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Value Generation through Integrated Teams: A Socio-Cognitive Approach

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Abstract: Value generation is defined as meeting client requirements while minimizing waste. Researchers concur on the issues related to sequential design in handling client requirements, and suggest the use of an integrated design approach as an alternative. Little has been said, however, about the impact of adopting integrated design's work organization to traditional design practice, processes and tools, nor about the importance of breaking down socio-cognitive barriers related to mental model fragmentation between design professionals, clients and users. This may result in cognitive inertia, a major source of waste. The objective of this research is to develop and test the introduction of boundary objects, such as new technologies, to the context of integrated teams and organizations to break the cognitive inertia that hinders value generation. The research is conclusive about the effectiveness of using boundary objects to transform practices in construction. This research also contributes to a better understanding of the new purposes of construction projects by framing its context and process dimensions within a theoretical framework, as well as to the evolution of practices in construction – and of practices that could be applicable to other fields.

Key words: Integrated design, value management, activity theory, boundary artefact.

1. Introduction

Buildings are designed by coalitions: representatives of various organizations or firms assembled within a short timeframe to achieve specific outcomes. Their work is usually organized in a sequence in which work functions are conducted independently. A sequential approach to design and delivery is considered ineffective for generating the best value. Reports [1, 2] suggest changing the dynamic of project coalitions in construction by first transforming the relationship between the client and their suppliers, and second, by reorganizing the project definition and delivery around integrated teams and supply chains.

The core concept of Integrated Design is that work is organized around multidisciplinary teams, whose members are co-located to favour collaboration and innovation. In this new organization of work, the team members need to share and develop the knowledge related to their activity, thus generating value with more efficacy and efficiency. One study of an integrated team relates their performance to team members' ability to develop shared mental models [3]. Problems in generating value and reducing waste are, in this context, not related to processes themselves, but to the quality of the relationships the team manages to establish for defining and realizing the purpose of their project.

This paper adopts a design science perspective to investigate this phenomenon, using an activity theory approach. It draws from the application of connectivist social learning theories on innovation and on the transformation of professional practice to explore, through case studies, the dynamic of integrated teams in construction. Connectivist social learning theories focus on knowledge production and sharing among the members of a group participating in a common activity. These theories shed new light on the role of

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mediating artefacts–tools or symbols–to facilitate dialogue and sense-making within teams in the definition and management of the client and stakeholders' requirements. New methods, such as those proposed in activity theory development, provide an interventionist approach to examine the performance of traditional design tools in the new context of integrated teams, and to test new artefacts that may improve team performance in generating value.

This paper focuses on the study of boundary objects as mediating artefacts for crossing knowledge boundaries between practices, and for breaking down socio-cognitive barriers among members of a project's coalition. The research also explores the influence of context in the use of these artefacts. The expected theoretical contribution first looks at the testing of social learning theories to explain the dynamics of integrated teams in construction, and then evaluates the testing of theories regarding the use of boundary objects to help teams break barriers that hinder value generation. The research will contribute to current practice by providing the industry with the theoretical and empirical background to build a body of knowledge formalizing integrated design in construction.

2. From Fragmentation to Integration

While the problems with the sequential design and delivery approach to construction have been widely discussed, there is still no recognized body of knowledge regarding integrated design processes. Dupagne [4] identifies three factors affecting value generation in sequential design: the lack of iterations in the design process; the lack of consideration of constraints within subsequent phases or the unnecessary constraints set in the design for these phases; and the lack of leadership and responsibilities, leading to suboptimal solutions, poor constructability and operability, rework in design and construction and lack of innovation. Two solutions are proposed in the industry to address these problems: moving from a sequential to an iterative approach to design, or integrating client(s) and suppliers into a unique value chain by using integrated teams and integrated supply chains. Through collaboration, both approaches aim to deliver superior value by assembling, integrating and harnessing all the collective skills and capabilities of clients and their supply chains. They do differ, however, in how they achieve this change in their organization of work. In the first approach, an Integrated Design Process is proposed that focuses on the design, construction, operation and occupancy of a building over its complete life-cycle. It proceeds from whole-building system strategies, through increasing levels of specificity, to realizing more optimally integrated solutions. The second approach assumes that integrating the value chain over all the processes encourages continuous improvements and reduces waste [2]. Integrated collaborative design is considered to be an approach that establishes design as the common thread linking organizations together.

