Overcoming Barriers to Innovation in the Building Industry

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We live in an era of accelerated innovation. All around us we are immersed in a sea of new technologies and products that were very recently confined to comic books and science fiction tv-series. Yet in this storm of innovation the building industry seems to stand out for its committed old fashioned-ness.

While some incrementally innovative materials do rapidly diffuse through the market, there have been relatively few disruptive innovations. In particular a number of developments that claim to offer significant and disruptive benefits through integration have been very slow in coming. Innovations in process integration seemed to be stuck on the lower part of De Tarde’s S-curve of innovation diffusion (Kinnunen 1996).

For example, the principles of Building Information Modelling (BIM) have been known since the 1970s (Eastman, Fisher et al. 1974). Yet it has only relatively recently begun to diffuse through the industry, first in North America, and now in other countries such as The Netherlands. It seems therefore that, in the building industry, there is a significant gap between the development of new technologies and innovation. Innovation, which we use to describe precisely those new technologies and processes that become disseminated throughout an industry – leading to significant change in practices or products. Thinking up the new technology, whether it is a new material, device or process, is only half the work. A new technology has to be taken up and change an industry to become a proper innovation.

In the building industry it is new developments in process integration that seem to offer the best chance for significant or disruptive improvement in performance, e.g., BIM, Integrated Contracts and Supply Chain Management. The principle of integration in the building industry has had many advocates among both practitioners and academics, e.g., (Howard, Levitt et al. 1989, Nam and Tatum 1992, Dulaimi, Y.Ling et al. 2002, Baiden, Price et al. 2006, Forgues and Koskela 2009, Gambatese and Hallowell 2011b). However it is only in the last few years have businesses in the construction industry begun systematically to take up these initiatives. One is therefore entitled to ask why it is that these promising technologies and processes have been so slowly taken up?

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What are the key factors that have made it possible for these new technologies and processes to be taken up now?

A number of researchers have examined this problem, and the most succinct statement of their results is that: “Innovation in the construction industry requires three components: idea generation, opportunity and diffusion.” (Gambatese and Hallowell 2011a) The process of uptake occurs on two distinct levels: adoption, or the decision by an individual business to adopt an innovation; and diffusion, or the social process through which innovations spread throughout an industry. The importance of making the distinction is that, while diffusion is to a significant extent the result in individual decisions, many factors influencing those decisions that only apparent on the broader scale.

The process of diffusion was first characterized by Everett Rogers (1995). His goal was to determine why it was that some inventions take off, while others have little impact. He proposed that there are five intrinsic preconditions for successful innovation:

1) relative advantage,
2) compatibility,
3) complexity or simplicity,
4) triability, and
5) observability.

Relative advantage refers to the net financial benefit offered by the invention. Compatibility refers to the degree to which the new device or process is compatible with existing products, practices and markets. Complexity seems self explanatory, but refers particularly to interaction and with other existing partners, practices and technologies. Triability refers to the costs of trying out the invention – purchase of equipment, training, convincing others to accept the novelty. Finally observability refers to the degree to which the invention and its relative advantage are visible to actors in the relevant markets.

Taking BIM as an example again we can see how these pre-conditions were not at first met. BIM certainly was not compatible with existing practices such as manual drawings or the clear separation of responsibilities of different designers. Even with the eventual development of CAD programs, porting data back and form from 2-D CAD models remains a significant barrier to the use of BIM systems. BIM is conceptually simple, but appears quite complex, especially to firms not yet familiar with the technology. This complexity is perhaps most evident in the extensive training involved in learning to use BIM – not just learning to draw, but also to use the databases and associated applications, the acquisition of powerful computers, and the coordination of BIM and CAD systems and file and layer naming among designers and with contractors and suppliers. All this presents significant problems with triability.

Finally the benefits of BIM use, and the real experiences of early adopters has not been clearly visible to other players suspicious of the enthusiasm of the occasional booster. Existing methods seemed good enough. (Especially when the cost of mistakes could so easily be transferred to clients.) All of these have been considerable barriers to the diffusion of BIM systems through the manufacturing sector, in the building industry they were for many years insurmountable. One of the major factors making the diffusion of innovations more difficult in the building industry is that unlike in manufacturing, there is no stable supply chain and few strategic relationships (Brandon, Betts et al. 1998). Coordination across an ever fluctuating series of temporary supply chain constellations in an industry with an unusually large number of players has proved to be a major problem in the adoption and diffusion of new developments. In addition, long supply chains make it difficult for product suppliers to appeal directly to clients. Given such significant barriers to implementation, it seems surprising that BIM was adopted by even the most daring and technically ambitious firms. As we shall see, in fact it required the presence of a driver to provide the motivations to overcome these barriers.

The diffusion of innovations is considerably influenced by the existence of factors known as motivators, enablers or drivers. Several researchers, including Nam & Tatum (1997), Winch (1998), Gann (2000), and Bossink (2004) have modelled these factors. Gambatese and Hallowell (2011b) state that regardless of the process undertaken and the nature of the adopters, the diffusion of construction innovations does not occur in the absence of a motivator. Quoting Blayse and Manley (2004) Gambatese and Hallowell went on to identify the key factors that influence construction innovation on projects, and identified the following as the six major influencing factors: (1) clients; (2) production structure; (3) innovation networks; (4) procurement systems; (5) regulations; and (6) organizational resources by focusing on the interface between innovation development and project implementation. These factors can be seen as corresponding to potential strategies, both intended and emergent, top-down and bottom-up, through which organizations in the construction industry attempt to implement innovations.

