dependent variables were not statistically significant. There were positive correlations between the covariate variable problem construction and solution originality (r = .33, p < .10) and solution quality (r = .35, p < .10), though at marginal significance levels. The two covariates were not significantly related to each other.

Table 2. *Descriptive Statistics and Correlations*

Variable	*M*	*SD*	1.	2.	3.	4.	5.
1. Solution originality	3.38	0.82	-				
2. Solution quality	3.52	0.79	.73***	-			
3. Solution complexity	5.73	1.86	.47**	.44**	-		
4. Problem construction time	4.41	0.84	.33*	.35*	.14	-	
5. Team history	2.89	1.90	.51***	.23	.14	.10	-

Note: N = 28.
*p < .10 **p < .05 ***p <.01

Hypothesis testing

We first hypothesised that the impact of goals and constraints on problem construction will manifest differently in the three dimensions of solution creativity scores. Specifically, we hypothesised that groups consisting of members both primed to think of goals (*HoGG* groups) would score higher on solution originality (Hypothesis 1a) and complexity (Hypothesis 1b), whereas those groups consisting of members both prompted to think of constraints (*HoCC* groups) would score higher on solution quality (Hypothesis 1c). In examining the hypotheses, analyses could only be conducted for groups in the homogeneous condition (n = 11). Levene's test results indicated that the variances of solution creativity scores were equal between the two groups, however, a series of Shapiro-Wilk tests revealed that solution originality scores were not normally distributed in the HoGG condition (p = .001). In order to test the differential effects of goals and constraints on solution creativity scores, we submitted the solution scores (originality, quality, and complexity) to a Mann-Whitney U test with group conditions (HoGG vs. HoCC) as the between-subjects factor. Descriptive statistics showed trends in the predicted directions, however, none of the results were statistically significant. Groups in the HoGG condition (*Median* = 3.50; Mean rank = 7.00) scored higher on solution originality than those in the HoCC condition (*Median* = 3.00; Mean rank = 4.80), however, the difference between the two groups was not statistically significant, U = 9.00, p = .14 (one-tailed). Groups in the HoGG condition (*Median* = 5.75; Mean rank = 6.25) also scored higher on solution complexity than those in the HoCC condition (*Median* = 4.50; Mean rank = 5.70), however, the difference between the medians was not statistically significant, $U = 13.50$, $p = .42$ (one-tailed). On the other hand, solution quality scores were greater for groups in the HoCC condition (*Median* = 4.00; Mean rank = 6.30) than groups in the HoGG condition (*Median* = 3.50; Mean rank = 5.75), however, the difference was not statistically significant, $U = 13.50$, $p = .41$ (one-tailed). On the basis of these results, we rejected Hypotheses 1a, 1b, and 1c, suggesting that groups in the HoGG and HoCC conditions did not differ in their solution originality, quality, and complexity scores.

Hypothesis 2a, 2b and 2c predicted that groups consisting of members whose individual-level problem representations are structured to be heterogeneous (i.e., both He-TPC and He-NTPC groups) would score lower on all dimensions of solution creativity than those in homogeneous individual-level problem representation conditions (i.e., both Ho-TPC and Ho-NTPC groups). Results of a series of Shapiro-Wilk tests revealed that solution originality scores were not normally distributed in the homogeneous group condition ($p = .02$). Levene's test results also revealed that the variances of solution originality scores (F (1, 26) = 4.28, $p = .05$) and complexity scores (F (1, 26) = 9.16, $p = .01$) were unequal across homogeneous and heterogeneous groups. Thus, we submitted solution scores (originality, quality, and complexity) to a Mann-Whitney U test with individual-level problem representation heterogeneity (homogeneous vs. heterogeneous) as the between-subjects variable. The results of the test revealed that, contrary to our expectation for Hypothesis 2a, the solution originality scores were significantly greater for heterogeneous (*Median* = 4.00; Mean rank = 16.82) than for homogeneous (*Median* = 3.00; Mean rank = 10.91) groups, $U = 54.00$, $p = .03$ (one-tailed), and the difference between the groups was moderate ($r = .36$). A trend in the direction opposite to our prediction indicating that heterogeneous groups (*Median* = 3.50; Mean rank = 14.88) scored higher on solution quality than homogeneous groups (*Median* = 3.50; Mean rank = 13.91) was found, however the difference was not statistically significant, $U = 87.00$, $p = .39$ (one-tailed). The same pattern of results was found for solution complexity: heterogeneous groups (*Median* = 6.00; Mean rank = 14.97) scored higher on solution complexity than homogeneous groups (*Median* = 4.50; Mean rank = 13.77), however the difference was not statistically significant, *U* = 85.50, *p* = .36 (one-tailed). These results indicate that groups in the heterogeneous conditions, compared to their homogeneous counterparts, scored higher on solution originality, however not on solution quality and complexity. Thus, Hypotheses 2a, 2b, and 2c were rejected.

We further anticipated that groups in the He-TPC condition would outperform those in the other three conditions on solution creativity. Table 3 presents the means and standard deviations of the three solution creativity scores in each group.

Table 3. *Means and Standard Deviations of Solution Creativity Scores per Groups.*

	Group conditions							
	Ho-TPC		Ho-NTPC		He-TPC		He-NTPC	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Solution originality	3.08	0.49	2.90	0.65	3.23	0.82	4.33	0.52
Solution quality	3.42	0.58	3.50	1.17	3.27	0.68	4.08	0.66
Solution complexity	5.42	1.99	6.20	3.33	5.55	1.54	6.00	0.84

First, we hypothesised that groups in the He-TPC condition would produce significantly higher originality scores than He-NTPC (Hypothesis 3a), Ho-TPC (Hypothesis 3b), and Ho-NTPC (Hypothesis 3c). Results of a series of Shapiro-Wilk tests revealed that solution originality scores in the Ho-TPC (*p* = .04) and He-NTPC group condition (*p* = .001) were not normally distributed. To evaluate differences among the four group conditions on solution originality scores, we submitted the solution score to a Kruskal-Wallis test with the group conditions as the between-subjects variable. The results of the test revealed that there was a statistically significant difference in solution originality scores across the groups, χ^2(3, *N* = 28) = 10.63, *p* = .01. The proportion of variability in the ranked originality score accounted for by the group conditions was η^2 = .39, indicating a fairly strong relationship between the group conditions and the originality scores.

Post-hoc analyses were carried out using pairwise Mann-Whitney U tests (Dytham, 2011). Tests of the three a priori hypotheses were conducted using the Bonferroni approach to control for Type I error. The results of these tests indicated that there was no statistically significant differences in solution originality scores between groups in the He-TPC and Ho-TPC conditions (*U* = 31.50, *p* = .93), and between groups in the He-TPC and Ho-NTPC conditions (*U* =

22.50, *p* = .63). However, there was a significant difference in solution originality scores between groups in the He-TPC and He-NTPC conditions such that the scores were greater for groups in the He-NTPC condition (*Median* = 4.00; Mean rank = 12.83) than for those in the He-TPC condition (*Median* = 3.00; Mean rank = 6.91), *U* = 10.00, *p* = .008 (one-tailed), *r* = .57. The result indicates that, contrary to the prediction of Hypothesis 3a, groups in the He-TPC condition scored lower on solution originality than those in the He-NTPC condition.

Follow-up tests revealed that groups in the He-NTPC condition (*Median* = 4.00) scored higher on solution originality than those in the Ho-NTPC condition (*Median* = 3.00), *U* = .00, *p* = .002 (one-tailed), *r* = .85; and those in the Ho-TPC condition (*Median* = 3.25), *U* = .00, *p* = .001 (one-tailed), *r* = .86. These results indicate that those groups consisting of members respectively prompted to think of goals and constraints, but not engaging in the team problem construction scored highest on the solution originality. On the basis of these results, Hypotheses 3a, 3b and 3c were rejected.

