Assessing construction innovation: theoretical and practical perspectives

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Abstract

Innovation is key for productivity improvement and advancements in different sectors of the economy, including the construction sector. The criticism of the slow pace of innovation in construction industry may be unwarranted, considering the structure of the industry and nature of the construction business. The loosely coupled nature of firms, mostly Small and Medium Enterprises (SME's), delivering 'projects' through partial engagement, together with the distinction between the project innovation and firm innovation makes it difficult to extract innovations in a meaningful way. The problem also lies in conceptualising, defining, articulating and assessing innovation in construction. The literature is replete with research into construction innovation, however, there is limited research into understanding how innovation is perceived and narrated in practice. The paper aims to explore how innovation is assessed and narrated in construction, specifically analysing theory and practice perspectives. A theoretical model was constructed from a structured literature review illustrating existing discourse and narratives of construction innovation assessment. A qualitative analysis of 'Professional Excellence in Building' submission documents to the Australian Institute of Building was performed to identify the practice perspective of innovation. The findings suggest that internal organizational and process innovation account for the majority of improvements identified. Importantly a taxonomy of narrative is developed that articulates how the construction industry in Australia views industry innovation.

Keywords: Innovation discourse, the construction industry, Small and Medium Enterprises (SMEs), construction innovation, types of innovation.

Paper type: Research article

Introduction

The construction industry is important to the Australian economy in terms of its contribution to economic growth. According to the Australian Bureau of Statistics (2015), the construction industry was the second largest contributor to the Australian Gross Value Added in the year 2014–15. Construction is among the largest economic sectors in the world, with construction-related spend amounting to 3 trillion dollars in 1998 (Crosthwaite, 2002). Compounding this, the built environment supports significant economic and social activities and has a wide range of responsibilities that include enhancing quality of life (Manseau, 1998).

Significant challenges to the construction industry make it difficult to assess construction innovation. For example, coping with rapid changes in customer demands for increasingly functional and sophisticated buildings and equipment; offering flexibility whilst anticipating capital and operational cost reduction; increased building renewal/maintenance requirements;

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globalisation of markets, and new technologies providing major transformational effects on the industry. Compound this with difficulties relative to problems of knowledge sharing, industry fragmentation, lack of skilled personnel for example, have resulted in a lack of capability for construction industries to be innovative (Nam and Tatum, 1992; Manseau, 1998; Gann, 1997). Moreover, the loosely coupled nature of construction firms comprising largely Small/Medium Enterprises (SME's) who deliver 'projects' through partial engagement, together with differences between project innovation and business innovation makes is difficult to identify innovations in a meaningful way. Moreover, regular incremental innovations, rather than radical innovations', makes it more difficult to identify innovation per se.

On a broader scale, the Organization for Economic Cooperation and Development (OECD) categorised innovation based on international research conducted across a number of industries. The OECD Oslo manual described innovation as technical or organizational in nature (Anderson and Manseau, 1999). It is noted that construction innovation incorporates a wide range of participants which includes the government, suppliers of building materials, private capital providers, vendors and distributors, educational institutions, professional and certification bodies, amongst others (Marceau et al., 1999). However, innovation in construction from a project perspective, have been studied primarily through case studies. The lack of broader discourse of construction innovation through project practices in literature warrants research attention. Specifically, how site and construction managers see innovations from a construction project perspective will provide better insights into how in practice innovation is conceived and narrated. This finding will assist with improving innovation reporting and management practices.

The paper is structured as follows; a taxonomy of theoretical perspectives of innovation is produced via a comprehensive structured literature review. A theoretical framework of construction sector innovation is presented based upon these findings. To compare the theory with industry practice, a qualitative analysis of industry documentation was performed; specifically, the 2010 Australian Institute of Building Innovation (AIB) 'Professional Excellence Award' applications. These assist in providing exemplars of practice innovation authored in the main by Construction Site Managers and their peers.

Theoretical perspectives of construction innovation

Studies on innovation can be traced to the seminal works of Schumpeter (1934) whose work shaped and rapidly gained popularity amongst academics, policymakers, and professionals alike (Freeman, 1982; Nelson and Winter, 1982). The well-known view that innovation is a major driving force of economic growth through technological development has been communicated in numerous policies and initiatives over many years (Marshall, 1920; Nelson, 2008). Whether construction industries are innovative or engage in organisational or technological development has been a widely contended issue within the construction and political arena (Egan, 1998; Miozzo and Dewick, 2004).

