Knowledge integration in multidisciplinary teams as an enabler of innovation in technology-based industries (Work in progress)

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Today´s complex sustainability problems require solutions that integrate knowledge from different disciplines. However, the diversity of perspectives in multidisciplinary teams introduces conflict in knowledge integration and delays novel solutions creation. To achieve a common perspective, the existing literature focuses on extensive deep-knowledge dialogue to understand the cross-epistemic boundary, dialectics to resolve contradictions, or the use of abductive logic to reframe problems, but no practical model clarifies how to maximize knowledge integration during technical innovation in multidisciplinary teams. This ongoing retrospective longitudinal exploratory multiple case study aims to identify which processes facilitate the integration of engineering, management, and design knowledge to create innovative solutions. The emerging model may agilize organizational response to sustainability challenges.
Keywords: knowledge integration, abductive logic, innovation, multifunctional teams

INTRODUCTION

Responding to today's sustainability complex problems transcend the order of disciplines and requires boundaries to be crossed and intertwined, which leads to the creation of innovation teams with diverse specialties and the development of cooperation skills in the organization´s personnel [1]. Many chemical companies have initiated their transformation under technological reinvention, industrial decarbonization, and eco-ethical products [2]. Although each organization has its unique innovation system, they all share a common difficulty: integrating diverse knowledge in multidiscipline teams to create novel solutions.

In this context, we focus our attention on one chemical company located in South America that aims to respond to sustainability challenges with a novel product portfolio and an enhanced business model: Chemcorp (a pseudonym). Based on an external diagnosis, Chemcorp needs to overcome three relevant gaps in its innovation process: a) a moderately developed social process of idea correlation, hindered by the difference in the perspectives of the members of the teams; b) the incipient ability to observe and discover the environment and its details from an anthropological vision, and c) the underdeveloped ability of people to ask provocative questions inviting to face challenges from different angles. In summary, this company requires effective and creative multifunctional teams.

This ongoing Ph.D. research project aims to identify which processes facilitate the integration of engineering, management, and design knowledge during technological innovation to give novel answers to highly complex real problems. Advancing in this understanding will enable Chemcorp to build a systematized model of multidisciplinary innovation and improve its constant adaptation to the changing business environment.

LITERATURE REVIEW

A. Knowledge-based dynamic capabilities and Innovation carried out in teams.

Dynamic capabilities are a set of routines that help extend, modify, and reconfigure existing operational capabilities in organizations. They serve innovation by leveraging the detection and capture of opportunities and organizational evolution to respond congruently to a changing environment [3].

Dynamic capabilities, DC, have been moderately studied inside teams, where they have attributed an essential social, collective foundation and are expressed as semi-routinized organizational activities executed by groups of people. The analysis of DC at the team level and the literature on agile organization identifies teams as the essential units as generators of innovation and competitive advantages [4]. Still, no clear explanation of how an organization might develop DC is given.

Dynamic knowledge-based capabilities explain how teams within an organization can generate DC by following a knowledge transformation process to generate value [5]. This iterative process, which uses dialectics and abductive logic to resolve contradictions, allows one to absorb, adapt, and create new knowledge that is finally expressed as an operational capacity when knowledge is fully internalized [5]. This coincides with the concept of contradiction resolution as an enabler of creativity and innovation presented in the neurocognition literature.

Generating dynamic capacities is leveraged in a multidisciplinary team with a learning culture, an exploratory attitude toward the unknown, prone to collaboration, cohesion to achieve the objective, and autonomy in decision-making [6]. Despite understanding the theoretical process to generate dynamic capacities and their leverage factors, the absence of practical models that facilitate achieving conditions and simplifying their implementation represents a barrier to adoption for organizations.

B. Cross-functional teams and knowledge integration

In an organization, a cross-functional team is a unit in charge of completing projects, composed of individuals from various functional units [7] with different but complementary knowledge domains [1]. One critical problem in cross-functional teams engaging innovation is knowledge integration, defined as the interaction of prior knowledge and new knowledge to generate a synergistic output distinct from inputs [8]. This critical problem arises since the problem-solving process demands individuals to transform and integrate their knowledge with others repeatedly.