These approaches, however, are focused on processes and do not take into consideration the peculiar context of construction projects. We argue that procurement and socio-cognitive issues can hinder an integrated teams' performance in delivering better value. Koskela et al. [5] posit that it is the adversarial business context created by transactional contracting methods that discourages any collaboration between contract parties–even for the goal of defining the solution that will best fit the business purpose. They suggest that relational contracting creates a more appropriate context for value generation.

Socio-cognitive issues are related to the change from a fragmented to a co-configuration organization of work. Integrated teams could be referred to as highly mature. Victor and Boynton [6] characterize this form of work as a continuous relationship of mutual exchange between customers and producers, indicating an ongoing configuration and customization of the

product/service combination. These integrated teams profit from active customer involvement and input into the configuration, multiple collaborating producers that need to operate in networks within or between organizations, and mutual learning from the interactions between the parties involved in the configuration actions. The concept of mutual learning is central to co-configuration.

3. Solving the Socio-Cognitive Issues

What distinguishes an interpretivist from a positivist perspective in value management is the dimension of learning in the value definition process [7]. As emphasized by Thiry [8], value creation in projects follows an iterative cycle of learning and acting in which project stakeholders articulate the project purpose and expected features through conversation and sense-making. Druskat and Kayes [3] defines team learning as: "Team members acquiring and sharing unique knowledge and information and examining what is helping and hurting team performance to continually improve as a unit."

The aspect of evaluating shared knowledge and information for its negative and positive effects implies that team learning requires the discussion of novel information and, sometimes, uncomfortable topics. It may include learning how to behave under the new context of multidisciplinary teams, how to learn new roles and skills, and how to unlearn old habits and behaviours. It also requires growth in a team's capacity to manage themselves as a unit, and to acquire, share and use knowledge to make effective decisions [3]. Research has indicated various socio-cognitive factors that may undermine a team learning process in project coalitions.

The first factor is the lack of self-regulation of typical collaborations in coalitions, where team members coordinate their activities by talking to one another as well as by interacting with their tools. Participants may duplicate each other's efforts, and many problems often fail to be resolved either quickly or to anyone's satisfaction [9]. The second factor is that groups tend to do the opposite of sharing unique information or knowledge held by individuals, preferring to discuss jointly held information or knowledge [10]. The third factor is the concept of "knowledge boundaries" that specialized knowledge creates. The characteristics of knowledge that drive innovative problem-solving within a function actually hinder problem-solving and knowledge creation across functions [11]. The fourth factor is cognitive inertia, which is associated with two typical behaviours among experts of different disciplines: "groupthink", a mode of thinking that people engage in when they are deeply involved in a cohesive in-group--"groupthink" typically leads to an overestimation of the in-group, closed-mindedness and stereotypes of out-groups; and, paradoxically, "compartmentalization", a fragmentation of viewpoints and lack of shared mental models. Compartmentalization and fragmentation may make it impossible for experts from different contexts to "speak the same language" and exchange ideas about a problem [12].

Some authors [3, 13] also contend that, since shared mental models affect behaviour, their content is of central importance in team effectiveness. Shared mental models are socially constructed cognitive structures that represent shared knowledge or beliefs about an environment and its expected behaviour. They influence team members' behaviour and improve coordination by enabling members to anticipate one another's actions and needs [14]. Druskat and Kayes [3] identifies three core components of a self-managed team's' performance: (1) psychological ownership over team processes and outcomes, (2) a need for continuous learning, and (3) a need for heedful interrelating.

Boundary objects could play a key role in generating and mediating learning [15, 16]. Star and Griesemer [17] describe them as objects that are shared and shareable across different problem solving contexts;

objects that work to establish a shared context that "sits in the middle". Boundary objects circulate through networks playing different roles in different situations. They work at the edges of communities of practice, mediating their external relationships; they enable coordination, but they can do so without actually creating a bridge between the perspectives and the meanings of various communities [17]. Boundary objects are a means of representing, learning about, and transforming knowledge to resolve the issues that exist at a given boundary [18].