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Winch (1998) proposed a model that places these factors in a social system demonstrating how they influence the diffusion of innovation. Drawing in on the work of Miller et al (1995), on innovation in the flight simulation industry, Winch adapted their model for innovation in "complex systems industries" to the construction industry.

The model consists of a three-layer system with System Integrators (principal architects, engineers and contractors), are positioned at an interface between a Superstructure consisting of clients, regulators and professional institutions, and an Infrastructure consisting of specialised trade contractors, specialist consultants, and component suppliers. The Innovation Superstructure governs the innovation environment, specifying demand, regulating performance, and supplying knowledge processes and tools to the System Integrators. The System Integrators assemble complex systems products (flight simulators in (Miller, Hobday et al. 1995)) using components and sub-systems supplied by the Innovation Infrastructure.

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Table 1: Winch's Model of Innovation Structures

One might think that the system integrators would be the agents of change, but not in construction. Where in manufacturing a single System Integrator would be in control of both design and assembly, in construction these roles have been divided. Further, where is in manufacturing serial production is based on a stable design (or variations on it) and a stable supply chain, this is not so in construction.

In innovation in construction process integration it is clear that adoption of innovations in process integration only occurs if the superstructure plays a sufficiently strong role; the presence of a strong client demanding the application of the new technology is the key factor. In the construction value chain, clients can act as a catalyst to foster the diffusion of innovation by exerting pressure on the supply chain partners to improve overall performance and by helping them to devise strategies to cope with unforeseen changes (Gann and Salter 2000).

Further, clients have the ability to demand the adoption of innovation on a project-by-project basis. On the infrastructure level (trade contractors and suppliers) no intended or emerging strategic action can be distinguished. On the other hand system integrators (building firms, architects) reacted to developments by starting pilot projects, exchange of experiences, building knowledge networks and joint developments.

Stated simply, the demand of a major client, often from the public sector, is necessary to drive the diffusion of any innovations which involve a significant departure from existing practice. And it the Netherlands this demanding client has more often than not been the Rijkswaterstaat-bedrijf. However, once the motivator is in place, the system integrators must realize the new technology.

And here we shift our focus from diffusion to adoption. At the level of adoption, other factors play the critical role. But where we might easily accept that on an industry wide level innovations should be taken up as quickly as possible it is important to acknowledge that for individual businesses it will be rational not to adopt an innovation until several preconditions are met. This is particularly true of process innovations intended to significantly change how projects are delivered.

In the building industry, the adoption of any major process innovation will always be in the context of a pilot project. Whether this is for a single firm (where other project members already use the technology in question), or for all members of a project trying out the technology for the first time.

We can use Rogers' 5 conditions for diffusion as a guide to these preconditions:

1) Relative advantage
There must be a clear business case for taking up the new technology. The potential for profitability must be evident, either within an immediately available project or so clear that an temporary loss will be quickly earned back.

2) Compatibility
Assuming that the new technology requires a step change, there must be a clear path to overcoming compatibility problems. (In the case of BIM one form of this was the development of software for importing and exporting different file types.)

3) Complexity
There must be sufficient incentives for other members of the project
team to adopt the technology, and to coordinate their practices with each other.

4) Triability
The costs, including the cost of acquisition of equipment and training personnel must be recoverable from a single project. There must be sufficient information available to plan a pilot project and determine the costs and risks involved.

5) Observability
The benefits of the new technology must be measurable in someway. It must be clear at the end of a trial project that there has or has not been a benefit delivered by the new technology.

For each of these five criteria there will be substantial uncertainty and therefore risk. The calculation of the possible down side risk will need to be made, and this risk must be within limits set by project budget and firm turnover. Few firms will have significant reserves for investment or to cover substantial down side risk. Hence the difficult in calculating down side risks will in itself be a barrier to up take. Hence, one may expect that there will be significant initial resistance by the majority of system integrators to innovations in process integration. Such technologies will be perceived as too costly, too risky, and little perceived benefit to justify the risk and outlay required for a pilot project. And once you have tried and new integrative technology once, and found it to be advantageous, there is no guarantee that your collaborators on the next project will be willing to use it.

This leads to our final point. Given that at first it will be rational for most firms to reject new technologies, managers will develop a form of inertia or bias that resists an eventual change of their earlier decision and the adoption of what previously was an undesirable novelty. Young professionals can play a crucial role here. Not only will the opportunity costs of training young professionals be lower, they will likely have been exposed to new technologies and processes (at least in a theoretical sense) during their education. They are thus likely to be more up to date on some new technologies than their managers. Finally, young professionals, lacking the sober wisdom that comes with experience, have a relatively optimistic outlook, and will often continue to enthusiastically endorse new technologies after their seniors have decided to pass them over. The championing of new technologies by younger professionals may be an irritant to their seniors, but they are likely eventually to provoke a reconsideration of technologies which may have matured in the interval since their previous rejection. The ignorance of youth can be a powerful force in the adoption and diffusion of innovations.

Literature