As an example, public policy research from Spain suggested the construction industry is perceived as non-innovative, with market mechanisms being blamed for industries' failure to achieve better efficiency (Ingemansson, 2015). Moreover, international empirical research highlighted several reasons why construction companies encounter challenges implementing innovation to enhance productivity. Contributing factors included the fragmented characteristic of construction and high degrees of specialisation in processes, together with production activities carried out within projects (Slaughter, 1993b; Winch, 1998; Gann, 2000). The project-based characteristic of construction was also viewed both as a hindrance and a source of innovation. Several writers suggested the organisational structure of a project may affect inter-organizational relationships negatively, whilst a converse positive effect was suggested to

encompass creativity and problem-solving techniques within (different) projects (Dubois and Gadde, 2002; Miozzo and Dewick, 2004).

As a source of innovation, the *project* is often viewed as a creative environment in which different actors with skills and specialties can harness their knowledge to solve specific problems within a specific time frame (Slaughter, 1993a; Winch, 1998). Winch (1998) suggested a challenge lies in the transfer of new, innovative solutions from the project to the firm, with explicit inclusion provided for in successive projects. They reported that for problem-solving to become innovative, the solutions must be learned, codified and deployed for the future, stressing, "knowledge that remains tacit is difficult to manage…" (Winch 1998, p 273). This suggests that innovation is a process that is project-related in nature and affects the type of innovation that is deployed during project implementation. Since some core activities of construction companies often revolve around contracting engagements, system integration and assembly methods, it is during these stages that innovation comes into play and needs to be negotiated with those taking part in the project (Slaughter, 2000; Seaden and Manseau, 2001; Winch, 2003). However, existing confusion around taxonomies and measurement of innovation, and the absence of common language used to define innovation make it difficult for construction firms to pinpoint existing cases of innovation within their projects and management structures and thus make it difficult for these innovations to be identified and transferred from one project to the next. In the context of this paper, with its focus on SME, it is argued that innovation counters complexity in the project environment and as such is equally applicable to projects undertaken by SME as significantly larger enterprises that much of the forgoing literature draws upon.

Types of innovation

Innovation has been identified as the consequence of the introduction of new products, processes, markets, organizational structures and new services (Slaughter, 1998; Dulaimi, Nepal and Park, 2005; Gajendran et al., 2014). These innovation outcomes often make more sense when distinguished between technical innovation and organizational innovation (Bygballe and Ingemansson, 2014). According to Manley (2008), construction innovation can be categorized based on technological and organizational basis. Technical innovation is usually influenced by the orientation of both managerial and economic structure. For example, a firm is able to transform technical innovation into economic results through training and changes in organizational structure (Lundvall, 2007). Whilst Organizational innovation involves the utilization of businesses practices, for example when a new approach is launched into a system that replaces an already established pattern of traditionally accepted products and processes. Technological innovation involves the utilization of technical approaches of either process or product innovation (Manley, 2008). Tatum (1989), is of the view that process innovations are improvements in construction methods that are designed or developed for the accomplishment of usual construction operations or the improvement in the efficiency of a standard operation. Also, process innovation has been viewed as advances in technology that enable greater output with corresponding inputs. However, this view is in contrast with product innovation which is the introduction of a new idea which is transformed into a new component of a constructed product of economic, technological or functional value (Nam and Tatum, 1989). Gajendran et al. (2014), provided additional taxonomies for possible outcomes of innovation. They studied the role of cognitive and organizational routines cognisance of external environment (client requirements, supply chain, volatile markets etc.) and internal environment (organizational structure, values, culture etc.) and concluded that innovative outcomes could manifest in product/services innovation, process innovation, organizational innovation and business model innovation; for example, marketing or managerial innovation (Manley, 2008).