Previous research on cross-functional knowledge integration difficulties in teams has focused on facilitating the integration by an extensive deep-knowledge dialogue that leads to a complete understanding of the cross-epistemic boundary that needs to be crossed and the differences between perspectives. Overcoming the barrier of understanding between disciplines requires coordinating activities and ensuring empathetic but critical communication that stimulates creativity. Agile teams question this approach because it is a time-consuming and uncertain process requiring high political effort [9].

A different stream affirms that the effective coordination of specialist teams should not focus on the transfer of knowledge among their members but on establishing rules and guidelines or routines that regulate interactions between individuals [10] since they support a high load of simultaneity in execution, as well as a lower demand for oral communication.

Alternatively to protocols and routines, another type of coordination emerges as a rapid sharing of general knowledge and joint sensemaking that blurs the specialty distinction beyond the sequential performance of activities [1]. In this sense, the organization´s role is to effectively manage social interaction spaces or teams and provide the conditions to acquire and create knowledge [11].

The reviewed literature recognizes the tendency of organizations to maximize the use of routines, rules, and other mechanisms that economize communication and knowledge transfer seeking efficiency and does not solve the apparent dichotomy between a time-intensive process and the growing need for agility to respond to a changing environment.

C. Cognitive perspective of problems in multidisciplinary teams

From a cognitive perspective, the problems in multidisciplinary teams are caused by the communication impediment in the process of the interpretation of information derived from the cognitive differences. Hence, a solo social process perspective provides a limited explanation [1].

Behaviors and work practices can be explained by how individuals conceive and analyze situations and the characteristics of their assumptions [1]. The reasoning patterns that develop in each profession seem to modify the way of solving problems, learning, and innovating [12], and one of its micro-foundations is the reasoning logics: deductive, inductive, and abductive. The first two, known as analytical logics, are part of scientific, engineering, and business reasoning [13] and are well suited to detect and capture opportunities when the environment does not present anomalous or surprising events. On the other hand, the form of abductive logical reasoning used by designers works in vaguely defined systems with limited data and introduces a hypothesis to generate the most plausible explanation for the observations [13]. It differs mainly from analytical logic in that it does not seek to arrive at a statement of fact but attain a certain value [13]. The literature suggests the effective use of abductive logic as a relevant lever in integration as it facilitates resolving contradictions and paradoxes [8].

According to the analysis of the literature reviewed, it can be affirmed that mastering abductive logic by all team members could ease the integration of specialized knowledge in multidisciplinary teams.

D. Research question

Fig. 1 presents a summarized scheme of the literature´s most relevant enablers for multidisciplinary innovation. This diagram is a conceptual guide of the most relevant findings in the literature and does not represent a model.

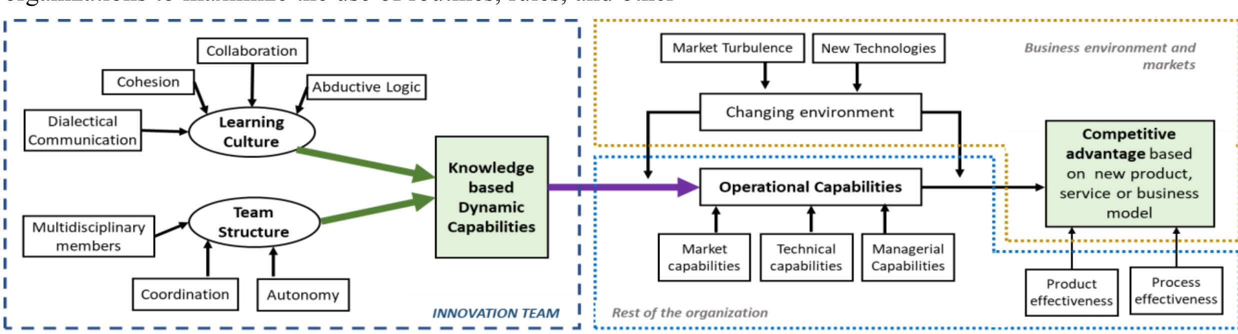

Fig. 1 Summary of innovation and its enabling factors at technology-based companies.

