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Collective Intelligence in Project Groups: Reflections from the Field

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Abstract

Project performance is contingent upon the continuous ability of key decision-makers to collaborate effectively when solving emerging complex problems. In settings of large and complex projects, the ability to make sound decisions collectively across multiple tasks and phases increases in importance.

Experimental studies have pointed to the existence of collective intelligence, i.e. the ability of groups to perform well across a variety of tasks. Nevertheless, we are not close to a process theory that clarifies why and how some groups are more 'intelligent' than are others, i.e. why and how they are better at solving a variety of complex problems. In order to answer these questions, we conduct an exploratory study of the drivers and manifestations of collective intelligence among a group of key decision makers in a large and dynamically complex project. The study reveals how these decision makers in general demonstrate a collective ability to solve a wide range of emerging problems in this project. This problem solving ability is characterized by very short and direct (face to face) lines of communication, the combination of divergent and convergent modes of thought, and small subgroups that are formed spontaneously dependent on the problem at hand and the expertise required to solve it.

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Keywords: Project management; dynamic complexity; collective intelligence; judgement; decision-making; problem solving

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1. Introduction

Projects rely on the ability of their key decision makers to – often in concert – effectively assess and handle continuously uncertain and changing circumstances[1]. Chronological methodologies capable of representing the complicated structure and process of large and complex projects are generally a prerequisite for project planning and performance, but this approach alone is not fully capable of dealing with unforeseen challenges that emerge during a complex project life cycle. We cannot expect a given state of affairs to be stable over time, and we can expect an array of 'unknown unknowns'[2] to emerge and warrant a resolution. Many facets of the complexity facing a project are unknown both in advance and during the project, and they emerge as results of decisions and changing circumstances both inside and outside the project during the course of its lifecycle, e.g. from previous decisions, new technologies, force majeure, and change orders. In addition, projects are in and by themselves time-constrained, and they draw participants from different disciplines and functional units in order to produce one-time outputs[3]. Each person brings specific expertise and experience to the project team[4] enabling them to solve complex problems. The successful outcome of projects may often be contingent upon the compiled problem-solving abilities of its key decision makers.

Cooperation makes sense when the problem complexity warrants individuals to bring different parts of the answer to the table[5,6]. Emphasizing the synergy emerging from cooperation, Driskell and Salas[7] link team performance to the rate with which individuals take part in collective, cooperative behaviors, including accepting and receiving input and suggestions from teammates. At high rates of collaboration, team members are likely to integrate each member's efforts through even team collaboration, generating productive interactive effects among members[8]. Hence, individuals of a team in combination embody more cognitive resources than that of the individuals simply put together.

Although scholars have recognised that individuals vary in their cognitive ability[9], limited attention has been shown to the intelligence of groups, i.e. their 'collective intelligence'[10]. We know many pieces of the puzzle about the processes of well performing groups – e.g. the mere distribution and integration of knowledge among members – but we are still not close to a complete process theory that explains why some groups are more 'intelligent' than are others, i.e. over time are better at solving a variety of dissimilar problems. Experimental research of collective intelligence has indicated that compositional features of a group, combined with interactional processes, may be a source of collective intelligence[11], i.e. mutual cognitive capacities being successfully mobilized and coordinated in groups solving a diversity of problems.

To further our understanding of how groups of decision makers managed to solve a variety of problems during the execution of a project, and to assess the properties of their collective intelligence on project performance, we conducted a longitudinal in-depth qualitative process study of key decision makers in the production of a large and technologically advanced offshore vessel. Our data broadly supports the link between collective intelligence and the performance of projects characterized by a high degree of uncertainty and dynamic complexity. In situations of short and direct lines of communication, the combination of divergent and convergent modes of thought, and where small subgroups were formed spontaneously dependent on the problem at hand and the expertise required solving it, swift problem solving increased. Exploring the mechanisms that bring about collective intelligence in a dynamic environment have implications for team and group work in general, and for project management in particular.

2. Project complexity, decision making and collective intelligence

Seen as a social task, projects involve the interpretation of events and development of shared understanding and conceptual schemes before arriving at a particular action[12]. Project teams are assembled as a result of the combination of individual team members who together perform better by using the sum of individual effort and skills[13]. In large and complex projects with dynamic effects on decision-making, the imperative to plan and execute projects successfully (optimising both speed and quality) put particular high demands on the decision-making and problem-solving capacity of the key decision makers as they collectively need to integrate information, knowledge and opinions to arrive at decisions or solutions. Focusing on the project manager, Sengupta, Abdel-Hamid and van Wassenhove[14] found that even experienced project managers failed to learn and meet targets in time-limited and dynamically complex settings. Similarly, van Oorschot, Akkermans, Sengupta and van Wassenhove[15] found that a new product development team of a leading semiconductor manufacturing company failed to notice the derailing of the project until it was too late. Therefore, it might seem that experienced project members in some situations are insufficient per se for the efficient performance of a large and dynamically complex project. The interaction effects in projects demonstrate that a combined increase in uncertainty and scope amplifies overall project complexity[16] adding to the required collective intelligence among the key decision makers.

