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## **IS RADICAL INNOVATION A NEW VALUE-ADDING PARADIGM FOR CONSTRUCTION ORGANISATIONS OR JUST A CURRENT FAD? – A CRITIQUE –**

*T. Puolitaival<sup>1</sup>, L. Kestle<sup>2</sup>*

<sup>1</sup>Lecturer, Unitec Institute of Technology, Auckland, New Zealand

<sup>2</sup>Associate Professor, Unitec Institute of Technology, Auckland, New Zealand

tpuolitaival@unitec.ac.nz

### **ABSTRACT**

The Construction Industry, globally, has long been accused of low levels of productivity and innovation and arguably cannot be as readily measured using mechanisms common to other industries. Innovation is described and defined differently according to the particular context of discourse. This research investigated a process known as 'radical innovation' from a published and funding perspective longitudinally over time in a range of industries, including how it may or could be interpreted, applied and add value in the construction context. A systematic and in-depth literature review was undertaken involving sources from longstanding and credible journal data bases. The findings were analysed using an interpretative methodology that incorporated a multi-dimensional measurement approach. The findings, and the subsequent critique, were broken into two components – 'radical innovation' *persé*, and 'radical innovation' in construction. The resultants established that 'radical innovation' has been explored by researchers from the 1930's in the context of many industries, but not within the Construction Industry context – where only a handful of journal articles having been published. In addition, enablers and obstacles have been identified, with only minimal evidence of previously proven methods within the Construction Industry. A poor track record of investing in research and development, the nature of the industry being adversarial and fragmented, with many micro organisations, suggested that an action research project will be the next step to test and potentially embody 'radical innovation' and increase productivity.

*Keywords:* collaboration, construction industry, knowledge management, organisational culture, radical innovation

## INTRODUCTION

Government and industry organisations that promote research and development (R&D) in New Zealand, set strict criteria and guidelines for the research projects that will or might be funded. How do these organisations view radical innovation /what are their key research funding criteria:

1. MBIE - The investment mechanism is intended to support ambitious, excellent, and well-defined research ideas which have credible and high potential to positively transform New Zealand's future in areas of future value, growth or critical need. Radical innovation tends to be implicit not explicit, in criteria descriptors.
2. Callaghan Innovation seeks to assist businesses take innovation to the next level through technology, and collaborative partnerships between CI and businesses to lift productivity in the Built Environment Sector, for example.
3. BRANZ - The Building Research Levy, (1969) is used by BRANZ to offering grants for construction industry-related and scientific research. Of note, Lincoln University has been conducting research into cultural aspects of innovation, since 2008 in New Zealand and overseas, including building. The Ministry of Science and Innovation are the main funders, with BRANZ a co-funder. A paper published by Lincoln in 2010 looked at the potential need for a dedicated innovation centre in New Zealand focused on the building sector.
4. Building and Construction Sector Productivity Partnership. In 2011 this partnership reported that 45% of companies with 6+ employees were reporting levels of increased innovation.

Innovation can be divided into incremental and 'radical innovation' (RI) (Norman and Verganti, 2012), or even more specific divisions (Slaughter, 1998). Within these are different descriptors of innovation: product, process, organisational, input and marketing (Schumpeter, 1934). What differentiates RI from the incremental innovation is that it does not just significantly improve the existing patterns, but breaks existing patterns, and produces something new and unique (Dahling and Behrens, 2005).

There has been some discussion on RI in the published literature since the 1930s', when Schumpeter (1934) introduced the concept of creative destruction and disruption, but the concept has become popular during the last couple of decades. It can be argued that RI in construction has existed for a long time in the form of new materials, tools, engineering and architecture inventions. Examples would be Portland cement in the 1700s', steel construction in the 1800s', and the engineering and construction techniques needed to build the pyramids over four and half thousand years ago and the Megalithic Temples of Malta 4<sup>th</sup> millennium BC (Unesco, 2015).

However, evidence of proven methods for RI within the Construction Industry is lacking in published literature. A poor track record of investing in R&D, and the nature of the industry being adversarial, and fragmented with many micro organisations has had a serious impact on innovation levels in construction (Abbot et al., 2006; Barlow, 2000; Blayse and Manley, 2004; Sexton and Barrett, 2003a).