Hypotheses 4a, 4b, and 4c predicted that groups in the He-TPC condition would outperform groups in the other three conditions in quality of their solutions. Results of a series of Shapiro-Wilk tests revealed that solution quality scores in the He-NTPC group condition (*p* = .01) were not normally distributed. Levene's test results also revealed that the homoscedasticity assumption was violated for solution quality scores (*F* (3, 24) = 3.09, *p* = .05). To evaluate differences among the four group conditions on solution quality scores, we submitted the solution quality scores to a Kruskal-Wallis test with the group conditions as the between-subjects variable. There was no statistically significant difference in solution quality scores across the groups in different conditions, χ^2(3, *N* = 28) = 5.07, *p* = .17. Therefore, Hypotheses 4a, 4b, and 4c were rejected.

The last set of hypotheses predicted that groups in the He-TPC condition would score higher on solution complexity than those in the He-NTPC (Hypothesis 5a), Ho-TPC (Hypothesis 5b), and Ho-NTPC conditions (Hypothesis 5c). Levene's test results revealed that the homoscedasticity assumption was violated for solution complexity scores (*F* (3, 24) = 8.00, *p* = .001). To evaluate differences among the four group conditions on solution creativity, we submitted the solution complexity scores to a Kruskal-Wallis Test with the group conditions as the between-subjects variable. The results of the test revealed that there was no statistically significant effect of different group conditions on solution complexity scores, χ^2(3, *N* = 28) = .52, *p* = .91). Therefore, Hypotheses 5a, 5b, and 5c were also rejected.

Additional analysis

Tests for Hypotheses 2a and 3 revealed results opposite to our expectations. Contrary to Hypothesis 2a, solution originality scores were greater for heterogeneous groups than for homogeneous groups. Findings from Hypotheses 3 suggested that groups in the He-NTPC condition scored higher on solution originality than groups in the other three conditions. Consequently, we examined the influence of two covariate variables – problem construction time and team history – to determine whether the two variables could account for the differences in solution originality scores found between different group conditions. The additive effects of the two covariates were tested using two ordinary least squares (OLS) hierarchical regression analyses. The data met the assumptions required for multiple linear regression analysis. The relationships between the predictor variables and solution originality scores were all roughly linear. The values of the residuals were independent (for the first regression analysis, Durbin-Watson = 2.21; for the second, Durbin-Watson = 2.33) and normally distributed. VIF and tolerance scores for all predictor variables were well below 10 and above 0.2, respectively. The plots of residuals versus standardised predicted values showed no obvious signs of funnelling, suggesting the assumption of homoscedasticity has been met. Finally, no influential cases were found to be biasing our models.

The first regression analysis assessed the effects of heterogeneity in individual-level problem representations (hereinafter *heterogeneity*) on solution originality scores after accounting for the impact of problem construction time and team history (see Table 4). First, we entered heterogeneity into the regression model. Replicating the findings from Hypothesis 2a, the effect of heterogeneity was statistically significant, R^2 = .14, *F* (1, 26) = 4.20, *p* = .05 (β = .37, *p* = .05). Then, we entered the covariate variables problem construction time and team history into the model. The model including the two covariates predicting solution originality scores was also significant, R^2 = .41, ΔR^2 = .27, *F* (3, 24) = 5.46, *p* < .01. When problem construction time and team history were included in the model, heterogeneity did not significantly predict solution originality scores (β

= .26, *p* = .12). On the other hand, problem construction time was positively related to solution originality scores at a marginal significance level (*β* = .28, *p* = .10). Team history significantly predicted solution originality (*β* = .42, *p* = .02), suggesting that solution originality was higher for teams consisting of members that had worked more with each other previously.

Table 4. *The Effects of Heterogeneity, Problem Construction Time, and Team History on Solution Originality*

		Unstandardised coefficients		Standardised coefficients		
Model		*B*	*SE*	Beta	*t*	Sig.
1	Intercept	2.38	.51		4.71	.00
	Heterogeneity	.62	.30	.37	2.05	.05
2	Intercept	.95	.80		1.20	.24
	Heterogeneity	.44	.27	.26	1.63	.12
	Problem construction time	.27	.16	.28	1.74	.10
	Team history	.18	.07	.42	2.60	.02
	Adjusted R^2 = .33					

Note: Heterogeneity = Heterogeneity in individual-level problem representation structures.

The second regression analysis examined the effects of the group conditions (He-NTPC vs. Ho-TPC, Ho-NTPC, and He-TPC) on solution originality scores controlling for the impact of problem construction time and team history. Corroborating the findings from Hypotheses 3, the model (see Table 5, Model 1) using the group conditions as predictors was significant, R^2 = .40, *F* (3, 24) = 5.41, *p* < .01. Compared to groups in the He-NTPC condition, the average solution originality scores were significantly lower for groups in the other three conditions. Specifically, the average difference in solution originality scores between groups in the He-NTPC condition and groups in the Ho-TPC conditions was 1.25 (*β* = -.63, *p* = .00), between He-NTPC and Ho-NTPC conditions was 1.43 (*β* = -.68, *p* = .00), and between He-NTPC and He-TPC condition was 1.11 (*β* = -.67, *p* = .00). Subsequently, we entered the covariate variables problem construction time and team history into the model. The model including the two covariates predicting solution originality scores was also significant, R^2 = .50, ΔR^2 = .10, *F* (5, 22) = 4.39, *p* < .01. When problem construction time and team history were included in the model, however, significant differences in average solution originality scores were only found between groups in the He-NTPC and Ho-NTPC conditions (*β* = -.53, *p* = .02). Neither team history (*β* = .34, *p* = .11) nor problem construction time (*β* = .22, *p* = .19) demonstrated incremental prediction of solution originality scores. These results indicate that after accounting for the effects of team history and problem construction time, solution originality scores were greater for groups in the He-NTPC condition than for groups in the Ho-NTPC conditions.

Table 5. *The Effects of Different Group Conditions, Problem Construction Time, and Team History on Solution Originality*

		Unstandardised coefficients		Standardised coefficients		
Model		*B*	*SE*	Beta	*t*	Sig.
1	Intercept	4.33	.28		15.73	.00
	Ho-TPC	-1.25	.39	-.63	-3.21	.00
	Ho-NTPC	-1.43	.41	-.68	-3.51	.00
	He-TPC	-1.11	.34	-.67	-3.23	.00
2	Intercept	2.59	.94		2.75	.01
	Ho-TPC	-.64	.50	-.32	-1.28	.21
	Ho-NTPC	-1.11	.42	-.53	-2.62	.02
	He-TPC	-.58	.42	-.35	-1.38	.18
	Problem construction time	.21	.16	.22	1.36	.19
	Team history	.15	.09	.34	1.65	.11
	Adjusted R^2 = .39					

Exploratory analysis

Individual contribution to team solution

As previously discussed, the present study investigated the extent to which identifying two important elements of a problem (i.e., goals and constraints) prior to solving the problem influences the creativity of team's solution. Previous studies have demonstrated that focusing on goals, constraints, and both goals and constraints at the same time respectively had different impacts on creativity of solutions (Herman, 2008; Butler et al., 2003; Wigert, 2011). However, to our knowledge, the differential and combined effects of goals and constraints in problem construction have only been examined at the individual level. In the present study, the way the members' individual problem representations are combined to the team level may have fundamentally differed from the way individuals combine their self-generated representations. For example, in heterogeneous groups, the exploratory nature of goals may induce the goal-focused member to take on a more directive role in working on an ill-defined creativity task. Inversely, it is also possible that the preventive nature of constraints induces the constraints-focused member to restrict the range of problem representations explored and adopted in the group. On the other hand, in homogeneous groups where both members hold the same focus in problem construction, the members may be more readily able to share and process the individually generated problem representations, and to contribute to generating a team problem representation on more equal grounds. Further, when heterogeneous groups are instructed to engage in the TPC processes, the members may be able to balance the opposing nature of goals and constraints, and to generate a team's problem representation that has little overlap with individual members' representations.