Innovation within construction industries can occur in different ways. Slaughter (1998) illustrated this by characterizing the concept based on whether the innovation is incremental, changes slightly/ based on experience and knowledge; radical, scientific or technological breakthrough; modular, changes detected in a concept within a given concept; or architectural, change in the links to other systems or components. Arditi, Kale and Tangkar (1997), whilst investigating innovation in construction equipment identified driving forces of innovation such as, rate and type of technological push or pull, environmental factors, strategic decisions and marketing policies utilized by firms production practices. They concluded that improvement in productivity, safety, quality of working conditions, cost efficiency and competitiveness could be explained by incremental innovations.

Hartmann (2006) reviewed innovation management from within the boundaries of construction firms, arguing that conscious management of innovation in construction firms is becoming increasingly relevant, albeit successfully implementing innovative ideas is a challenge. Hartmann identified a range of variables and developed a framework for this purpose that revealed innovation management depends on external environment (i.e. client and location, form of innovation, acceptance of innovation from the client and degree of regulation) with variables such as technology, market, economy, physical, political and legal orientation; internal environment (service offer, cooperative behaviour, financial strength, time needs and knowledge strength). Other variables included; characteristics of organizational entity, organizational units and members. The study concluded by identifying instrumental variables such as organisational culture, strategy, structure/ process and specific measures for fostering innovation.

From an Information Technology (IT) systems perspective, organizations may be different from other types of innovation in terms of the introduction of new processes or products. Although there have been benchmarking projects (see Smith et al., 1997) and frameworks for measuring benefits (Andresen et al., 2000; Ramcharan, 1997) within the confines of IT innovation in the construction industry, it has been argued that there exist very little empirical and theorised studies within these organizational contexts.

It is widely acknowledged through literature that there is an increase in inquiries regarding how innovation processes can contribute to enhanced business outcomes for construction firms, with key research identified features of their interactive models (Winch, 1998; Seaden et al., 2003; Sexton and Barrett, 2003; Hartmann, 2006). These models have been identified to highlight the significance of feedback loops between various stages of innovation while recognizing two main types of innovation drivers which are internal (strategies, capabilities and characteristics) and external (environmental factors). Classification of strategies based on key management functions within construction firms have been identified relative to employees, marketing, technology, knowledge, relationships. Burgelman, Christensen and Wheelwright (2004) affirmed that a strategy in this context was viewed as the planned processes utilized by firms for the improvement of core competencies as well as the facilitation of innovation. The concept of core competencies however refers to cooperate-wide technologies and skills in production capable of empowering firms to quickly adapt to changing opportunities. The core competency of an organization can however be viewed as intangible assets which includes organizational routines, networking linkages, management skills, routines, knowledge base, etc. Therefore the role of adopting business strategies is to facilitate innovation and enhance these intangible assets (Malerba and Marengo, 1995; Barney, 2001).

Evident within the literature is the attainment of innovation through the collaborative efforts or alliance of construction organisations (inter-organisational collaboration). Rutten, Doree and Halman (2009), while drawing on a synthesis of literature review on innovation and inter-organisational cooperation, affirms that collaboration is a critical factor for construction innovation. An important feature of the construction industry is the varied supply chain---

adding to the fragmented nature of the construction industry relative to the range of required skills, materials and technologies employed, which makes it challenging for various organisations to achieve cooperation internally. Though studies have shown that the negative impact of supply chains (inclusive of poor organisational cooperation) have the propensities of hindering innovation (Dulaimi et al., 2002), studies have also shown that inter-organisational cooperation, especially those that comprise multiple projects, play significant roles in construction (Holmen, Pedersen and Torvatn, 2005). Some factors have been identified as stimulants of inter-organisational cooperation though the adoption of a new procurement method Bresnen and Marshall (2000), or of a new organizational structure (Nicolini, Holt and Smalley, 2001).

Theoretical framework

The literature review highlights some challenges in clearly articulating innovations in construction. One of them is the difficulty in the noticeability of small but new incremental changes delivering business improvements. Moreover, the loosely coupled nature of organizations, make it difficult to account any the new changes made in the project, particularity on the periphery of two firms. Figure 1 illustrates the assessment of innovation in a simple sense, i.e. by identifying new changes to aspects of a firm or in project leading to improvements in business parameters. However, the evidence to support the level of newness of changes and improvements are mostly self-assessed by firms.