Neither the literature of dynamic knowledge-based capabilities nor that related to the integration of knowledge, or the logical foundations associated with innovation provide a complete and precise practical process for the generation of innovative solutions in multidisciplinary groups. Therefore, we aim to answer the following research question:

Through what processes is it possible to integrate knowledge of engineering, management, and design in the technological innovation teams of Chemcorp to respond to a changing environment?

METHODOLOGY

The present study is proposed as qualitative research and will be carried out under the retrospective cross-sectional exploratory multiple case study methodology. An interpretive research approach is taken, where events and their interpretations are first examined from the point of view of team members (first-order analysis) to subsequently build notions that organize and explain first-order events from the researcher's point of view (second-order analysis). Finally, the researcher generates aggregate dimensions considering contextual factors and the related existing literature to develop a grounded theory. Fig.2 shows the summary diagram with the eight stages of the methodology that will be used for the research.

Internal validity will be sought through the presentation of phenomena in a coherent way, highlighting the similarities and differences of the experiences and beliefs of the participants, as well as identifying the most significant aspects of the phenomenon to be studied and the mechanisms that produce them. A set of operational measures are established that aim to avoid subjective judgments of the researcher: a) the triangulation of information sources and actors, b) establishing a chain of evidence that makes explicit the reasoning of the researcher, and c) the inclusion of experts to review the construction of codifications and results of the case.

On the other hand, external validity will be established through analytical generalization, understood as contrasting the empirical results of the case with existing theories or literature.

PRELIMINARY RESULTS

A. *Context analysis*

In the chemical sector, growth and profits have been globally challenged due to accelerated commoditization of products, rapid growth in competition in developing countries, customers demanding more at lower prices, and increased pressure to replace chemicals due to their impact on health or the environment. To respond competitively to this changing environment, a transformation in the product portfolio and the execution of operations, as well as a shift from linear to circular business models and a workforce with new skills, are required. Despite this, only 7% of chemical companies believe their organization possesses the ability to capture opportunities in an agile manner, and only 15% of organizations have initiated measures for the transition to sustainability and the digital age. Additionally, sectorial analysis reports an incipient level of collaboration and partnership to systematically capture opportunities combined with engineer personnel with a low ability to focus design on humans [2].

The current transformation in the chemical industry suggests the alteration of its future trajectory, seeking the generation of a business essence based on highly a resilient combination of research and development plus enhanced production and customer relations [2]

In Colombia, the chemical sector also seeks to alter its future trajectory to the year 2032. focusing on the specialization of production according to world-class quality standards [14]. Based on the global trends, the Colombian government points out that the sector should promote innovation to improve the supply chain and introduce new products to the market while maintaining a sustainability approach based on chemical recycling, composting, biopolymers, biorefineries, bioactive ingredients, oleo-chemistry, and sucrose-chemistry among others. This planned alteration of the sector´s trajectory aims to increase its contribution to the Colombian economy.

From this context analysis, the focus of the study is defined, and the research question is posed. A review of the literature associated with the possible causes of the problem is carried out, to define some preliminary tentative theoretical constructs as presented in the Literature review section.