It has been argued that certain group processes conducive to creative team performances such as effective communication can moderate the relationship between individual member creativity and group creativity (e.g., Taggar, 2002). Based on the idea that team processes play an important role in determining how members contribute to team outputs, we designed the present exploratory analyses to examine whether individual members' contributions to team solutions differed across group conditions they had been assigned to. In doing so, we compared the team solutions to the Marketing Problem with individual problem representations (i.e., goals and constraints of the Marketing Problem) participants had generated. It should be noted, however, that the way goals and constraints are translated into the team solutions may have been implicit, and that identifying the goals and constraints that have been transferred to the team solutions in most cases required the raters to make inferences. Thus, the ratings may have been subject to the raters' biases. In all cases, only those goals and constraints that were seen to be evidently related to the team solution were rated. For example, a goal to "turn the marketing campaign into an opportunity to learn about potential customers" was seen to be related to the solution to "use survey to learn about customer preferences", and a constraint that "older customers may have difficulties operating a three-dimensional holographic television" was seen to be related to the solution to "target younger customers equipped with technological expertise". For more examples, see Appendix L.

The number of goals or constraints that were translated into the team solution was counted for each team member to produce *individual contribution complexity* scores. In addition, the originality and quality of those individual contributions were rated, based on Mumford and colleagues' (1996) guidelines for evaluating problem representations. Specifically, the degree to which the goals or constraints were free from the assumptions presented in the Marketing Problem and would be likely to result in an unusual approach in producing a solution to the Problem determined the originality of those individual problem representations. The *individual contribution originality* scores were rated ton a 5-points Likert scale (1 = very unoriginal; 5 = very original). The quality of the goals or constraints hinged on the extent to which they were appropriate with regards to the problem situation and were likely to result in a logical approach in producing a solution to the Marketing Problem. The *individual contribution quality* scores were also rated on a 5-points Likert scale (1 = very low quality; 5 = very high quality). Table 6 shows the mean and standard deviation of these variables, as well as the correlations among them.

Table 6. *Descriptive Statistics and Correlations*

Variable	*M*	*SD*	1.	2.	3.
1. Individual contribution originality	2.93	1.11	-		
2. Individual contribution quality	3.27	1.20	.89**	-	
3. Individual contribution complexity	2.71	1.25	.46**	.54**	-

Note: $N = 56$.
$^{**}p < .01$

In order to test whether individual members' contributions to team solution differed across group conditions, we compared the individual contribution scores (originality, quality, and complexity) against the group conditions. A series of Shapiro-Wilk tests and Levene's tests revealed that normality and homoscedasticity assumptions were violated in most cases, thus, all analyses were performed using non-parametric tests.

We first examined whether the individual contribution scores (originality, quality, and complexity) differed between participants who generated goals and those who generated constraints. The results of a Mann-Whitney U test revealed that having generated goals or constraints did not influence the number of individual problem representations participants utilised to produce a team solution (i.e., individual contribution complexity; *U* = 373.50, *p* = .77), and how original (i.e., individual contribution originality; *U* = 371.50, *p* = .74) or of high quality (i.e., individual contribution quality; *U* = 354.50, *p* = .54) those representations were. Thus, goal-focused members and constraints-focused members did not contribute differently to their teams' solutions.

Comparing the individual contribution scores between participants in the homogeneous and heterogeneous group conditions, marginally significant differences were found. A Mann-Whitney U test result indicated that individual contribution complexity scores (i.e., the number of the goals or constraints that had been translated into the team solution) were marginally greater in homogeneous groups (*Median* = 3.00; Mean rank = 31.82) than in heterogeneous groups (*Median* = 2.00; Mean rank = 26.35), *U* = 301.00, *p* = .10 (one-tailed), *r* = .17. On the other hand, individual contribution quality scores (i.e., the quality of the goals or constraints that had been translated into the team solution) were marginally greater in heterogeneous groups (*Median* = 3.50; Mean rank = 31.24) than in homogeneous groups (*Median* = 3.00; Mean rank = 24.27), *U* = 281.00, *p* = .06 (one-tailed), *r* = .22. These results suggest that when members hold the same focus (i.e., either goals or constraints), they utilised more of the individually generated goals or constraints in the team solution, compared to when members hold different foci. On the other hand, the quality of the goals and constraints utilised in the team solution were higher when members were prompted to hold different foci.

Finally, we examined whether the individual contribution scores (originality, quality, and complexity) differed across participants in the four group conditions employed in the primary study (i.e., Ho-TPC, He-TPC, Ho-NTPC, and He-NTPC). The results of a Kruskal-Wallis test revealed that individual contribution quality scores differed at a marginal significance level across participants in the four group conditions, $\chi^2(3, N = 56) = 6.89$, *p* = .07, $\eta^2 = .13$. No statistically significant differences across the conditions were found for individual contribution originality ($\chi^2(3, N = 56) = 3.31$, *p* = .35) and individual contribution complexity scores ($\chi^2(3, N = 56) = 3.16$, *p* = .37). Post-hoc analyses were carried out using pairwise Mann-Whitney U tests, using the Bonferroni approach. The results of these tests indicated that individual contribution quality scores were marginally greater for participants in the He-NTPC condition (*Median* = 4.00; Mean rank = 14.33) than for those in the Ho-NTPC condition (*Median* = 2.50; Mean rank = 8.10), U = 26.00, p = .009 (one-tailed), r = .50, indicating that participants in the He-NTPC group condition contributed higher-quality goals or constraints compared to those in the Ho-NTPC group condition.

Discussion

The present study focused on problem construction – a process held to influence performance on creative problem-solving. Problem construction helps identifying important elements of a problem, such as goals and constraints, that should be tended to throughout the problem-solving process (Mumford et al., 1994). The effective application of the subsequent problem-solving processes, therefore, is contingent upon the context and direction provided by problem construction activities (Mumford et al., 1996). Despite the significance of these activities, previous studies predominantly examined the effect of problem construction on individual creativity. In this study, we aimed to investigate how problem construction can influence team-level creativity. In particular, the purpose of the present study was to examine how the differences in individual-level problem representations and team-level problem construction processes influence the team's creativity.

Summary of findings

In this study, participants received a fictional marketing problem to solve, and were prompted to adopt either goals-focus or constraints-focus in problem construction by generating either goals or constraints of the given problem. After the individual generation of goals or constraints, participants were assigned to two-member groups, where they received instructions regarding team-level problem construction processes. Since past research has shown that the self-generated goals and constraints influence the creativity of solutions in different ways (Herman, 2008; Wigert, 2011), we expected the effects of goals and constraints to manifest differently between the groups consisting of members focusing on goals and groups with members focusing on constraints. That is, we anticipated that when team members think of goals, the exploratory nature of goals will prime them to select novel problem representations, and thus they will be able to produce a highly original and complex solution. On the other hand, we hypothesised that when team members are prompted to concentrate on constraints of the problem, they will be more likely to resort to tried-and-true problem representations, and a high-quality solution will ensue. However, no significant differences in the three solution creativity scores were found between the two groups.