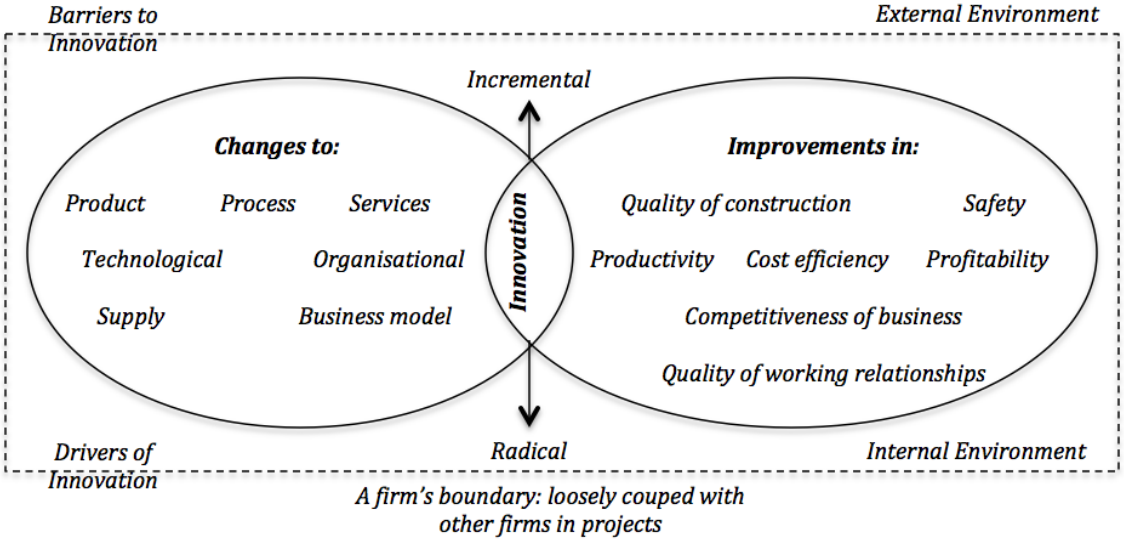

Figure 1: Theoretical Perspectives on Innovation Assessment

Research method

This research is embedded in constructivism philosophical position; exploring the narratives of events/situations in construction organisations leading to outcomes which are perceived as innovation. A critical literature review was conducted with the aim of making sense of the discourse into innovation within the confines of construction management domain. To achieve this a wide range of published materials were sourced and filtered. Sources of data selected for this research were mainly from journal articles, but books, conference papers, reports, and thesis were also reviewed. The initial literature search yielded a total of one hundred and ninety-two (192) materials published in the last thirty-five (35) years (1980-2015) with exceptions of Schumpeter's book titled "Theory of Economic Development" published in 1934 and Alfred Marshall's 1920 book titled "Principles of Economics" which were basically utilized for illustrating the origin/development of the innovation from an economic perspective.

The scope included revisiting: (i) How construction academics have conceptualised innovation assessment (ii) How construction industry innovation has been illustrated in literature. The use of scoping as well as keywords aided the filtering process. Key words such as: (i) Construction project and innovation (ii) Construction firm and innovation (iii) Construction Innovation assessment (iv) Project Innovation and construction (v) Innovation behaviour and construction and (iv) Construction Industry and innovation were utilized for narrowing the search from databases, for example *Scopus*. A total of seventy-four (74) peer reviewed journal articles selected for the literature review were sourced from journals relating to construction management, engineering and economics.

The empirical data for this research was collated in the form of submission documents that were prepared for Australian Institute of Building Professional (AIB) Excellence awards. Some sections of the documents were prepared with specific intention to identify innovation in construction projects, the submission provides a consistent framework within which the narratives are explored. The AIB provided copies of applications for their building awards. Using 24 construction applications submitted in 2010, none of whom were category winners. The research team focussed upon retail and office building projects. The project value ranged from less than AU$1 Million dollars to over AU$100 Million, they were constructed in time frames ranging between 6 months to 3 years by teams of companies that individually would be normally referred to as SME, and were located in all States of mainland Australia except the Northern Territory. Any instance of described or demonstrated innovation found in the 24 individual applications were coded using NVivo10™.