## **RESEARCH METHODS**

The research method was primarily exploratory, and involved looking for patterns of activity, similarities, and changes that have occurred over time in terms of the descriptor 'radical innovation'. A systematic and in-depth literature review was undertaken, including historical archives, journal articles and case studies from 189 longstanding and credible journal data bases. Peer reviewed published literature was investigated, analysed and compared longitudinally over time across a range of industries, with the main focus being, how 'radical innovation' may, or could be interpreted, applied and add value in the construction context. To commence the process, an historical archival journal article literature review, and quantitative analysis, was undertaken to confirm when the process of 'radical innovation' was first introduced, and published in quality assured academic literature, and how widely it has been investigated and evidenced to date. This literature review involved all disciplines e.g. art, literature, education, social sciences, business and construction, using the descriptor 'radical innovation' in the title of articles, and in the text of the articles. One hundred and eighty nine data bases were selected and included the following key data bases: Academic One File; Academic Search Complete; Business Source Complete; Ebsco Journal Service; Emerald Management Xtra 200; Engineering Source; Sage Premier; Science Direct.

The process was then systematically repeated by using the search descriptors 'radical innovation' AND 'construction', to try and identify if, and how the process has been explored, investigated, or applied over time in the Construction Industry. Only a small number of published references were found that involved the Construction Industry, so the search descriptors - 'discontinuous innovation', 'breakthrough innovation', 'disruptive change', 'fundamental change', 'revolutionary change', and 'paradigm shift', were individually added to the search involving 'construction'. For example, 'discontinuous innovation AND construction'. Resultant published case studies provided a variety of relevant sources, and data that included quantitative and qualitative research methods. A few of the reference articles were exploratory case studies that could provide a starting point for ongoing research. The Findings in the selected literature were then collectively critiqued under the key headings: Definition and types of innovation and radical innovation; Radical innovation persé in peer reviewed published literature; Value, enablers

and obstacles of innovation and radical innovation persé; Radical innovation in construction in peer reviewed published literature; Value, enablers and obstacles of innovation in construction; and Construction industry vs. other industries. Conclusions and recommendations were then drawn from the findings.

## **FINDINGS AND DISCUSSION**

### **Definition and types of innovation and radical innovation**

To understand the context of the research it is important to define what is meant by 'radical innovation' (RI). Even though some innovations are clearly incremental and some clearly radical, it is not always easy to make the distinction, the line between the two is somewhat blurry.

Crossan and Apaydin (2010), defined innovation as production or adoption, assimilation, and exploitation of a value-added novelty in economics and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome. Crossan and Apaydin also noted that novelty is relative, what is common practice for one, can be innovative for others. RI, was also considered as revolutionary, disruptive, discontinuous or breakthrough (Crossan and Apaydin, 2010). Dahlin and Behrens (2005) defined RI as something novel, unique and having impact on future products and processes, when incremental innovation is a significant improvement to the existing products or process, but not totally novel or unique (Martinez-Ros and Orfila-Sintes, 2009). Ettlie et al. (1984) argued that RI can be distinguished from incremental, continuous innovation by looking at if the innovation is a clear, risky departure from existing practice. Leifer (2000), added into this by stating that RI either introduces totally new performance features, improves things by at least 5 times, or there is at least 30% reduction in cost. Norman and Verganti (2012), explored the differences between incremental and radical product innovation distinguishing them by the differing processes. They state that incremental innovation is a result of a deliberate design research strategy whereas RI in contrast is related either to the introduction of new technology or finding new meanings for a product. Story et al., (2014), came to the same conclusion noting that in order to achieve RI one has to depart from current design trajectories. In conclusion, RI breaks the existing patterns, whereas incremental innovation simply improves them, albeit significantly.

Keeley et al. (2013) created a framework of ten types of innovation by looking at over 2000 successful innovations including Google, Lego and McDonalds. Their framework consists of three areas, which are further broken down to innovation types:

- Configuration: profit model, network, structure, process
- Offering: product performance, product system
- Experience: service, channel, brand, customer engagement

This framework puts more emphasis on the experience, service and customer as part of innovation.

### **Radical innovation persé in peer reviewed published literature**

When investigating peer reviewed journal articles, the term RI was rare before 1980s' (Table 1), although Schumpeter (1934), who is considered the godfather of innovation studies (Sledzik, 2013), discussed creative destruction and disruption in the 1930s'. Schumpeter was an economist and political scientist, but the first quality assured journal articles mentioning radical or disruptive innovation in early and mid-1900s' were related to other disciplines, such as art, literature, theology and education. From the 1980s', several disciplines joined the discussion including social sciences, medicine and business. New themes of innovation started to emerge such as intern-organisation innovation and innovation management (Stringer, 2000). In 2000, the discussion expanded to introduce open innovation, and the relationship of knowledge management and innovation (Chesbrough, 2003; Berchicci, 2013; De Wit et al., 2007).