Our next set of hypotheses was built upon research on diversity in team members' cognitive structures. Because inconsistencies between individual members' problem representations may interfere with the dynamic process of information sharing and processing within teams, we hypothesised that when members adopt opposing foci in problem construction, the originality, quality and complexity of solutions would be lower compared to when both team members adopt the same focus. The findings from our analysis revealed that, contrary to earlier research and our predictions, groups that are heterogeneous in members' representational structure outperformed groups that are homogeneous in members' representational structure on solution originality. However, this difference was not statistically significant once the effects of team history (i.e., how much the two teammates had worked together *a priori*) and problem construction time (i.e., how much time the members spent thinking of goals and/or constraints of the problem) were controlled for.

Finally, Hypotheses 3, 4 and 5 posited that groups that are heterogeneous in individual members' problem representation structure would be able to capitalise on members' cognitive diversity without endangering the information flow within the team when given the opportunity to engage in problem construction as a team, and eventually would outperform groups in all other conditions in terms of solution originality, quality and complexity scores. However, the results of our analyses revealed that heterogeneous groups that did not engage in the team problem construction process scored higher on solution originality than groups in all other conditions. Once the effects of team history and problem construction time were accounted for, only the differences in solution originality scores between heterogeneous groups that did not engage in the team problem construction process and homogeneous groups that did not engage in the team problem construction process remained significant. For the remainder of the discussion, we will reflect upon the implications of these findings.

Differential effects of goals and constraints

As previously discussed, focusing on goals during problem construction can prevent problem-solvers from selecting problem representations solely based on previous experience, and allow them to conceptualise a problem in a novel way (Mumford et al., 1994; Redmond et al., 1993; Reiter-Palmon et al., 1997). On the contrary, constraints lead problem-solvers to focus on retaining most viable representations. This dismissal of problem representations based on salient constraints may lead problem-solvers to eliminate potentially novel ways of framing a problem (Mumford et al., 1996). Therefore, we anticipated that groups adopting goals-focus (HoGG groups) will produce highly original and complex solutions, whereas constraints-focus (in HoCC groups) will enhance the quality of group solutions.

We believe that the reason we did not find any significant differences in solution scores between the two groups could have been the two-sided nature of constraints. It has been argued that an assessment of constraints in problem construction can restrict the use of problem cues or relevant information, however, at the same time can provide direction when structuring a problem (Stokes, 2009). Mumford and colleagues (1996) suggested that because constraints eliminate potential ways of framing a problem, they might help problem-solvers focus their divergent thinking efforts on particular aspects of the problem. Narrowly defined problem representations driven by constraints do not necessarily impede originality and complexity of resulting solutions. For example, Rietzschel, Nijstad and Stroebe (2014) showed that participants who brainstormed on a narrowly defined problem generated more original ideas than participants working on a broader problem. It has been argued that an in-depth exploration within few conceptual categories can help problem-solvers engage in a more deliberate and persistent information search, which in turn can lead to greater fluency in idea generation (De Dreu, Baas, & Nijstad, 2008). Furthermore, the likelihood of discovering original ideas increases as more ideas are explored in a narrow conceptual category, because only a limited number of unoriginal ideas are possible in the category (Rietzschel, Nijstad, & Stroebe, 2007). As such, constraints could have induced as directive and exploratory focus in problem construction as goals could have, and thus could have enhanced the originality and complexity of solutions in HoCC groups.

Conversely, the individual generation of goals may have inadvertently created goal conflicts in HoGG groups where both members were instructed to focus on goals. Even though both members focused on the same representational element, it is very likely that the members produced different sets of goals. The same account could be applied to HoCC groups where both members were instructed to individually generate constraints of the problem. However, the level of overlap needed for effective group functioning may have differed between goals and constraints. In other words, unaligned goals among members may impede with the team's collective effort in a much more serious manner than unaligned constraints may, because differing beliefs about the desired end-state of the team's problem-solving efforts can impede with coordination and can lead to intra-group conflict (Cronin & Weingart, 2007; Weingart et al., 2010). The significance of congruent goals among team members on team creativity and innovation has been documented by Hülsheger and colleagues' (2009) meta-analysis: goal interdependence, or the extent to which team members' goals are related, was found to be one of the most influential antecedents of team innovation in the workplace. When team members strive towards common team goals, they want each other to perform effectively, and communication and cooperation within the team is likely to be enhanced (Campion, Papper, & Medsker, 1996).

Effects of heterogeneity in member problem representations

As explained, after controlling for the effects of team history and problem construction time, no differences in solution creativity scores between heterogeneous and homogeneous groups were found. The solution scores also did not differ between heterogeneous groups that engaged in the team problem construction process (He-TPC groups) and homogeneous groups that engaged in the team problem construction process (Ho-TPC groups). On the other hand, we observed that compared to homogeneous groups that did not engage in the team problem construction process (Ho-NTPC groups), solution originality scores were greater for heterogeneous groups that did not engage in the team problem construction process (He-NTPC groups), even after the effects of team history and problem construction time had been accounted for. This may suggest that heterogeneity in member problem representations did not influence team creativity, or even be beneficial for team creativity. This finding was somewhat puzzling because it is in contrast with previous research on TMM, which suggests that the gaps between members' problem representations should degrade team performance (e.g., Marks, Zaccaro, & Mathieu, 2000). We propose three explanations for these findings. First, the nature of the problem given in this study (i.e., the Marketing Problem) was different in task demands from the tasks used in previous research. Unlike intellective coordination tasks (e.g., war-game simulations) where members need to be in sync with their teammates in order to coordinate their actions, the ill-defined creativity problem used in the present study may not have required participants to all have aligned mental models to work together effectively.

Another possibility is that members of homogeneous groups may have had different *a priori* cognitive structures. As previously discussed, problem representations are formulated based on problem-solvers' past problem-solving experience. As such, we expected urging participants to work on an example problem (i.e., the Flexitime Problem) would manipulate their representational structures by making either goals- or constraints-focus more salient and accessible in their memory. However, problem representations can also arise based on problem-solvers' personality or values (Cronin & Weingart, 2007). Problem representations built upon different value systems, compared to those based on different knowledge or experience, may cause more severe intra-group conflict because they dictate what should be done, rather than what can be done (Cronin & Weingart, 2005). Our measures in this study did not allow us to tap into members' value systems, and therefore the relationship found between heterogeneity in member problem representations and team creativity may have been confounded by other types of cognitive diversity within the teams.

Finally, heterogeneity in member cognitive structures may have indeed heightened the originality of solutions. Findings from our exploratory analyses may shed light upon this argument. Individual contribution complexity scores were marginally higher in homogeneous groups than in heterogeneous groups, indicating that the number of individually generated goals or constraints that were translated into group solutions was greater for homogeneous groups. This implies that homogeneous groups' solutions were mostly built upon the goals or constraints generated by individual members. It is possible that since homogeneous group members were already in sync with each other regarding their problem representation structures, it was easier for them to induce acquiescence from each other when they pooled individual representations together. However, it has been suggested that limiting the base of idea generation to the nearest and most available problem representations restricts the plasticity of the problem-solving process, and this in turn may impair the originality of solutions (Skilton & Dooley, 2010). On the other hand, individual contribution quality scores were marginally greater for heterogeneous groups than for homogeneous groups, and also greater for He-NTPC groups than for Ho-NTPC groups, suggesting that the quality of goals and constraints the groups' solutions were built upon were higher in heterogeneous groups and He-NTPC groups. Perhaps the presence of diverse perspectives on how to manage the problem has prevented the members of heterogeneous groups from prematurely reaching consensus on how to define the problem, and this careful consideration may have helped the members make sound sense of the problem (van Knippenberg et al., 2004; Mumford et al., 1996). Mumford and colleagues (1996) demonstrated that the originality of problem solutions was enhanced when the representation screening stage of problem construction was focused on high-quality representational elements. Further, the consideration of high-quality representational elements was more conducive to solution originality than the consideration of high-originality elements was, because high-quality elements can reduce ambiguity needed to organise the problem-solving effort (Mumford et al., 1996). Considering that the effect of problem construction on creativity hinges upon its ability to guide the subsequent problem-solving efforts in a coherent and structured manner, we believe that heterogeneity in member cognitive structures could have helped members to focus on high-quality goals and constraints, and this led the He-NTPC groups to score higher on solution originality.