4. Exploring the Dynamic of Integrated Teams

Research on team-working practices in construction is almost non-existent. The topic has nonetheless been discussed extensively in organizational theory. However, as asserted by Blackler et al. [19], research on team-working practices in general is based on biased assumptions--avoiding featuring elements of context as variables that can impact team effectiveness, such as the hierarchical aspect of group regulation, the politics of relationships between different experts or functional groups, the nature of the broader institutional contexts and ways in which participants have become socialised to participate within these structures. The dimension and dynamic of team learning itself is (also) rarely considered.

The aim of this research is to evaluate the influence of boundary objects in reducing waste and stimulating value creation within integrated teams. A design science perspective is adopted to investigate and/or intervene in case studies. Simon [20] argued that traditional models of science (natural and social) give a misleading picture of fields that are concerned with design, and proposes creating a new model for the understanding of what he qualifies as "design science": an investigation of the transformation process that man follows to build his world of the artificial. He described design as an iterative process of finding ways to build reality through concepts and models, and attempting to transform the real world by applying them.

Design Science is not only about making sense, but also about intervening in the phenomena. According to Van Aken [21], "the mission of a design science is to develop knowledge for the design and realization of artefacts." It is argued that activity theory aims at understanding and intervening in the way man builds his artificial world by transforming its outer environment through artefacts he designs within his activities. This should be classified as an interpretive design science approach to context.

Activity theory is an interpretivist approach aimed at understanding and acting on activity networks. "Activity theory is considered as the richest framework for studies of Context in its comprehensiveness and engagement with difficult issues of consciousness, intentionality and history" [22]. It is based on the notion of the object relatedness of human activity, taking the theoretical stance that knowledge and adaptation to human outer environment is socially constructed. Activities are oriented toward something and driven by something larger and more durable than the specific goals of particular actions and individuals. This something, "the object", is constantly in transition and under construction, and it manifests itself in different forms for different participants and at different moments of the activity [12]. The activity system is the unit of analysis.

5. Research Method

Two types of cases are considered: revelatory and instrumental cases. Revelatory cases are extreme cases–usually single cases–for which there is a belief or an assumption that the study of the phenomenon may represent a significant contribution to knowledge and theory building, or may even help to refocus future investigations in an entire field [23]. In an instrumental study, according to Stake [24], the researcher may be interested in issues or research

questions of importance and frame one or more case studies to address them. In this form, it is the questions of the researcher that are paramount, not the case itself or the organizational unit.

Data collection for these cases includes observations, interviews and review of corporate and/or project documents. Eight brainstorming and design workshops were conducted and videotaped in a collaborative design laboratory. Ancona's Team Process Observation Guide [25] was used to analyze disturbances during the inquiry stage. Semi-structured interviews were recorded and fully transcribed. The interviews lasted between 40 and 120 minutes. Qualitative analysis was conducted using Nvivo software, and an activity theory mediational structure [12] was used to investigate the use of design tools to facilitate mutual learning in the project definition process. A new technology, a requirement-management software tool was introduced as a boundary object in the instrumental case, and changes in the team behavior were recorded through a questionnaire. The results were validated within a focus group.

The revelatory case is part of a new procurement route, Procure-21, established by the UK Department of Health to improve their performance in delivering better buildings. Procure-21 was recognized by the National Audit Office as one of the most representative of the UK initiatives in transforming existing procurement practices in construction. Following Egan's [2] report recommendations, this department has undertaken a substantial business transformation, reflected in the Healthcare modernisation Programme. Part of this transformation is the delivery of an ambitious construction portfolio, the largest in the history of the British government. The purpose of this programme is to provide Best Value in facilities, and the most suitable environment for patient health and social care.

The project is the first delivered in the London area using this procurement route. The aim of the project was to transform the way patients with mental illness could be treated and integrated back into society. It is a low security two-storey mental health rehabilitation unit accommodating 18 patients.

The instrumental case is a sustainable construction demonstration project undertaken by a coalition of non-profit organizations devoted to sustainable development. The project was led by one of the organizations, whose business intentions were to position itself as a leader in sustainable development, and to develop a new business line on sustainable construction. The client had great ambitions: the project had to be a statement to the group's values on sustainability; a rallying point for sustainability activists; an education centre on sustainability, and a laboratory aimed at developing best practices for the design and construction of sustainable buildings. The case was built within a research agreement with the university. The meetings of the integrated team were held in the researcher's design laboratory.