*Table 1. Frequency of the term 'radical innovation' in quality assured journal articles from 1950 to 2015.*

Timeline	Included in the title	Included in the text	Disciplines
1950-1959	0	3	Art, literature and theology
1960-1969	0	37	Art, literature, theology and education
1970-1979	0	16	Art, literature, theology and education
1980-1989	5	100	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction
1990-1999	12	>500	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction
2000-2009	>70	>2000	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction
2010-2015	>100	>3000	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction

## **Value, enablers and obstacles of innovation and radical innovation persé**

Considering that the line between incremental and RI is sometimes blurry. Value, enablers and obstacles are similar for incremental and 'radical innovation'. Whyte (2003) surmised that innovation was important for the long-term economic success of organisations, by offering market growth or a stabilised position in the market. In some cases, incremental innovation is enough to create competitive advantage, but in many cases RI is required in extremely competitive markets just to maintain the market position with competitive advantage, (Kim and Maubourgne, 2005; Rosenbusch et al., 2011). RI is considered to be a driver for technological, industrial and societal change, as well as growth and wealth of organisations (Schoenmakers and Duysters, 2010; Tellis et al., 2009).

Incremental innovation is enabled by organisational learning, which allows the development, acquisition, transformation and exploitation of new knowledge (Jiménez-Jiménez and Sanz-Valle, 2011). RI on the other hand requires more than this by combining internal knowledge base with external sources (Forês and Camisón, 2015), but preferably with unbiased external sources, (Schoenmakers and Duysters, 2010). Existing knowledge needs to be connected in new ways, (Keupp and Gassmann, 2013). Alliances and open innovation are offered as solutions to enable external knowledge acquisition, transformation and exploitation, (Besant et al. 2014; Schoenmakers and Duysters, 2010). Tellis et al. (2009) listed five main enablers for RI: educated and skilled workforce, capital, supportive government policies including intellectual property policy, support for academia-industry collaboration, tax credits for R&D, government's own procurement, and corporate culture. Corporate culture, attitude and practice, had the biggest impact on RI; companies need to be willing to cannibalise, be orientated to future markets, have a good risk tolerance, and empower and provide incentives to champions (Tellis et al., 2009). Ability to unlearn (Yang et al., 2014), adapt and reconfigure routines (Bessant et al., 2014; Starbuck, 2014) are core to RI.

The list of enablers for RI can also be turned into obstacles of RI: lack of skilled and educated workforce; lack of capital; restricting government policies; no support for academia-industry collaboration; no monetary incentives from the government, and an unsupportive organisational culture. There were some contradicting views though, for example when Tellis et al. (2009), listed capital as one of the main enablers, Keupp and Gassmann (2013) argued that restricted resources can actually be a driver for RI. Exploring more deeply, no tolerance for risk and no future vision hinder RI according to Tellis et al. (2009). Green and Cluley (2014), Sandberg and Aarikka-Steenroos (2014), added hierarchical, bureaucratic and unsupportive organisational structure, to the list of obstacles for RI.

## **Radical innovation in construction in peer reviewed published literature**

Only a handful of peer reviewed journal articles discussing RI in construction context was discovered. Slaughter (1998) with the article 'Models of Construction Innovation', was the first published researcher to mention RI in construction context. Slaughter (1998) divided innovation in construction to incremental, modular, architectural, system and radical. To assist the construction companies to innovate she further specified activities for implementation by type of innovation. The main difference between the implementation activities for RI compared to the others is that the activities involve higher organisation level (top level) and require more specialised resources and links. Boland et al. (2007), studied Frank O. Gehry's adoption of digital three-dimensional representations, and the wakes of innovation it created in projects. The disestablishment of old practices by creating collaborative project networks, and the use of disruptive technology by adopting aviation industry software to be used in a construction project, was described. Yu et al. (2012), created a model for the automated generation of innovative alternatives (MAGIA), which used published specifications and patent databases to generate innovative technology solutions. The roles of the supplier and the end-customer in RI processes were highlighted by Mlecnik (2013) and Sivunen et al. (2013). Sivunen et al. (2013) argued that the RI process in construction is affected by external factors such as economic, social and political factors, competition and infrastructure, but also internal factors such as resources, organisational structure and organisational culture.

When the combination of descriptors, 'radical innovation' and 'construction', resulted in only a handful of articles, the search was expanded to include 'discontinuous innovation', 'breakthrough innovation', 'disruptive change', 'fundamental change', 'revolutionary change', and 'paradigm shift'. An additional small number of articles were found that introduced RI from the areas of product and process development, and digital technologies. In addition, a number of articles discussed the need for RI, but did not offer any proven examples.