Effects of team problem construction

Findings from our additional analyses suggest that team history, or the extent to which teammates had worked together *a priori*, had a major impact on the team's originality scores. Specifically, our results show that teams with high levels of team history outperformed teams with low levels of team history. We argue that team members who have worked together before may have been able to internalise the behavioural patterns of each other (Granovetter, 1985). This shared understanding on how one another works has been postulated to transfer to ambiguous task situations (Skilton & Dooley, 2010). In other words, the understanding of how one another behaves could have served as templates for how they can go about solving an ill-defined problem together in teams with high levels of team history. It is also plausible that this cognitive structure developed over time may have increased the members' tolerance for conflict that can stem from fundamental differences in opinions on how to manage the problem.

We expected that the effects of team problem construction (TPC) processes would operate in a similar manner. That is, we anticipated that TPC processes will help teams establish a TMM on how to interpret and define the given problem, and subsequently, facilitate information search and sharing in the subsequent problem-solving processes. Therefore, we hypothesised that heterogeneous groups that engage in the TPC process (He-TPC groups) would best be able to reap the benefits of cognitive diversity, without impeding the flow of information within the group. However, our findings suggest that there were no significant differences between the solution scores for the He-TPC groups and other groups. Moreover, neither groups in the Ho-TPC and Ho-NTPC group conditions, nor those in the He-TPC and He-NTPC group conditions significantly differed on solution scores. These results indicate that the TPC process as used in this study did not show the hypothesised impact.

As previously discussed, creating a shared understanding on how to define the problem entails expanding one's individual problem representations to accommodate the concerns of others. This shift in cognition requires team members to exert an additional effort that represents an extra cost for their cognitive resources (Bunderson & Sutcliffe, 2003). We believe that the five minutes given to participants for the TPC process may not have been sufficient for some teams to develop a shared cognitive structure. For example, teams in the He-TPC conditions had the added complication of having to explain what goals or constraints are to one another during the TPC process, and likely needed a greater amount of time and cognitive resources to establish a shared understanding of how the problem can be defined. Therefore, the allocation of additional cognitive resources demanded for the TPC process in He-TPC groups may have made it difficult for the members to deploy an adequate amount of resources for problem solutions.

Alternatively, the TPC process as used in the present study could have created divergence, rather than convergence, of individual problem representations. Research on incongruence among members' cognition suggests that when members establish different representations of the team's problem, the members may focus on winning the arguments during task conflict instead of exerting an effort to make sense of one another's thought world (Weingart et al., 2010). This tendency makes the arguments made by others be perceived as less valid, and as a result, the members may become more committed to their own positions (Weingart et al., 2010).

On the other hand, literature suggests that reconciling the differences between group members' representational structures may not always be beneficial for the group's creativity. Weingart and colleagues (2010) investigated student product development teams and found that the quality of the products developed was better for the teams that were more polarised in their member viewpoints. Teams adopting to resolve the differences in the members' viewpoints by accommodating others' viewpoints were successful in converging the different perspectives, however, the decreased polarisation in perspectives was negatively related to the product quality (Weingart et al., 2010). Therefore, Weingart and colleagues (2010) argue that resolving the differences in members perspectives by simply accommodating them may erode the creative abrasion and eliminate the subtleties that make alternative perspectives powerful. However, in order for a team to move forward, some enlargement of perspectives is needed for members to take a common course of action (Skilton & Dooley, 2010). Therefore, a process which establishes teams' joint problem representation that is conducive to creativity needs to strike a balance between integrating diverging individual-level representation structures and homogenising those structures.

This points to the possibility that not only whether or not teams address members' diverse problem representations, but also how the teams address it may influence the creativity of team output. Harvey (2014) has proposed several approaches that can facilitate the integration of members' diverse views, including *collective attention* and *building on similarities from within different perspectives*. Collective attention is a process by which team members can agree upon a prevailing paradigm and consider emerging ideas in terms of the shared understanding of that paradigm. Importantly, having a shared understanding of the paradigm does not necessitate that individual team members agree with the understanding of the paradigm, as team members can disagree with specific actions and ideas (Heracleous & Barrett, 2001). By collectively paying attention, or attending to the dominant view of the team, team members would be better equipped at diverging together from these dominant assumptions, values and rules (Harvey, 2014). This type of integration approach is argued to facilitate creativity by allowing team members to make meaningful connections between different and new ideas by rooting them back to the agreed-upon dominant view (Vera & Crossan, 2005). In other words, collective attention to ideas in light of the teams' shared understanding of the dominant paradigm will provide individual members with meanings to new ideas (Csikszentmihalyi, 1999), as individuals tend to pay attention to ideas that fit their own understanding of a situation (Bartunek, 1984). Thus, these meanings can enable team members to be more deeply engaged with ideas that receive the team's collective attention.

The integration process of building on similarities can also be conducive to creativity, by allowing members to see similarities in perspectives divergent from their own (Koestler, 1964). Identifying the similarities may allow team members to broaden their own ideas by identifying new ways the ideas can be applied, and to develop a more complex and thorough understanding of the ideas (Langer & Moldoveanu, 2000). Furthermore, by identifying the similarities between divergent perspectives, members can compare and bridge otherwise disconnected ideas, which in turn may help the members shape new ways of understanding problems (Dunbar, 1997; Gentner, 1989; Hargadon, 2002).

Harvey (2014) contended that these two integration methods operate by enabling teams' cognitive processing of ideas, as well as their affective environment, and social interactions among members. Since the integration methods could tap into different factors that are conducive to team creativity in different ways, it is plausible that the effectiveness of these integration methods in facilitating team creativity will be contingent upon the level of differences amongst individual members' problem representations. However, neither how teams address the differences in individual problem representations, nor the differing effect of these methods on team creativity has been extensively researched. Further exploration will need to examine what strategies can be used to maintain the delicate balance between integration and assimilation of individual representations.

Limitations and future research directions

There are several limitations to the present study that deserve mention. First, issues pertaining to the generalisability of our findings should be borne in mind. Our small sample size increased the probability of Type II error. We attempted to ameliorate this problem by limiting our investigation to only a few variables and lesser group conditions. Also, the results were obtained in a laboratory research using a sample that mostly consisted of students enrolled at a business school. Since domain-specific knowledge can influence creative performance substantially (Amabile, 1996), some teams in this study whose members were equipped with marketing knowledge could have been provided with a greater advantage in solving our experimental task (the Marketing Problem). Furthermore, the teams were not interacting in an organisational context. Weingart and colleagues (2010) implied that the hypothesised negative effects of incongruences between members' problem representation structures may be exacerbated within an organisational context, particularly for cross-functional teams, because the silos across different functional areas and misaligned incentives can magnify the conflicts within the teams. Hence, future research is needed to see whether our results generalise to wider population in different settings.