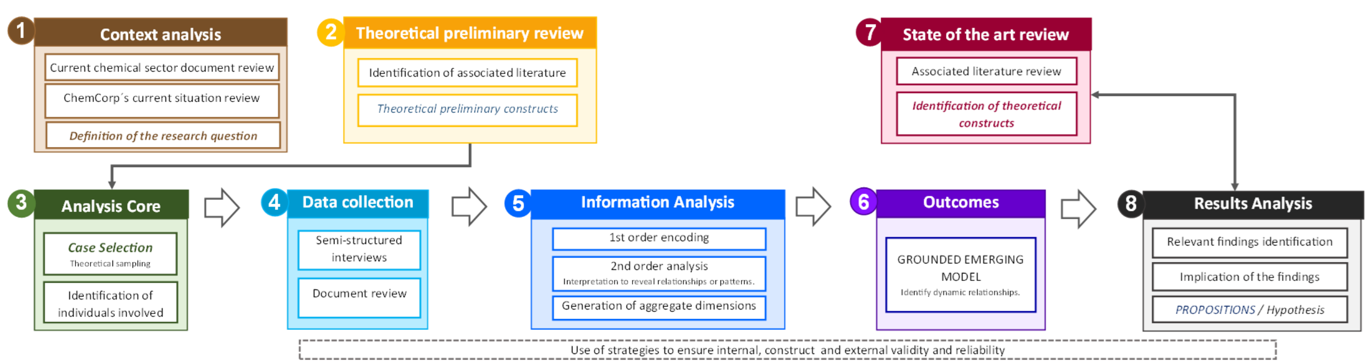

Fig. 2 Research design and stages: a retrospective cross-sectional case study with an interpretive approach for the generation of a grounded theory

B. Case study selection

From a preliminary theoretical sampling, 7 finished projects listed in Chemcorp´s innovation project portfolio were selected. To verify the case´s relevance regarding the research question, projects were located in the Ansoff matrix (1970), to identify the product-market relationship from the internal perspective of the company. The two groups of projects identified in the Ansoff matrix show congruence with the challenges facing Chemcorp: a) refresh the products and solutions currently offered achieving alignment with sustainability trends and b) operate in new lines of business with innovative and sustainable solutions. Fig 4a. Therefore, from a product-market vision the 7 projects could be candidates for the proposed research.

To disaggregate the groupings obtained with the Ansoff matrix, the novelty of the value proposition of each project is analyzed against the degree of novelty to the market using the concept of Innovation horizons [15]. Fig.3.

This analysis shows that projects differ in their value proposition novelty. In summary, projects 1,2,3,6 and 7 have characteristics of distancing from Chemcorp's current business Projects 2 and 3 stand out from the market's perspective and the novelty and show a greater potential to transform Chemcorp´s current portfolio as well as a greater contribution to solving complex problems as the use of feedstocks from extractive systems (oil), the massive use of plastic packaging.

The technical level of the projects was diagnosed by the Ansoff matrix modified by type of innovation [16], positioning projects 1,2 and 3 as new products with game changers characteristics, that respond to a diversification strategy. Fig. 4(b) The combined analyses showed the following main findings: a) Projects 1, 2, and 3 are innovations that move away from the core of Chemcorp's current business and leverage a new trajectory for the company. b) Only projects 1,2 and 3 require modifications to the business model, making it the most demanding project from the point of view of the diversity of required capabilities and in turn the project with the greatest potential to modify the trajectory of Chemcorp. c) Projects 1,2 and 3 are game changers innovations with differentiated value propositions and relevant technology progress for Chempcorp

Projects 3 and 1,2 were executed by two innovation teams, RAMBA and CYAN, (pseudonyms of the names within the organization), which are, respectively, a chemical recycling project and a sucrose-based product portfolio development, both aligned with the sustainability trend and focused on sectors and markets of greater value for Chemcorp.

Each member of a team represents a different expertise, with specialized knowledge (e.g., function and expertise on R&D or Plant design or supply chain or marketing and sales or Finances). The membership was temporary and ended when the product was launched and introduced to the target market.

Combining an analysis of the project's innovation level and the team characteristics the most suited cases for this research are Ramba and Cyan since they offer the greatest opportunity to answer the research question.

The qualitative case study methodology allows us to understand the individual and collective experiences within Chemscorp´s specific context of the two selected cases. The study will consider 13 current or former workers of the company, who participated in its execution with different roles, such as senior management, middle management, and operative positions. All the above belong to the areas of Research and Development, Commercial, Production and Processes, Supply and Finance.

