

BREAKING SOCIO-COGNITIVE BARRIERS TO VALUE GENERATION IN INTEGRATED TEAMS

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ABSTRACT

Value generation is defined as meeting client requirements while minimizing waste. Authors agree on the issues related to sequential design in handling client requirements, and suggest the use of an integrated Design approach as an alternative. Little is said, however, about the impact of adopting integrated Design new organization of work on traditional design practice, processes and tools, and 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 the research is to develop and test the use of boundary objects, such as requirement management tools in 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 such as a requirement management construct to transform practices in construction. The research also contributes to a better understanding of the new purpose of construction projects by framing its context and process dimensions within a theoretical framework, and to the evolution of practices in construction.

KEY WORDS

integrated design, value management, activity theory, boundary artefact

Reports (Latham 1994, 1998) suggest changing the dynamic of project

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. Sequential approach to design and delivery is considered ineffective for generating best value.

coalitions in construction by first transforming the relationship between the client and its 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

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new organization of work, the team members need to share and develop knowledge related to their activity, thus generating value with more efficacy and efficiency. Recent research on an integrated team relates their performance to team members' ability to develop shared mental models (Druskat 2000). Problems in generating value and reducing waste are, in this context, not related to processes, but to the quality of relationships the team manages to establish for defining and realizing the purpose of the 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 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 a group participating in a common activity. These theories shed new light on the role of mediating artefacts – tools or symbols – to facilitate dialogue and sense-making within teams in the definition and management of the client and stakeholders' requirements. Methods, such as activity theory development work research, 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 the project 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 dynamic of integrated team in construction, and second the testing of theories regarding the use of boundary artefacts to help teams break barriers that hinder value generation. The research will contribute to practice by providing the industry with theoretical and empirical background to build a body of knowledge formalizing integrated design in construction.

WHAT IS INTEGRATED DESIGN?

While the problems with sequential design and delivery approach to construction have been widely discussed, there is still no recognized body of knowledge regarding integrated design processes. Dupagne (1991) 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 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 and suppliers into a unique value chain through integrated teams and integrated supply chains. Through collaboration, both aim to deliver superior value by assembling,

integrating and harnessing, all the collective skills and capabilities of clients and their supply chains. They differ in the means of achieving this change in their organisation 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. In the second approach, Egan (1998) contended that integrating the value chain overall processes encourages continuous improvements and reduces waste. Integrated collaborative design is considered as an approach that establishes design as the common thread linking organisations 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 integrated teams' performance in delivering better value. Koskela et al. (2006) argue that it is the adversarial business context created by transactional contracting methods that discourages collaboration between contract parties for 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 organisation of work. Integrated teams could be referred to as highly mature. Victor and Boynton (1998) characterise this form of work as a continuous relationship of mutual exchange between customers,

producers, and the product/service combinations, ongoing configuration and customization of the product/service combination, 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 interactions between the parties involved in the configuration actions. The concept of mutual learning is central to co-configuration.

MUTUAL LEARNING, COLLECTIVE MIND, AND BOUNDARY OBJECTS

What distinguishes interpretivist from positivist perspective in value management is the dimension of learning in the value definition process (Green and Liu 2007). As emphasized by Thiry (2004), 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 (2000) 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."

This implies that team learning requires 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 the team's capacity to manage themselves as a unit, and to acquire, share and use knowledge to make effective decisions (Druskat 2000).

Research indicates various socio-cognitive factors that may undermine the 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 through talking to one another as well as through interacting with their tools. Participants duplicate each other's efforts, and many problems often fail to be resolved either quickly or to anyone's satisfaction (Zager 2002). The second factor is that groups tend toward the opposite of sharing the unique information or knowledge held by individuals, by preferring to discuss jointly held information or knowledge (Stasser and Titus 1987). The third factor is the "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 (Carlisle 2002). 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. Such fragmentation may make it impossible for experts from different contexts to "speak the same language" and exchange ideas about a problem (Engeström 2000).

Authors (Weick and Roberts 1993, Druskat 2000) 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 (Cannon-Bowers et al., 1993). Druskat (2000) identifies three core components to self-managed teams' performance: (1) psychological ownership over team processes and outcomes, (2) a need for continuous learning, and (3) a need for heedful interrelating.