Secondly, apart from team history and problem construction time, other factors that could have confounded our results were not accounted for. For example, even though we set an intermediate level of English proficiency as the requirement for participation in our experiment, we did not check if participants actually had a requisite level of proficiency. We believe that participants' varying level of English proficiency could have played a large role in their performance, particularly in terms of the degree of articulation in their solutions. Moreover, we observed during the experiment that some groups consisting of members with differing levels of English proficiency had difficulties communicating with each other. Thus, the flow of information may have been obstructed and the effect of divergence in the members' problem representation structure could have been magnified in these groups. We collected data on participants' English skills in the form of task comprehension. Specifically, we asked participants how easy it was for them to understand the task instruction and to elaborate on the solution (see Appendix I). However, there was no meaningful correlation between the three solution scores and English skills ($p > .10$) and therefore English skills were not included in our data analysis.

How the groups managed their team problem construction (TPC) processes was also unaccounted for. We observed during the experiment that members of some groups were more actively engaged in discussing goals and/or constraints of the problem. These disparities between groups could have influenced the effectiveness of the TPC process, such that groups that exerted more efforts in the process could have been able to develop a higher-quality shared cognitive structure among members, thus facilitating their collective efforts in the subsequent problem-solving processes.

Another important consideration to make in regards to the study design is the effectiveness of our manipulation instructions. Following Wigert (2011), we validated the effectiveness of the instructions by assessing whether participants could correctly identify the individual-level problem construction instruction they had been given. However, it can be argued that the manipulation check question assessed how well the participants remembered the manipulation instructions, rather than whether the manipulation had actually occurred. Utilising a question asking participants to recall the instructions does not necessarily ascertain that they internalised the instructions (Sigall & Mills, 1998). Therefore, future research should aim to create or use more robust manipulation checks that measure the various assumptions involved in the conceptual interpretation of the manipulation. For example, one could assess the extent to which participants actually engage in the behaviour prescribed by the manipulation instructions by evaluating their problem-solving strategies on a series of example problems.

On a related note, although definitions of goals and constraints were provided in the instructions, participants may have conceptualised them differently. While evaluating the goals and constraints generated by participants, we noticed that participants who were instructed to generate goals listed those that could be seen as constraints, and vice versa. However, a follow-up interview with participants revealed that even those who failed to identify the correct answer to the manipulation check question understood that goals are something that should be achieved, whereas constraints are something that should be avoided or overcome. Therefore, we argue that participants' understanding of the promotional nature of goals and the preventive nature of constraints are more important than accurately distinguishing the characteristics of goals and constraints.

On the other hand, we acknowledge the possibility that representational elements other than goals and constraints were considered in problem construction. As previously discussed, problem representations typically contain four types of information: goals, constraints, key information, and key procedures (Holyoak, 1984). It has been postulated that these four representational elements in conjunction help problem-solvers abstracting key features of a problem that should receive attention during subsequent problem-solving processes (Barsalou, 1991; Holyoak, 1984; Mumford et al., 1994). Hence, it is plausible that key information and key procedures elements were also tended to when participants engaged in problem construction. It is difficult to conjecture how the key information and procedures elements would have influenced our participants' problem construction processes, however, because to our knowledge, no research has teased apart the effects of these two elements on creativity. Future research should examine how key procedures and information components of problem representation help shape problem representation selection and retention during problem construction. Such a study would provide insight into how the use of combinations of the different types of representational elements influences the production of creative solutions.

Another avenue for future research is to investigate the effects of heterogeneity among members' problem representations when they are built upon personality or value systems. Whereas problem representations formulated based on knowledge or skills inform problem-solvers how to conceptualise the problem in ways they can attempt to solve it, value-based problem representations dictate what is desirable and therefore what should be done (Cronin & Weingart, 2005). Thus, when value-based problem representations are incongruent among team members, a more severe intra-group conflict may be elicited. Since value-based beliefs can arise from domain-specific training and socialisation, future research could also examine how the conjunction of value- and knowledge-based problem representations influences creative problem-solving.

Furthermore, future research is needed to replicate and extend our findings in bigger teams. We used dyads in the present study, yet team size has been argued to impose significant influence on both individual and team creativity (Hülsheger et al., 2009). Our investigation focused on how the difference in two members' problem representation structures affects the team's creative output. However, the consideration of teams comprised of more than three members opens up a new avenue for research on the topic. That is, the levels of incongruence among member representations are affected not only by the amount of difference in the representations across each pair of members, but also by how evenly the differences are distributed across the pairs. For example, a team composed of three members A, B and C can have incongruity between each pair (A vs. B; B vs. C; C vs. A). The amount of incongruity across each pair can also vary (e.g., A and B defines the team's problem in a similar way, whereas C defines the problem differently). A recent investigation on the gaps between team members' problem representations and team effectiveness indicated that the asymmetry in the gaps may play a central role in increasing team performance on innovative tasks (Weingart et al., 2010).

Finally, it should be noted that the scope of our investigation was limited to one process – problem construction – which is only one of a number of processes posited to influence creative performance. As previously discussed, the core cognitive processes involved in creative problem-solving includes: problem construction, information encoding, idea generation, idea evaluation and selection, and implementation and monitoring (Reiter-Palmon et al., 2008). Our choice to focus on problem construction was in part due to a limited amount of research conducted on problem construction at the team level. Nonetheless, the processes ensuing problem construction have a substantial impact on creative performance. For example, a failure to accurately evaluate the creativity of ideas will result in less than optimal choices of ideas for further development or implementation (Harms et al., 2017). Whereas research on team idea generation has been abundant (e.g., Lam & Chiu, 2002; Paulus & Yang 2000; Valacich, Jung, & Looney, 2006; Vosburg, 1998), that is less so the case with other processes. Thus, future investigations should study not only each of these cognitive processes, but also how the specific processes interact with and influence one another.

Conclusion

Creativity and innovation is thought to be the driving force behind organisational effectiveness. In order to tackle problems that require high levels of diversity in skills and expertise, organisations use teams to bring together diverse perspectives. However, aside from research on group brainstorming, a dearth of research has been conducted on other cognitive processes underlying team creative problem-solving. In the present study, we focused on an early-stage process of team creative problem-solving that has received little attention in the team literature: problem construction.

Problem construction is a process by which problem-solvers define the nature of a problem. Since problems that require creative solutions tend to lack structure, identifying important aspects that should receive attention throughout the problem-solving effort by engaging in problem construction has been held to determine the effectiveness of the subsequent problem-solving processes. On the other hand, the very reason organisations rely on teams for innovation and creativity – a broader pool of skills and knowledge – leads team members to define the nature of a problem differently. The objective of the present research was to examine the extent to which these differences in how team members define the problem influence the creativity of team's output. Although research on team cognition has emphasised sharedness of member cognition and its benefits, our findings indicate that these cognitive differences between members' problem conceptualisations might not need to be resolved for effective team creative problem-solving efforts. That is, maintaining these differences can result in more novel and imaginative team problem solutions.

The degree to which the process of establishing a shared team cognition on how the given problem should be defined influences team creativity was also considered in the present investigation. Contrary to prior work suggesting the importance of team processes on the emergent state of shared cognition and resulting creativity, the team problem construction process induced to certain experimental conditions in this study did not show impact on the creativity of team problem solutions. Instead of negating the effects of group processes and shared cognition on team effectiveness, however, we suggest that future investigations explore different ways team members can accommodate diverse perspectives without homogenising those perspectives altogether. We firmly believe that advancing theories on the mechanisms and pathways through which the diverse perspectives can be optimally integrated would help teams reach their creative potential.