## **Value, enablers and obstacles of innovation in construction**

Abbott (2006), Barrett (2006), Davey (2004), Hardie (2010, 2011), Manley (2008), Sexton (2003a, 2003b, 2004) and Whyte (2003), all published literature on innovation in construction, focusing on the specific fragmented and project-based nature of Construction Industry, and on small and medium sized construction organisations/enterprises (SMEs). The need for SMEs to network and collaborate both with other organisations and academia to innovate, was highlighted. Gann and Salter (2000) argued that project and business processes should be better integrated to enable innovation in project-based organisations. Keegan and Turner (2002), favoured more organic project management. Knowledge management and organisational learning were

seen as a key for innovation creation in construction (Barlow, 2000; Davey, 2004; Egbu, 2004; Issa and Haddad, 2008; Maqsood and Finegan, 2009).

Xue et al. (2014) implemented a systematic literature review of construction innovation. This identified collaboration, inter-organisational cooperation, academia-industry cooperation, complex product systems, culture, innovation climate, champions and leadership as the main categories of discussion in published literature. Blayse and Manley (2004) listed clients, manufacturers; structure of production; relationships between individuals and organisations; procurement systems; regulations, nature and quality of organisational resources as primary drivers of innovation.

### **Construction Industry vs. other industries**

Construction is a project-based industry with two main types of organisations: temporary project organisations, and permanent company organisations. The Construction Industry is very fragmented with many small and micro organisations, being described as adversarial in nature, due to the dominating forms of contracting, which enable exploitation and development of a hostile and litigious environment, with a strong blame culture (Egan, 1998; Egbu, 2004; Latham, 1994).

Investment on R&D in construction, has been historically poor, (Winch, 2003). In the European Union, the Construction Industry invests less than 1% of its net sales in R&D, leaving the industry in the lowest category among all industries, (Hernandez et al., 2014). The figures are even lower in Australia, and in New Zealand, (Barlow, 2012; Morrison, 2001). Although innovation is often measured by the amount of R&D investments, it has been argued that R&D should not be used to measure innovation in construction, particularly if innovation levels are low in construction, compared to other disciplines (Bygballe and Ingemansson, 2014; Winch, 2003).

The nature of the Construction Industry tends to have a negative impact on RI, and innovation in general. The often fragmented and hostile environment does not support the development of an open, collaborative learning environment. Competition between organisations to win projects is often the main or only driver. Hierarchical and rigid organisational management structures do not allow full integration of project and business processes, nor more organic management methods, to enable innovation. Learning at project level is often not exploited at company or industry level, and company-level learning is not always shared at the project level. Internal networks are valued more highly than external networks, and there is a lack of integration in the supply chain across projects (Bygballe and Ingemansson, 2014). Adversarial procurement systems hinder collaboration, and a blame culture, and litigious

environment lowers tolerance for risk, discourages creativity and reduces innovative initiatives. However, there are increasing examples of better integration across the supply chain (Bygballe and Ingemansson, 2014), and more collaborative ways for procurement are emerging (Blayse and Manley, 2004). Construction organisations have finally started to understand the importance of collaboration at the early stages of the project, and that the value added to the client is the key driver and goal of the project (Sivunen et al., 2013).

## **CONCLUSIONS AND RECOMMENDATIONS**

It is evident that the term RI is new to construction and construction is more prone to other types of innovation: incremental, modular, architectural and system innovation. Nevertheless, considering the relatively extensive and representative historical references and the journal articles reviewed, it can be argued that RI definitely exists in the construction sector.

Whether RI adds value to construction, and identifies the proven methods, cannot be drawn from the limited published literature on RI in construction. However, when looking at innovation in general, its value, enabling, and hindering factors in the wider industry context, could and do apply in the Construction Industry context. Therefore it could also be argued that most of the factors for RI in the wider industry context apply in the construction context.

RI requires adaptation of new routines, and reconfiguration of existing processes and habits. Organisational structure and management need to allow this to happen. Due to the project-based nature of construction, project and business processes need to be better integrated, and project management needs to be more organic. Construction organisations still have a long way to go to become innovative organisational cultures, which provide incentives for innovative champions.

Knowledge management and organisational learning were seen as important enablers for RI in the wider industry context. Innovation in construction tends to happen at the project level. However, construction requires methods which suit temporary project-based organisations, when it involves development, acquisition, transformation and exploitation of new knowledge, in order to transfer that new knowledge to the next project.

Project-based practice needs ways to collaborate and to form external networks, which include the whole supply chain from the manufacturer to the client. This can be enabled by procurement systems, which allow true collaboration across the supply chain. In these networks, restricted resources, especially in the SME sector, can become drivers of innovation

instead of being an obstacle, and the client becomes an important initiator of innovation.

This literature review has provided some insights into 'radical innovation' in construction, but to further explore the process an interventional 'radical innovation' action research project in conjunction with a construction organisation is the proposed next step, and will be commenced in mid-2016.

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