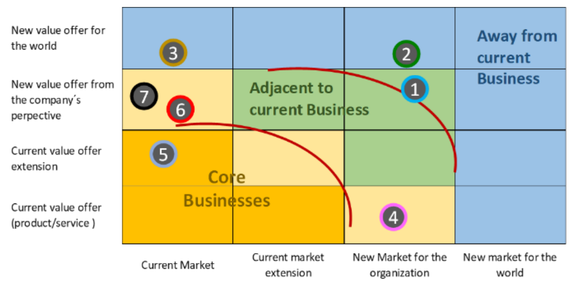

Fig.3 Projects in the Innovation Horizons Matrix [15]

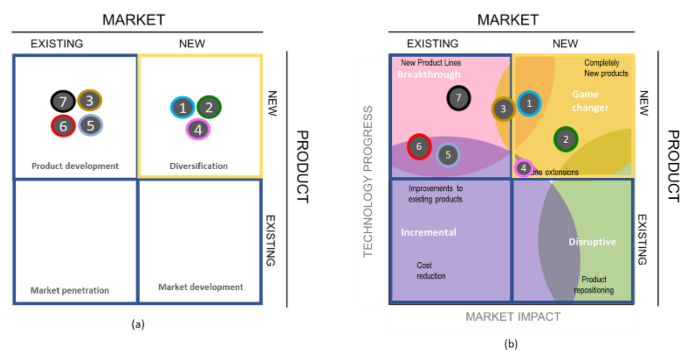

Fig. 4 Projects in the modified Ansoff Matrix
(a)Product Market Matrix Ansoff (1970),
(b) Ansoff matrix modified by innovation´s type referenced by [16].

C. Data collection

The written material regarding the two teams´ projects, from the ideation stage until the commercial launch was collected. A semi-structured interview collected information from each team member dedicated to Ramba and or Cyan. The instrument was applied to all 13 individuals and each interview had on average a duration of 1 hour.

The question was focused on understanding the process that enabled the knowledge integration process during the development of the innovative chemical solution that responds to sustainability challenges. We inquired if the team had a learning culture that supported acquisition, sharing, and creating new knowledge, if the type of communication was based on reasoning confronting ideas and theories to contradictory ones before reaching to conclusion, and if during the process the thinking mode was centered on value creation as well as on reframing the problem to obtain creative solutions. We were also interested in the collaboration style and the degree of cohesion existing within each team.

Besides the description of the innovation process, the interview also inquired about the team´s coordination and if the autonomy level encouraged agile decision-making despite the diversity of points of view.

CONCLUSIONS AND NEXT STEPS

Online interviews were recorded and then transcribed. In the analysis of the collected data, an exhaustive coding of the transcripts of the interviews and meetings will be carried out, seeking to consolidate them into concepts related to the vision of the informants or team members (first-order analysis). To facilitate the analysis and avoid constructs or first-order concepts containing nesting or overlapping, the N-VIVO qualitative analysis software will be used. To increase confidence in assigning codes to the correct categories at least one evaluator of the coding scheme will be included. This measure seeks to ensure convergence in the key aspects of the coding scheme and increase the plausibility of interpretations.

A. *Emerging model generation*

A theoretical model will be constructed based on the identification of the emerging relationships between the aggregate dimensions and their components. The analysis of the relationships will be carried out in the light of the evidence shown in the cases, verifying the validity of the constructs, and supporting the interrelationships with evidence. Propositions on the integration of knowledge for technology-based innovations at Chemcorp will be iteratively formulated, based on the findings of interrelationships and their implications.

B. *Analysis of the results: the emerging model generated against the existing literature.*

Finally, the relevant findings, interrelationships, and propositions associated with the grounded theoretical model will be confronted against the identified theoretical framework, ensuring that the literature that contradicts the findings, as well as that which supports it, is included.}

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