Once a project is exposed to a problem, the subsequent decision might, on the one hand, solve the problem and stabilize the project. On the other hand, the decision might also open up a series of emerging subproblems, thereby destabilizing the project. Extended time lags between actions and outcomes, or causes and effects, slow down the learning cycle, which reduces the ability to accumulate experience[17]. A decision-making process can therefore be seen as iterative, prone to multiple inputs, and difficult to both describe and comprehend in linear and rational terms. The process becomes dynamic and uncertain, and so do the demands for both individuals and groups in arriving at sound decisions. While groups and organizations may coordinate through the explicit creation of plans and routines, dynamic situations necessitate planning that happens in real time[18].

Collective intelligence has been found to correlate non-significantly with member intelligence (both highest and average) but significantly with the equality of participation and the ability to reason about the mental states of others[†]. While Woolley, Chabris, Pentland, Hashmi and Malone[19] measured this "social perceptiveness" by interpreting the mental states of others from looking at their eyes, Engel, Woolley, Jing, Chabris and Malone[20] found the same strong correlation between social perceptiveness abilities and group performance in online environments with limited nonverbal cues, indicating a domain-independent aspect of social reasoning deeper than the recognition of facial expressions. Curseu, Jansen and Chappin[21] found that collaborative decision rules have superior synergic effects over the average intelligence of groups although on average not outperforming their best member. One important implication of these findings is that participative decision-making[22] can facilitate higher collective intelligence. Despite the fact that most research on team cognition, has focused on relations in explicit team processes, DeChurch and Mesmer-Magnus[23] found that emergent (collective) cognition enables team members both to predict and anticipate each another's actions and to fully make use of the often diverse collection of expertise present in the team. A number of conceptualisations of team cognition have included the importance of implicit coordination substituting or supporting explicit communicative processes[6,24,25].

3. Research gap

Assessing how collective intelligence per se predicts group performance on different tasks has thus far mostly been conceptual[5,11,26] and experimental[19-21]. DeChurch and Mesmer-Magnus[23] in their meta-analysis of team cognition found that its effects on both behavioural process and team performance are stronger when its emergence is represented through compilation (synergetic) than composition (congruent or accurate isomorphic emergence) – and that in future work on team cognition, the formative multilevel process underpinning emergent cognition should be addressed. It might be that the manifestation of collective intelligence is more profound among real-life groups where members often know each other better and are better able to reason about each other, and where intelligent solutions are contingent on distributed professional knowledge. In addition, it would be advantageous for research on team cognition to further incorporate the role of time[27], e.g. how groups in real-life settings under dynamically complex circumstances and partial uncertainty interactively arrive at sound decisions. Such temporal considerations include problem solving, dynamic cognition[24], and adaptive team performance outcomes[28].

Yet, how collective intelligence emerges and exists over time in real-life projects or organisations operating in settings of dynamic complexity and delayed feedback remains unexplored. Curseu, Jansen and Chappin[21] point towards investigating the development of strong cognitive synergy in groups, i.e. how the development of meta-cognitive processes in groups may play a key part in the emergence of concerted cognition and the development of collective intelligence. Considering project changes (and not collective intelligence per se), Zhang[29] calls for in-depth studies of decision-making patterns in which stakeholders encounter changes and handle varying and contradictory interests and objectives. Burke and Morley[30] similarly refer to a paper by Williams[31] pointing to the fact that the inability to manage complexity (back then) had been recognized as an important factor in project failure for a number of years. Collective intelligence as a construct is still in a state where its available theorizing lacks clarity and internal consistency in order to make specific predictions, and thus the construct cannot be tested in a rigorous way[32]. We still have some exploratory theory building to do.

4. Methodology

By tracing processes in their natural contexts[33], we sought to identify the manifestation of collective intelligence among the central decision makers of a large and complex project, i.e. how the central decision makers performed with regards to problem solving across a wide range of activities and emerging issues during the course of the project. As a research strategy this meant focusing on understanding the dynamics present within a single setting while crafting theoretical constructs, propositions and/or midrange theory from the empirical evidence[34]. Although being primarily inductive, this study began with ex ante focal and arranging concepts[35] (dynamic complexity, judgement, team cognition, collective intelligence, decision-making, problem solving) as a selective focus for observing the change processes. Tracing problem-solving and collective intelligence in their context, necessitated attention to events, information cues, and decisions as actors enacted them during the problem-solving process. Decision making in such a setting is a multilevel process[36], with smaller decisions typically nested within larger decisions, which may themselves be part of larger group projects[37]. Hence, the level of analysis was the process of collective problem solving among the key decision makers.