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Appendix A

Creative problem solving activity

In this study we are interested in creative problem solving. Particularly, we are interested in solutions that are creative, not how the typical person would respond. Creative ideas are most commonly defined as those that are *original*, as well as *useful and realizable*. This means you are required to provide not only *imaginative*, but also *achievable* solutions to the problem that will be presented. **Please do your best to generate highly creative solutions to the given problem.**

You will be first given an example problem showing you how to solve problems creatively, and then presented another problem you need to provide a solution to. Each problem will be given with a set of instructions. Please review the provided instructions carefully *before* thinking about how to solve the problem. Once the problem solving activities have been completed, you will be asked to answer a survey.

Appendix B

Example problem

Please go through the example problem and the instructions below individually.

Flexitime problem

You work for the government as a manager of a division comprised of 450 technical and administrative employees distributed among several departments. Your boss has asked you to prepare a plan for placing your agency on flexitime work schedule which would allow employees to schedule their eight hours of work any time between 6 a.m. and 6 p.m.

How to solve the problem

There is no one correct solution to the above problem. To find the best solution, you should first clarify your goals. In other words, goals are what you want to achieve when solving the problem, or the outcomes that need to be focused on. In this case, you are asked to design a flexitime plan for your agency. Below are some examples of goals you can achieve by designing a flexitime plan:

- Ensure that all employees still work 8 hours so that the department is still productive.
- Improve employee work-life balance to increase satisfaction.
- Impress boss by designing a good plan so that you can get a promotion or pay raise.
- Decrease turnover so that the department does not have to go through expensive hiring processes.

It is important to imagine what different goals you can achieve by going beyond what is stated in the problem. As in the example list above, consider what goals can be achieved from different points of view (e.g., you as a manager, employees, and the agency itself, etc.). In fact, the more goals you think of at this stage, the more creative your solution is likely to be.

If possible, list other goals:

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Appendix C

Example problem

Please go through the example problem and the instructions below individually.

Flexitime problem

You work for the government as a manager of a division comprised of 450 technical and administrative employees distributed among several departments. Your boss has asked you to prepare a plan for placing your agency on flexitime work schedule which would allow employees to schedule their eight hours of work any time between 6 a.m. and 6 p.m.

How to solve the problem

There is no one correct solution to the above problem. To find the best solution, you should first clarify possible constraints, in other words, obstacles or hindrances that must be overcome when solving the problem, because they would hinder the use of a particular solution.

In this case, you are asked to design a flexitime plan for your agency. Below are some examples of constraints you need to overcome when designing a flexitime plan:

- The union might object because they do not know how working conditions are upheld during different hours of the day.
- Lack of support from other managers because they might fear losing control over their subordinates.
- The agency may want certain employees dependent on each other to work during the same hours.
- Workers that have to work from 8 a.m. to 5 p.m., such as secretaries, might feel that the policy is unfair.

It is important to imagine what different constraints you need to overcome by going beyond what is stated in the problem. As in the example list above, consider what constraints might need to be overcome from different points of view (e.g., you as a manager, employees, and the agency itself, etc.). In fact, the more constraints you think of at this stage, the more creative your solution is likely to be.

If possible, list other constraints:

Appendix D

Creative problem solving exercise

Now you will be presented with an actual problem to solve. Please read the problem and the instructions *before* thinking about possible solutions to the problem.

Please go through the problem and the instructions below individually.

Marketing problem

You have been selected as a project manager intern at Zenith to prepare a plan to create a buzz about the company's new product: the 3-D holographic TV (you may check the product description on the next page). The head of marketing has informed you that the reason you were selected for this project is in part due to your knowledge of the Internet and technology, and that you may be able to use your knowledge to devise a plan. What type of customers do you think Zenith should target? How would you create hype around the product launch for these customers?

Before answering the above question

Think about what you want to achieve when solving the above problem, or the outcomes that need to be focused on. Imagine different goals by going beyond what is stated in the problem. Consider the goals from different points of view.

List the goals below:

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Appendix E

Creative problem solving exercise

Now you will be presented with an actual problem to solve. Please read the problem and the instructions *before* thinking about possible solutions to the problem.

Please go through the problem and the instructions below individually.

Marketing problem

You have been selected as a project manager intern at Zenith to prepare a plan to create a buzz about the company's new product: the 3-D holographic TV (you may check the product description on the next page). The head of marketing has informed you that the reason you were selected for this project is in part due to your knowledge of the Internet and technology, and that you may be able to use your knowledge to devise a plan. What type of customers do you think Zenith should target? How would you create hype around the product launch for these customers?

Before answering the above question

Think about the obstacles that must be overcome when solving the above problem, because they would hinder the use of a particular solution. Imagine different constraints by going beyond what is stated in the problem. Consider the constraints from different points of view.

List the constraints below:

Appendix F

Product Description

New product: 3-D holographic TV

Product Description:

- The company expects for the 3-D holographic TV to revolutionize the home entertainment experience for its customers. The computer in the TV generates the normally untelevised third dimension using lasers and mirrors.
- The TV is cylindrically shaped (20cm high, 60cm in diameter), and can project a large fully colored image (up to 200cm high, 140cm wide, and 140cm deep). The TV is also energy-efficient.
- The 3-D holographic image is projected to an area *on top of the set*. This 3-D projection allows the created image to be viewed *from all angles* (front, back and sides). For example, a moving object that appears to be travelling towards you when viewed from the front of the set will appear to be travelling away from you when viewed from the rear of the set.
- The company expects the retail price to be NOK 39,000 per unit. However, as more units are produced and sold, the average price will go down as follows:

Retail Pricing Curve

Number of units produced	Manufacturer's Suggested Retail Price (per unit in NOK)
1 – 10,000	39,000 – 50,000
10,000 – 100,000	32,000 – 39,000
100,000 – 1,000,000	25,000 – 32,000
1,000,000 and up	19,000 – 25,000

Appendix G

Marketing Problem Answer Sheet

Now you will work with a partner *as a team* to solve the given marketing problem.

Problem solution:

Please provide below your team's plan on creating hype around the product launch.

Elaborate on the plan as thoroughly as possible:

- Avoid using single words.
- Explain why you believe your plan would work.
- Record as much of the ideas discussed in your team as possible.

Remember, do your best to generate a creative plan.

Appendix H

**Answer sheet for teams in the HoGG-TPC condition*

Marketing Problem Answer Sheet

Now you will work with a partner *as a team* to solve the given marketing problem.

Team discussion (5 min.):

BEFORE attempting to solve the marketing problem, please discuss what each of you believe to be important goals of the marketing problem WITH YOUR TEAMMATE.

Problem solution:

Please provide below your team's plan on creating hype around the product launch.

Elaborate on the plan as thoroughly as possible:

- Avoid using single words.
- Explain why you believe your plan would work.
- Record as much of the ideas discussed in your team as possible.

Remember, do your best to generate a creative plan.

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**Answer sheet for teams in the HoCC-TPC condition*

Marketing Problem Answer Sheet

Now you will work with a partner *as a team* to solve the given marketing problem.

Team discussion (5 min.):

BEFORE attempting to solve the marketing problem, please discuss what each of you believe to be important constraints of the marketing problem WITH YOUR TEAMMATE.

Problem solution:

Please provide below your team's plan on creating hype around the product launch.

Elaborate on the plan as thoroughly as possible:

- Avoid using single words.
- Explain why you believe your plan would work.
- Record as much of the ideas discussed in your team as possible.

Remember, do your best to generate a creative plan.

**Answer sheet for teams in the He-TPC condition*

Marketing Problem Answer Sheet

Now you will work with a partner *as a team* to solve the given marketing problem.