Boundary objects were used in both cases to break the pragmatic barriers between practices. Carlile [11] distinguishes a series of three consecutive steps in the adoption of boundary objects: first is the achievement of a syntactic level in which a common language is agreed upon for knowledge sharing; second, at a semantic level, is the development of common meanings through mutual learning; third is reaching a pragmatic level in which there is a convergence of interests among actors. In Procure-21, boundary objects are used at this third level--achieving convergence by first breaking the traditional structure of power and influence found in traditional delivery processes through the redefinition of key actors' roles within the framework; and second, by using both symbols (empathy meeting) and tools (AEDET, NEAT and DART) as boundary objects to develop common language and meanings. A similar strategy was adopted for the instrumental case, changing the structure of power by introducing a sustainability gating process led by the sustainability adviser, providing him with

the authority to audit the design process through a set of events, and using a requirement management tool as a boundary object.

6. Discussion

The two cases represent integrated teams realizing projects of a similar size. Both clients aim to change practices in the industry, the first to deliver better value to the patient, the second to make behaviours and construction more sustainable. Both have a mapping process for documenting the project definition and performance measurement imbedded in their process. They differ, nonetheless, in their approach. In the instrumental case, a process reengineering method is adopted, introducing a new process to the team; whereas in the revelatory case, the intervention is aimed at changing the context in which projects are realized. Procure-21 is an adaptive procurement framework that redefines the relationships, roles and influence within and between a client and their supply chain.

The instrumental case highlighted problems identified in the literature regarding the boundaries of knowledge between experts, and the cognitive inertia engendered by group-thinking or fragmentation of perspectives. The design team acted as an in-group (architects, engineers and builder representatives), restricting interventions from the out-group (the client, their staff, and other experts in the design process). The in-group maintained the vertical hierarchy driving the traditional design decision-making process – the engineers or builders intervening only in their area of expertise, and not challenging the decision made by the architect. The interactions for decision-making were polarized between the architect and the executive, with little regard for the users or other experts. The design team watered down the process devised by the sustainability adviser, keeping only the concept of workshops, but removing the stepwise sustainability validation process.

The tools that the various experts brought to the team workshops for exchanging and generating knowledge pertained to three categories: design tools (brief, 2D-3D paper and virtual representations, simulations and e-collaborative tools); project management tools (budget, schedule, work breakdown structure and integrated process roadmap); and tools to assess building performance in meeting the criteria for sustainable construction.

The design tools proved to be quite inefficient for developing a conversation between the client and users. The traditional briefing process was ill-adapted to capturing the stakeholders' values in sustainable development. The users could not make sense of the relationships between their business needs or aspirations and the descriptions presented in the functional brief or represented in the simulations. The client stakeholders and the executive also confirmed that they could not make sense of the 3D representations used by the architect to present his concept.

The client expected to make decisions based on hard data that validated design solutions, based in turn on tools for calculating whole lifecycle costs and lifecycle analysis of embedded energy, but the architect did not understand these tools. Moreover, the client wanted the decisions to be made as a whole, and not on isolated design components. The project manager was unable to adapt the traditional project management tools to the context of integrated design. He brought the focus back on cost. The result of the process was a concept that was rejected by the client, and the design workshops were abandoned as they were considered both ineffective and too expensive.

Thiry [8] explains the problem, stating that tools used to manage construction projects are designed to reduce uncertainty in a sequential fashion. They are ill-adapted to addressing issues of ambiguity in defining and managing client requirements. What are needed are tools to facilitate dialogue and sense-making among the various communities of expertise composing the team.

Procure-21 is an adaptive framework built on

Egan's [2] five key drivers to change practices in the construction industry. It provides arenas and a learning infrastructure to induce continuous improvements within the communities of clients, designers and builders that are part of the framework. The actions on the project context were analysed using the activity theory mediational structure. In this structure, the process of mutual learning is mediated at three levels: (1) the division of labour (knowledge), (2) the rules established between the sponsor of the activity and the communities involved in achieving its purpose; and (3) the artefacts used by the participants for mediating the mutual learning and acting cycle.