Drawing on Langley[38] and Sminia[39], the raw data was recorded as incidents: basic descriptions about what happens, who does what, and at what level of analysis. Concepts were issues, information cues, (collective) judgements, ideas, decisions, context, and outcome with a special attention to the stimuli and processes that brought them about, and by their role in collectively solving a variety of problems. In order to identify a project in which a particularly high degree of dynamic complexity was present, the setting needed to have the characteristics of being technologically highly advanced, or exploratory; and the design cycles being preferable multiple, with design freeze well into the execution of the project life cycle.

The setting became "the Yard", one of several "Shipco" yards producing highly advanced offshore vessels. In a comparable work setting described by Emblemsvåg[40] and Vaagen and Aas[41], vessels often change substantially from contracting to delivery by frequent and unsystematic client input, as well as by frequent regulatory interventions, on the edge of known technology. At the same time, since short delivery times are critical, and almost every vessel is put into engineering and production before all technical uncertainty is resolved, it is common that the engineering of the vessel starts when only the footprint of a strategic component is known and large scale strategic adaptations, far into the production process, may also happen. The planning and decision making complexity is consequently arising from frequent design changes and advanced design and engineering taking place concurrently with production. Exploratory studies point to team interactions and tacit knowledge as important enablers of competitive advantage in this industry[42]. Other types of uncertainties and events external to the project, like harsh weather, further complicate problems.

We followed the project during the course of a year, collecting more than a hundred hours of observation around the Yard, and doing 21 semi-structured interviews with key decision makers. The key decision makers were the project planner, four production coordinators, the technical coordinator, the project planner, the procurement coordinator, as well as various supervisors with responsibility for individual activities and work packages. Albeit presenting a partial view, observing meetings of the key decision makers was a central window to the collective decision processes and solution capabilities among the key decision-makers. We also included emails and other correspondence between project stakeholders as "observations".

5. Summary of preliminary research findings

The project was both structurally and dynamically complex, i.e. the combined activities, work packages, individuals and components were almost interminable, and with their interrelations often impossible to fully take into account and plan for. In their planning, the key decision makers seemed attentive to this uncertainty. Ad-hoc problems emerged daily and were handled at all levels from supervisor to project manager. The issues and ad hoc problems were by nature unanticipated, ranging from the discovery of colliding cables to the occurrence of the strongest storm in local history. The involvement of key decision makers took place at both formal and ad hoc meetings, in production, and through encounters such as 'daily tours' by the Project Manager, Production Coordinators and Production Manager. Sometimes they solved problems one-to-one. At larger meetings, and more focused meetings involving single issues and typically with a technical drawing as visual reference points, participants seamlessly put forward and assessed each other's ideas and opinions.

Although key decision makers formally planned the specific dates, people and hours to use in the project, they were not able to take into consideration all related events. This uncertainty normally necessitates a time buffer, although there was all but none in this project. Possible delays were at the most to be counted in days, but the deadline remained unaltered. When a problem arose, reaction time was short. Decision makers contacted relevant people or called in for meetings where they quickly assessed aspects to do with technology, production and procurement. Effective communication was not only one-way but also being able to listen to what was being said and reported, and how it was prioritised. One key decision maker expressed it in this way: "*We delegate a lot of decision authority. […] There needs to be a dialogue, maybe involving several Departments discussing an issue – and involving an exchange of opinions with both 'for' and 'against' so that you obtain several views on a case before you make a decision.*"

From the view of the Production Coordinators, communication with the different supervisors was good, e.g. concerning ongoing problem solving and emerging issues. The Yard had no formal system to report issues, unless they were above a certain cost level. The open-door policy of the various Departments was in force with colleagues in need of answers or opinions visiting each other while they were in their offices or even in meetings. Although the issues of such encounters often were not resolved with absolute certainty, they did result in tentative decisions and decreased uncertainty. Trust was high among the project group, i.e. key decision makers employed by the Shipco Group. Among the decision makers employed at the Yard, the relations were particular close. Although not being the case for many projects, key decision makers in the studied project were usually from the same region and knew each other from previous projects, enhancing the degree to which they were able to conceive, understand, and communicate subtle details with relevance to decision making and problem solving. At informal meetings, the dialogue was fluid, participatory and based on relevant knowledge. At formal meetings, participants were encouraged to voice issues, e.g. through taking turn around the table. In general, different issues discussed were in a combined atmosphere of time pressure and good relations. Including a storm leading to a major adjustment in the project plan (known as "the project in the project"), the project group managed to handle crucial changes to planned activities. In planning the duration of some of the activities, the project group was a bit optimistic, although they considered this orientation towards action an enabler of project progress in a context of time pressure and uncertainty.