The data was extracted from primary sources, with actual submissions provided by the construction companies hoping to be awarded. The entries narrated the story of a particular building being built and were required to include information on what they perceived as difficulties, complexities, and innovations, as well as information on risk, training, environment, team management, and impacts in built environment. It was the applicant's written words that were coded, and the process involved seeking any cases of innovation first, and then attempting to match key narratives with predetermined nodes in NVivo10™. This often involved finding innovations by proxy through changes to practice, improvements to business and behavioural attribute examples. The accounts provided may have been perceived to suffer from bias, where the respective authors construct an account that they believe will be more successful than other submissions. Noteworthy, they were accepted as honest accounts as they were subject to scrutiny by their peers and a well-regarded panel of judges.

The 24 sources were then fully coded. Significance is drawn from this narrative not in terms of quantity but in terms of context and discourse utilised by the applicant expressing their view. The coding process referenced the updated codebook created for this project. Due to the nature of the applications, many of the sources repeated their statements throughout submission. In the case where no new information was provided in a repetitive statement, it was not coded again, reducing a false amplification of innovation nodes. After the coding process was complete, the coded items were reviewed and then the final results collated. A final total of 1527 data points were extracted from the set, and between 26-58 'child node' data items were found for each source. These nodes were then syntheses and fused to create themes. Under each 'parent node' there were between 7-15 'child nodes', which allow for recording of specific innovations in the area of the parent node. For example, a source extract which describes the new experience of deciding to include an integrated photovoltaic system in the building project would have been coded with the child node of Entirely New Process under the Process Innovation 'parent node', as well as the child node of 'Improved Environmental Features' under the Product Innovation 'parent node'.

The examples of possible innovation discovered, whether a diffusion of innovation or outcome of innovation, were categorised according to the area of operation in which the action of innovation was undertaken. It could be seen that innovations fitted into nodes of several types. Of the parent nodes, the product, process and supply innovation all fell into a more project based innovation: one that might only be a special case for that construction event, whereas the market/business, organisational and service innovations were all related to the organisation and would be more likely to be an ongoing innovation within the company. Interestingly, this correlates to the division between technological (product and process) and organisational innovation as described by Manley (2008).

Analysis and discussion

The analysis of the empirical data identified that innovation narratives by the practitioners aligned with most theoretical perspectives. Coding identified narratives relating to changes to projects, processes, supply, and organizational aspect creating improvements to business outcomes. The innovations were deconstructed in the narratives by descriptions of actions (Figure 2). In the analysis three nodes were identified as related to business operations, however they did not specifically define whether the business operations were internal (how the business operates) or external (what the business delivers); whereas the information in the sources (innovation application document) consistently clarified this difference. The coding process was reassessed and brought into line with the narratives by combining *Market/Business*, *Organisation* and *Service Innovation* original parent nodes into one large set, and then redistributing all of the previously coded data of these 3 sets into 2 different parent sets: *Internal Organisation Innovation* and *External Business Innovation,* which were applied to the sources.