Team discussion (5 min.):

BEFORE attempting to solve the marketing problem, please discuss what you believe to be important goals and constraints of the marketing problem WITH YOUR TEAMMATE.

Problem solution:

Please provide below your team's plan on creating hype around the product launch.

Elaborate on the plan as thoroughly as possible:

- Avoid using single words.
- Explain why you believe your plan would work.
- Record as much of the ideas discussed in your team as possible.

Remember, do your best to generate a creative plan.

Appendix I

Questionnaire

Q1. What is your gender?

□ Male □ Female

Q2. What is your age? _______

Q3. What is your highest level of education (if you are a student, what is your current academic standing)?

□ High School □ Bachelor's □ Master's □ Ph.D □ Other

Q4. If you are a student, what is your current major (field of study)?

____

Q5. Please provide your cumulative grade point average (letter grade) for your highest level of education.

____

Q6. Do you have any experience in marketing (educational or work-related)?

□ Yes □ No

Q7. Please provide your e-mail address (if you wish to partake in the chance to win).

____

Q8. I was instructed to list (X) before solving the marketing problem. Which of the following is (X) ?

□ Goals □ Constraints □ Both goals and constraints □ Nothing

Q9. How much time did you spend thinking of (X) ?

□ None at all □ Very little time □ A little time □ A moderate amount of time □ Quite a bit of time □ A lot of time □ A great amount of time

Q10. How many different (X) listed by you were used when developing your team's marketing solution?

□ None	□ 1-2	□ 3-4	□ 5-6	□ 6 or more

Q11. How frequently were there disagreements about the task you were working on in your team?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Q12. How often did your teammate disagree about ideas regarding the task?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Q13. To what extent were there differences of opinions regarding the task in your team?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Q14. How often did your teammate disagree about the work being done?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Q15. How much friction was present in your team?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Q16. To what extent were personality clashes present in your team?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Q17. How much emotional conflict was there in your team?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Q18. How satisfied were you with your own performance during the task?

□ Extremely dissatisfied	□ Dissatisfied	□ Slightly dissatisfied	□ Neither satisfied nor dissatisfied	□ Slightly satisfied	□ Satisfied	□ Extremely satisfied

Q19. How satisfied were you with your team's problem solving process?

□ Extremely dissatisfied	□ Dissatisfied	□ Slightly dissatisfied	□ Neither satisfied nor dissatisfied	□ Slightly satisfied	□ Satisfied	□ Extremely satisfied

Q20. How satisfied were you with the quality of your team's marketing plan?

□ Extremely dissatisfied	□ Dissatisfied	□ Slightly dissatisfied	□ Neither satisfied nor dissatisfied	□ Slightly satisfied	□ Satisfied	□ Extremely satisfied

Q21. To what extent did you enjoy the marketing task?

□ Extremely unenjoyable	□ Unenjoyable	□ Slightly unenjoyable	□ Neither enjoyable nor unenjoyable	□ Slightly enjoyable	□ Enjoyable	□ Extremely enjoyable

Q22. My team's solution to the marketing task was of much higher quality than the initial proposals of individual members.

□ Strongly disagree	□ Disagree	□ Somewhat disagree	□ Neither agree nor disagree	□ Somewhat agree	□ Agree	□ Strongly Agree

Q23. My team's solution to the marketing task generally reflected the best that could be extracted from the team.

□ Strongly disagree	□ Disagree	□ Somewhat disagree	□ Neither agree nor disagree	□ Somewhat agree	□ Agree	□ Strongly Agree

Q24. My team's solution to the marketing task extended the quality of individual member's input.

□ Strongly disagree	□ Disagree	□ Somewhat disagree	□ Neither agree nor disagree	□ Somewhat agree	□ Agree	□ Strongly Agree

Q25. How easy was it for you to understand the task instructions?

□ Extremely difficult	□ Moderately difficult	□ Slightly difficult	□ Neither easy nor difficult	□ Slightly easy	□ Moderately easy	□ Extremely easy

Q26. My team found it easy to elaborate on the marketing solution.

□ Strongly disagree	□ Disagree	□ Somewhat disagree	□ Neither agree nor disagree	□ Somewhat agree	□ Agree	□ Strongly Agree

Q27. How often have you worked with your teammate on tasks before?

□ Never	□ Rarely	□ Sometimes	□ About half the time	□ Often	□ Most of the time	□ Always

Appendix J

Solution Originality Scoring Scheme

Solution originality scores are based on the following three criteria:

- Novelty: Relative to other solutions, does the solution represent a unique approach to the problem?
- Imagination: Does the solution offer an imaginative or humorous approach?
- Structure: Does the problem-solver question the assumptions presented in the problem (i.e., "use your knowledge on the Internet and technology to devise a plan")?

1 = very unoriginal: a solution that is simple, minimum effort.

2 = unoriginal: a solution that is not novel, not imaginative, and is structured by the problem.

3 = neither unoriginal nor original: a solution that shows limited novelty or imagination, but is still structured by the problem.

4 = original: a solution that shows some novelty and imagination, and is less structured by the problem.

5 = very original: a solution that is novel, imaginative, and not structured by the problem.

(adapted from Wigert, 2011)

Appendix K

Solution Quality Scoring Scheme

Solution quality scores are based on the following two criteria:

- Completeness: How elaborate is the solution? Does the solution address both issues presented in the problem (i.e., "select potential customer base", and "devise a plan to create hype for potential customers")?
- Effectiveness: How viable, feasible, practical or appropriate is the solution?

1 = very low quality: a solution that is incomplete, minimum effort.

2 = low quality: a solution that is not elaborate, addresses only one of the issues, or is not feasible.

3 = average quality: a solution that tries to address more than one issue, but does so poorly, or with minimum elaboration.

4 = high quality: a solution that addresses both issues and is effective in addressing one and at least reasonably effective in addressing the other.

5 = very high quality: a solution that addresses both issues and is effective in addressing both.

(adapted from Wigert, 2011)

Appendix L

Participant ID	Goals	Constraints	Individual contribution in the solution
6A	N/A	• We can only target a very narrow market • The 3D-holographic TV may not be compatible with other devices or technologies • We may face resistance from customers, and hence it may not be possible to replace it with a regular TV	• We need to target a very specific group of consumers • Partner up with platforms like Netflix to see if the holographic TV can be made compatible with the platforms • We don't believe that the holographic TV will be able to replace the "normal" TV
6B	N/A	• The target market for this type of product will be too specific • The product may not answer any needs	• We need to target a very specific group of consumers • Convince other sectors than individual customers (e.g., educational institutions or hospitals) to use the product
10A	• Make people better able to enjoy a high quality 3D-holographic TV that is compact in size	N/A	• Emphasise the small size of the product: it can be carried to places when travelling
10B	• Ensure that all kinds of contents (TV programmes, movies, videogames) are available for the TV	N/A	• Showcase the versatile usage of the product. "You can play videogames, watch movies, or video-chat with others"

11A	• Make the product popular and desirable for households worldwide • Make improvements on the product	N/A	• Lower the price by achieving a high sales volume to make it accessible for households worldwide • Get customer feedbacks by doing in-store demonstrations to improve the product
11B	N/A	• The product might be too expensive	• Target consumers who are willing to spend for this type of product (e.g., young and rich, consumers in countries like Norway)
16A	N/A	• The TV may seem as a luxurious product, not a necessary item	• Link the luxuriousness of the product with top celebrities and rich businessmen, and have them advertise the product
16B	• Increase the sales and profit for the company • Use mostly the internet to make the plan more cost-effective	N/A	• Advertise all the advantages of the TV (e.g., environmentally friendly) to attract more customers • Use viral videos on the internet