While noting the above, there was a gap related to the work progress of the subcontractors between what participants discussed at the Production Meetings and what happened in the production. There seemed to be a lack of supervision from the side of the Yard regarding these outsourced tasks. In addition, the observed collective intelligence was higher within departments than between departments, and much higher than between the Yard and its subcontractors.

6. Discussion

Research on dynamically complex tasks demonstrates that even relatively minor flows of inventory when managing the production and distribution of a commodity bring about a great deal of complexity[17]. From a planning perspective, creating flexible project schedules to adapt to frequent design changes and other types of uncertainties means modelling very complex stochastic dynamic processes; schedules that would be difficult to follow due to bounded rationality, even when we disregard the complexity of developing such plans (for more details on this, see Vaagen and Kaut[43]). As a result, team interactions and judgmental processes largely underpin industrial state-of-practice planning and decision-making[42]. In the case of the Yard, having little or no time buffer in a large and complex project, left the key decision makers vulnerable to most unforeseen events. In addition to working in a dynamically complex setting in and by itself, the key decisions makers worked in a high pace environment and under severe time constraints. Events and activities affected other activities in uncertain patterns of which decision makers were not aware a priori. A recurring characteristic was the emergence a variety of new issues in need of being solved because of new or adjusted activity conditions. By fruitfully handling these issues over time, groups of decision makers regularly displayed a high degree of collective intelligence.

Davies and Brady[44] argue that firms often take on categories of projects that are similar and that they as a result involve repeatable and predictable patterns of activity. This, in turn, leads to economies of repetition and predictability among the key decision makers, shown both in behavioural patterns and in outcomes. All this seems to enhance the effective coordination and application of information cues and knowledge over a range of problems being different in nature. Rico, Sanchez-Manzanares, Gil and Gibson[24] suggest longevity, knowledge diversity, trust, and group efficacy as four important factors enabling the formation of team cognition. In the case of the Yard, trust was a background prerequisite for the close cooperation between the key decision-makers at all levels. The process among the key decision makers of solving emerging problems at the Yard was by large organic[45]. This seemed to enhance the effect of both task and team mental model similarity on the problem solving ability of existing and emerging groups of key decision makers.

6.1. Practical implications

In order to facilitate swift problem solving, project managers need not only enhance congruence, accuracy, and complementarity of cognition among key decision makers – but also to consider frankness and even participation. Reacting intelligently on emerging events, and recognising that events and seemingly insignificant decisions in one phase of a project may have a major effect later in the project life cycle, may be vital concerning both performance and outcome of complex projects. The recommendation for managers that seek to increase collective intelligence among (ad hoc) groups of decision makers is to facilitate direct relations, social sensitivity and participatory judgement and decision-making.

6.2. Limitations and future research

Observing problem solving in groups is in itself complex. The appearance of judgements and decisions range from being easily noted to being tacit[46]. At the team level, however, the interpretative processes are easier to observe, as they do not occur only in the team members' minds but are shared through communication[47].

The study is undertaken in a single organization, limiting the ability to validate findings with a case from a different organisation and thereby generalizing the results. At the same time, it is possible to find a repetitive pattern of events in the same organization, which allows the validation of findings in the same sample but at a different time[35].

The study does not include leadership style as such. Rosing, Frese, and Bausch (2011) found for instance, that transformational leadership correlates more strongly for the opening-up phase, whereas transactional leadership was generally more effective for the later phase of idea implementation. Since the key decision makers in this case are characterized by a high degree of problem solving autonomy, this omission is somewhat counteracted.

Although based on the assumption that written and oral group communication reveal mental model content, in selecting coding, we influence the characterization of the observed intelligence of groups. At the same time, the informants articulate the cognitive content in their own terminology. Qualitative process research allows us to observe and describe emerging causal relationships, as well as permitting for independent and continuous data collection.

As such, this study opens opportunities for further research into the conditions under which collective intelligence of project groups exists and may be enhanced.

7. Conclusion

Using a combined theoretical framework relevant to collective intelligence, we found that the general problem-solving ability of groups of decision makers may be characterized by very short and direct (face to face) lines of communication, the combination of divergent and convergent modes of thought, and small subgroups that are formed spontaneously dependent on the problem at hand and the expertise required to solve it.

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