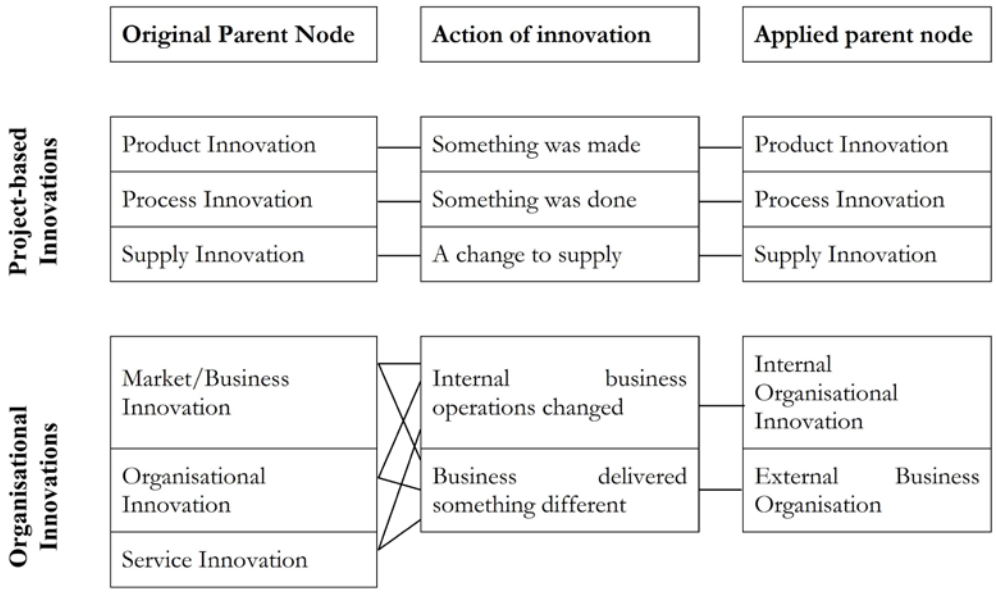

Figure 2: Nodes that deconstruct innovation in construction

Referring to Figure 2 it may be observed that five applied parent nodes were established. In the following a descriptive analysis is provided and aligned with the literature wherever possible.

Product innovation

Product innovation was found in 21 out of 24 sources leading to 13 aspects of improvements (Table 1) that can be classified as innovation outcomes. The most claimed innovation was through improving the environmental features of the building/project through product

integration. However, significant accounts of product innovation are attributed to new assembly methods, refining existing products and improving functionality.

Table 1: Product innovation nodes

Parent Node	Child Nodes- Improvements in/through	#	%
Product Innovation	Environmental features	60	18
	Performance of existing product	45	13
No. of sources 21	New assembly methods of existing product	39	11
	Refining products	38	11
Child nodes 13	Functionality of a product	35	10
	Design of new product with the suppliers	28	8
	New products replaces old one	22	6
	Introducing entirely new products	19	6
	New technology	17	5
	New component	12	4
	New approach reduces quantities	10	3
	Reuse of existing products	8	2
	New approach removing the need for old	8	2

The following claim from an applicant identifies 'refining a product' with 'new assembly methods of existing product' increasing productivity.

> "[We] put forward a proposal for the cast-in-plates to include two weld bolts (prior to install) which meant panels could be placed into position, bolted to the cast in plates as a temporary fixing detail and then could be finally welded off after the crane had release the panel allowing the crane to move onto the next panel. This saved approximately two hours per panel." (AIB, 2010, respondent 25).

Process innovation

Process innovation was found in 23 out of 24 sources leading to eight aspects of improvements (Table 2) that can be classified as innovation outcomes. The most claimed innovation was through improving safety for workers during process and this could be due to the specific criteria given in the professional excellence application guidelines to safety improvements.

Table 2: Process innovation nodes

Parent Node	Child Nodes- Improvements in/through	#	%
Process Innovation	Safety for workers during process	112	27
	Efficiency of process	90	22
	Method of construction	56	13
No. of sources 23	Introduction of new process	45	11
	Utilizing existing skills to improve process	35	8
Child nodes 8	Core competencies	29	7
	Entirely new process	24	6
	Building new capabilities to processes	24	6

An example of process innovations attributed utilizing existing skills to improve costing and defect process leading to improved efficiency of processes.

"The detailed cost control and defect process resulted in long term success. We received minimal return visits after practical completion to address issues and achieved an optimum project outcome" (AIB, 2010, respondent 7)

Supply innovation

Supply innovation was found in 7 out of 24 sources leading to seven aspects of improvements (Table 3) that can be classified as innovation outcomes. The most claimed innovation was through developing existing supply networks. The accounts of supply-based innovation are relatively lower than the other four categories of innovation.

Table 3: Supply innovation nodes

Parent Node	Child Nodes- Improvements in/through	#	%
Supply Innovation	Developing existing supply networks	20	41
	Interactions between businesses	13	27
No. of sources 14	Introduction of new collaborative networks	7	14
	Increasing customer connections	3	6
Child nodes 7	Creating entirely new supply chain channel/strategy	3	6
	Utilizing technology in supply chain	2	4
	Entirely new project procurement	1	2

The following claim from an application identifies developing the supply network and interactions between business-to-business improving the quality of the building.

"[We] consulted directly with Dulux to change the paint specification upon learning that the original was not adequate in a UV exposed environment" (AIB, 2010, respondent 36).

In this case, the contractor has directly communicated with the manufactures their specification to manufacture a product to suite their need rather than go through the retailers or wholesaled traders.

Internal organisational innovation

Internal organizational innovation was found in all 24 sources leading to 13 aspects of improvements (Table 4) that can be classified as innovation outcomes. The most claimed innovation was through enhancing internal collaboration and communication and this could be due to the specific criteria given in the professional excellence application guidelines about communications.