The Procure-21framework acts on three levels. First, a new division of labour is proposed, concentrating the business decision-making with the client project director, and giving the decision-making on how to deliver the expected outcome to the project manager of the integrated supply chain. The design champion plays the role of the "voice of the customers" making sure that staff and patients' wants and expectations are translated into the design solutions. Weick and Robert [13] argue that in a highly differentiated and complex context, a group could function as a highly integrated and effective team through the vigilant collaboration of key stakeholders. In this case, the three roles are closely interwoven. The project director's key role is to ensure vertical and horizontal integration, thus encouraging the development of shared mental models. He has executive decision-making power, and answers directly to the project owner within the board of the Trust. He also deals directly with the project manager, who has a similar role within the integrated supply chain. Together, they share the responsibility of reducing waste at the organization and production levels.

Second, new rules are defined for the conduct of the project definition and the project delivery. The project definition process is designed to reduce ambiguity in the project's purpose and building features, and to reduce uncertainty in delivering these features. The relational contract arrangement is a cost-plus fee using open accounting. When ambiguity and uncertainty are considered to be at a bearable level, the conditions of delivery are crystallized into a guaranteed maximum price contract, including penalties and incentives.

Third, new tools are introduced in the project definition process, with the aim of accelerating bonding and trust among the members of the integrated team. An interesting finding is that these boundary objects do not correspond to the traditional definition found in the literature: a tool that is used to create links between islands of specialized knowledge through semantic, syntactic or pragmatic bridges. In this case, boundary objects are used to resolve contradictions and conflicts between multiple points of view, and to encourage collaboration and innovation. They are used by the project director to stimulate project ownership, continual learning, and heedful interrelating.

The framework proved successful, in this case, in removing socio-cognitive barriers and in stimulating interrelating. These conditions led to multiple innovations in construction and in the configuration of the building to improve patient care and rehabilitation. It failed, however, to bring changes at the executive level in the importance of involving the integrated supply chain at the outset to leverage the potential for value creation. Some decisions were still made based only on short-term cost considerations, not taking into account the expected benefits. The capture, mediation and routinization of new practices through benchmarking did not perform as expected, and was a major source of tension with the Procure-21 Principal Supply Chain Partners. The requirement management boundary object tested in the instrumental case proved to be more convincing to achieve this purpose.

In summary, both cases demonstrate that because of the fragmented and temporary nature of coalitions in construction, reengineering the processes around an integrated design approach is doomed to fail. The context has to be reconfigured to stimulate changes in

existing practices, and to provide arenas or learning infrastructure to mediate or routinize new practices within and among disciplines. Proper incentives have to be established to encourage practitioners in the evolution of their way of doing design.

7. Conclusion

This paper reports the research results of two case studies, by examining the dynamic of integrated teams in different contexts, observing how boundary objects were used to change existing practices in order to deliver better value, and showing how enabling changes in practices to better align design solutions with stakeholders' wants and expectations was possible, using requirement management artefacts.

The analysis of the case studies confirmed the applicability of the situated learning and activity theories to understanding the dynamic of integrated teams in construction. Boundary objects is a concept that was first introduced in situated learning. The activity theory meditational structure provided a framework in which to analyze and intervene with integrated teams to solve the socio-cognitive problems that hindered the construction of shared mental models. It also demonstrated that design and project management practices need to be reconfigured and retooled to ensure efficiency and efficacy within this new organization of work.

Finally, the analysis highlighted the importance of configuring the project environment so that it provides an appropriate context for the development of shared mental models. The reconfiguration of the division of labour, new rules and the introduction of new boundary objects have a positive effect on the team dynamic, removing waste and encouraging value creation through innovative business and construction solutions.

This research demonstrates the complexity of issues regarding the evolution of current practices. In both cases, design professionals showed resistance to adopting and integrating new tools and practices. Nonetheless, Project-21 was successful in evolving both project management and quantity surveyor practices. In the instrumental case, the firm responsible for sustainable engineering adopted the requirement management framework to all their projects.

Much work remains, however, to tailor requirement management practices and tools to their context. Breaking barriers is not merely about boundary objects but shifting power and influence. More empirical research is needed to better understand the dynamic of integrated teams in construction, and the relationship between context and a team's ability to generate value.

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