Authors (Edwards, Engeström, Engeström and Karkkainen 1995) suggest that boundary objects could play a key role in generating and mediating learning. Star (1989) describes 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 (Bowker and Star 2000). They are a means of representing, learning about, and transforming knowledge to resolve the consequences that exist at a given boundary (Star and Griesemer 1989).

EXPLORING THE DYNAMIC OF INTEGRATED TEAMS

Research on team-working practices in construction is almost non-existent. The topic was nonetheless extensively discussed in organisational theory. However, as asserted by Blackler (1999), 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 of team learning is also rarely considered.

The aim of the research is the influence of boundary objects in reducing waste and stimulating value creation within integrated teams. A design science perspective is adopted to investigate or intervene on case studies. Simon (1996) argues 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” to investigate the transformation process that man follows to build his world of the artificial. Simon (1996), describes 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 Aken (2004) “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” (Nardi 1996). It is based on the notion of 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 just 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 (Engestrom 2000). The activity system is the unit of analysis.

Two types of cases are considered: revelatory cases, and instrumental cases. The 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 significant contribution to knowledge and theory building, or may even help to refocus future investigations in an entire field (Yin 2003). According to Stake (1995), in an instrumental study, 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 or the organizational unit.

Data collection includes observations, interviews and review of corporate or project documents. Eight brainstorming and design charrettes [find an English word] were conducted and videotaped in École de technologie Supérieure collaborative design laboratory. Ancona's Team Process Observation Guide (2005) was used to analyse disturbances during the inquiry stage. Semi-structured interviews were recorded and fully transcribed. The interviews lasted between 40 minutes and 120 minutes. Qualitative analysis was conducted using Nvivo software, and activity theory mediational structure (Engeström 2000) was used to investigate the use of design tools to facilitate mutual learning in the project definition process. A sustainability requirement management boundary object was introduced in the instrumental case, and changes of the team behaviour recorded through a questionnaire. The results were validated within a focus group

PRESENTATION OF THE CASES

The revelatory case is part of a new procurement route, Procure -21, established by the British Department of Health to improve their performance in delivering better buildings. Procure 21 is recognized by the National Audit Office as one of the most representative of UK initiatives in transforming existing procurement practices in construction, following the recommendations from the report for "accelerating changes" for delivering

"Value for Money." This department has recently undertaken a substantial business transformation, reflected in the Healthcare modernisation Programme. Part of this transformation is 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 the patient health and social care

The project is the first one 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 organisations devoted to sustainability development. The project was led by one of the organisations 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 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 school laboratory on design collaborative e-tools.

Boundary objects were used in the two cases to break the pragmatic

barriers between practices. Carlisle 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 redefining key actors roles within the framework, 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 two boundary objects, the integrated design roadmap and a requirement management tool.

DISCUSSION

The two cases represent integrated teams realizing projects of a similar size. Both clients aim at changing 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 documenting project definition and performance measurement imbedded in the process. They differ, nonetheless, in their approach. In the instrumental case, a

process reengineering approach 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 redefining the relationships, roles and influence within and between the client and his supply chain. It includes a mapping process but is aimed as a communication tool.

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, its staff, and other experts on 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 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. The client stakeholders and executive also confirmed that they could not make sense of the 3D representations used by the architect during the workshops to present his concept.

The client expected to make decision on hard data that validate design solutions, based on tools for calculating whole lifecycle costs and lifecycle analysis of embedded energy, but the architect did not understand these tools. Moreover, he wanted the decisions to be made as a whole, and not on 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 too expensive and ineffective.

Thiry 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 dialogues and sense-making among the

various communities of expertise composing the team.

Procore-21 is an adaptive framework built on Egan's (1998) five key drivers to change practices in the construction industry. It provides arenas and a learning infrastructure to induce continuous improvements within communities of client, design and builders that are part of the framework. The actions on the project context were analysed using 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.

Procore-21 framework acts at these three levels. First, a new division of labour is proposed, concentrating the business decision-making on the client project director, and 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 (1993) argue that, in 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 organisation and production levels.

Second, new rules are defined for the conduct of the project definition and the project delivery. The project definition process is first designed to reduce ambiguity in the project purpose and building features, second - 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 ownership, continual learning, and heedful interrelating.