Table 4: Inter organizational innovation nodes

Parent Node	Child Nodes- Improvement in/through	#	%
Internal Organisational Innovation	Internal communication and collaboration	225	33
	Reflecting/ rethinking/ redesigning	81	12
	Improved standard working practices	79	12
	Training	59	9
No. of sources 24	Internal organizational flexibility and diversity	53	8
	Improved organizational management competencies	45	7
Child nodes 13	Encouraging cross-company uptake of ideas	33	5
	Introducing new business models internally	28	4
	New behaviours	27	4
	Sharing of resources	22	3
	Utilisation of incentives	17	3
	Create and acquire external skills	4	1
	Alignment of behaviours with models	4	1

The following quote suggest that 'improved reflecting, rethinking, redesigning of standard working practices enhancing outcomes.

"One of the environmental actions to arise from the HSE committee was to direct funds received from recycling efforts back into the Project so that social activities can be organised"(AIB, 2010, respondent 68)

External business innovation

External business innovation was found in all 24 sources leading to eight aspects of improvements (Table 5) that can be classified as innovation outcomes. The most claimed innovation were enhancing external Market collaboration or communication and increasing customer value.

Table 5 External Business Innovation nodes

Parent Node	Child Nodes- Improvements in/through	#	%
External Business Innovation	External Market collaboration or communication	86	38
	Customer value	73	32
No. of sources 24	External business flexibility and diversity	22	10
	New business approaches	12	5
Child nodes 8	Introducing new business models externally	10	4
	New business scope	9	4
	New service delivery	6	3
	Increased capital ventures	2	1

The following quote provides an example of external innovation through market collaboration leading to improved customer value.

"Finally, a 'Lessons Learned' workshop was held after practical completion was achieved to allow the client and [the company] to collaboratively discuss areas that worked and areas for improvement. Reports from the client regarding [this] proactive approach to seeking feedback in an effort to improve future performance was applauded." (AIB, 2010, respondent 36)

Conclusion

It is suggested that the articulation of innovation in construction is difficult for a number of reasons, the nature of the sector and a loose coupling/partial engagement has been identified. Notwithstanding constructors' difficulty in conceptualizing, defining and articulating meaningful innovation. Significant challenges and rapid changes to the construction sector suggests an urgent need to redress this position. It is suggested that there is abundant literature regarding innovation in construction, the findings from this paper, whilst restricted to a small sample of SMEs identifying innovation in selected projects in 2010, provides clues as to how the theoretical contextualization of innovation is codified into general practice. Analysing twenty-four construction applications submitted as part of the 2010 Australian Institute of Building - Excellence in Building Awards examples of product innovation, process innovation, supply innovation, internal organizational innovation, and external business innovation are presented. Whilst incremental improvements were identified within all these fields (Tables 1 to 5), it was also noteworthy that the greatest number of improvements were attributed to inter-organizational innovation (Table 4 - internal communication and collaboration 24/24 sources 225 references 33% child nodes) and process innovation (Table 2 - safety for workers during process 23/24 sources 112 references 27% of child nodes). Reference to the child nodes in each instance provides some insight, nearly 60% of inter organization innovation is attributed to communication and collaboration, reflection and improving standard work practices (Table 4). This suggests that construction team leaders, the authors of the sampled applications, are cognizant of the benefit that relationship building and maintenance attributes have on successful project outcomes and use them to their advantage whenever possible in their highly competitive

construction industry sector (Davis, 2011). Twenty-seven percent of process innovation is attributed to safety for workers during process (see Table 2). Following the argument of the earlier notion, it is apparent that recognition of one particular aspect of improving standard work practices is actively applied to safety to generate innovative improvements. In recognising the industry imperative of safety and with the certain knowledge that better safety outcomes are a consequence of organized work practice construction team leaders are undertaking and articulating their reflection and primary collaboration in the design and construction phases of the project life cycle as a distinct and discrete form of innovation.

From the foregoing it may be seen that taxonomy of narrative is developing, that articulates how the construction industry in Australia views industry innovation. A developing discourse is entering contemporary construction management dialogue. The key finding is that specific examples displayed in the paper serve as a benchmark for future dialogue within the industry.

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