The framework proved successful, in this case, in removing socio-cognitive barriers and in stimulating heedful interrelating. These 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 are still made based only on cost consideration, and not taking expected benefits into account. The capture, mediation and routinization of new practices through benchmarking did not perform as expected, and was a major source of tension with principal [principle?] supply chains. The requirement management boundary object tested in the instrumental case proved to be more convincing to achieve this purpose.

In summary, the cases demonstrate that because of the fragmented and temporary nature of coalitions in construction, reengineering processes around an integrated design approach is deemed 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 among disciplines. Proper incentives have to be established to encourage practitioners in the evolution of their way of doing design.

CONCLUSION

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

The analysis of the case studies confirmed the applicability of situated and activity theories to understand 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 analyse and intervene on integrated teams to solve 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 organisation of work.

Finally, the analysis highlighted the importance of configuring the project environment appropriately in order to provide an appropriate context for the development of shared mental models. The reconfiguration of the division of labour, rules and the introduction of new boundary objects have 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 existing practices. In both cases, design professionals showed resistance to adopting and integrating new tools and practices. P21 was, nonetheless, successful in evolving project management and quantity surveyor practices. In the instrumental case, the firm responsible for sustainability engineering adopted the requirement management framework to all their projects.

Much work is required, however, to tailor requirement management practices and tools to the context. Breaking barriers is not only 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 team ability to generate value.

REFERENCES

- Ancona, D G (2005) *Managing for the future: Organizational behavior & processes*. South-Western College Pub.
- Blackler, F, Crump, N and McDonald, S (1999) Managing experts and competing through innovation: An activity theoretical analysis. *Organization*, 6(1), 5-31.
- Carlisle, P (2002) A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, 13(4), 442-55.
- Druskat, U (2000) Learning versus performance in short-term project teams. *Small Group Research*, 31(3), 328.
- Edwards, R Learning in context—within and across domains.
- Egan, J (1998) *Rethinking construction: The report of the construction task force*, London: DETR.
- Engeström, Y (2000) Activity theory as a framework for analyzing and redesigning work. In: Taylor & Francis, 960-74.
- Engeström, Y, Engeström, R and Karkkainen, T (1995) Polycontextuality and boundary crossing in expert cognition: Learning and problem solving in complex work activities. *Learning and instruction*, 5, 319-136.
- Green, S and Liu, A (2007) Theory and practice in value management: A reply to ellis et al. *Construction Management and Economics*, 25, 649-59.

- Koskela, L, Howell, G., Lichtig, W. (2006) Contracts and production**
In, CIBW92, Salford
- Latham, S M (1994) Constructing the team.** *In, HMSO, London, UK.*
- Nardi, B A (1996) Studying context: A comparison of activity theory, situated action models, and distributed cognition.** *Context and Consciousness: Activity Theory and Human-Computer Interaction, 69-102.*
- Simon, H A (1996) The sciences of the artificial.** Cambridge: MIT Press.
- Stake, R E (1995) The art of case study research.** Sage Publications Inc.
- Star, S L and Griesemer, J R (1989) Institutional ecology, translations' and boundary objects: Amateurs and professionals in Berkeley's museum of vertebrate zoology, 1907-39.** *Social Studies of Science, 19(3), 387.*
- Stasser, G and Titus, W (1987) Effects of information load and percentage of shared information on the dissemination of unshared information during group discussion.** *Journal of personality and social psychology, 53(1), 81-93.*
- Thiry, M (2004) Towards a program management body of knowledge.** *In, PMI Global Congress Proceedings, Prague, Czech Republic, 9.*
- Van Aken, J E (2004) Management research based on the paradigm of the design sciences: The quest for field-tested and grounded technological rules.** *Journal of Management Studies, 41(2), 219-46.*
- Victor, B and Boynton, A C (1998) Invented here: Maximizing your organization's internal growth and profitability.** Harvard Business School Press.
- Weick, K E and Roberts, K H (1993) Collective mind in organizations: Heedful interrelating on flight decks.** *Administrative Science Quarterly, 38(3).*
- Yin, R K (2003) Case study research - design and methods.** Vol. 5, London: International Educational and Professional Publisher.
- Zager, D (2002) Collaboration as an activity coordinating with pseudo-collective objects.** *In: Springer, 181-204.*

