

INNOVATION PROCESSES IN CONSTRUCTION: TWO CASE STUDIES

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ABSTRACT

The importance of innovation in construction is increasing. However, until now construction research has mainly focused on the implementation of new ideas and disregarded the interdependencies to previous phases of the innovation process. This paper presents the results of two case studies concerning the whole process of generating, developing and implementing new technologies in construction. The cases revealed institutional leadership and managing part-whole relationships as main problems that prevent a faster introduction of innovative technologies into construction. The paper concludes that fostering innovation in construction requires the early integration of application knowledge into the technology development process and the timely creation of a supportive institutional context.

Keywords innovation process, integration, supportive context

1. INTRODUCTION

Innovation is becoming more and more a key competence in the competitive environment of construction. Several studies have already focused on the barriers to and enablers of innovation in construction firms and projects (Tatum, 1987; Slaughter, 2000; Ling, 2003; Bossink, 2004; Blayse and Manley, 2004). However, most of these studies only address the implementation of new ideas and the management of the implementation process. There is a lack of viewing the innovation process in its totality, i.e., from recognition of new opportunities until the successful use of a new solution in practice. The emphasis on the implementation phase disregards the interdependencies between the different stages of innovation processes. The importance of addressing the whole innovation process has long been recognized in the general literature (Leonard-Barton, 1995; Van de Ven, 1986; Von Hippel, 1988). Therefore, we argue that for an increased innovation rate in construction, a process view is necessary that incorporates the generation, development and implementation of new ideas. We will use the four central problems in managing innovation as described by Van de Ven (1986) to analyze two cases of technology development processes in construction and, thereby, to reinforce our argument. In the following, we first outline these four problems. Then, we describe the innovation processes of the two cases and discuss them with regard to the ideas of Van de Ven. Finally, we summarize our main findings.

2. PROBLEMS RELATED TO THE MANAGEMENT OF INNOVATION

Van de Ven (1986) defines the process of innovation as “the development and implementation of new ideas by people who over time engage in transactions with others within an institutional context” (1986:591). Within this process, Van de Ven recognizes four central problems in the management of innovation: *drawing attention to new needs and opportunities*, *managing ideas into good currency*, *managing relationships*, and *institutional leadership*. These four areas of attention will be discussed in the following subsections.

Managing attention

Managing attention concerns the commonness of existing practices. For successful development and implementation of innovative ideas, people should pay attention to changing environmental conditions and customer needs. “Well-managed companies are not only close to their customers, they search out and focus on their most demanding customers” (Van de Ven, 1986:596). In technology development processes, successful implementation depends on the way the innovation deals with problem sources. Creating an understanding of these problem sources involves knowledge of the environment in which the innovation will be used and of the interaction with its environment (Leonard-Barton, 1995). Gathering this information and knowledge is a conscious effort, and managers need to trigger people to pay attention to shifts in the environment and identify “applications for which users have a need but for which they would be incapable of imagining a solution” (1995:198).

In construction, managing attention seems underdeveloped, as incentive structures are missing that favor innovation (Winch, 1998). Firms are accustomed to working according to specifications and are rarely rewarded for taking on risks with innovative ideas. In recent years new procurement forms have been introduced which ask firms to provide services associated with the goods they plan and construct (Ivory et al., 2003; Gann and Salter, 2000). These new forms of delivering construction projects are seen to offer a business environment that encourages innovation. However, we believe that a prerequisite to capitalizing on these opportunities is paying much more attention to the client needs in the early phases of construction processes as well as developing a sense for cross-project trends and demands.

Managing ideas into good currency

‘Managing ideas into good currency’ is to make sure that the ideas are implemented and institutionalized. This area of attention must be considered as a collective achievement in which different groups try to gain influence, power and resources to develop the idea, and consequently, the idea gains the legitimacy and power to change/challenge existing practices (Van de Ven, 1986). Within this collective achievement, internal and external stakeholders and sources are mobilized (Zahra and Nielsen, 2002). Integration of these diverse sources within the development process is necessary for successful implementation and commercialization of technology (Zahra and Nielsen, 2002).

In construction, professional clients and suppliers often play a major role in innovation processes (Pries and Janszen, 1995; Gann and Salter, 2000). This complicates the legitimization of ideas, as clients and suppliers often possess important knowledge and skills that are needed in the process. Furthermore, clients and suppliers will be more receptive to a change in practices if they are involved in the innovation process (Leonard-

Barton, 1995). Therefore, attention should not only be paid to the needs of the client. Considerable client and supplier involvement seem to be important factors in technology development and implementation in construction.

Managing part-whole relationships

In the process of managing an idea into good currency, the involvement of diverse specialists and partners leads to a proliferation into multiple transactions or relationships (Van de Ven, 1986). Managing these part-whole relationships is necessary to enable the integration of the divided tasks and interdependent relations among specialists and partners. Leonard-Barton (1995) offers several strategies for managing specialization in order to integrate diverse knowledge sets. Joint technology development has several benefits in terms of pooling complementary capabilities and accessing new markets and technologies (Powell, Koput and Smith-Doerr, 1996). However, there are several drawbacks to external sources of knowledge and skills. There is a potential loss of proprietary knowledge; partner firms might free ride or use joint activities to acquire skills of others (Siriram and Snaddon, 2004). Knowledge creation and technology development also require considerable learning by doing, which requires time and resources of the partners (Zahra and Nielsen, 2002).

In construction, the drawbacks mentioned seem to be important issues in technology development and implementation, as construction processes appear to be temporary coalitions of changing parties. This can severely impede the development of new ideas requiring large investments and, thus, a longer payback period. Furthermore, firms often only form project-based cooperation with a lack of actors brokering new ideas so “that those that improve the parts and complement the whole go forward and those that favor subsystem optimization at the cost of whole system suboptimization are quashed” (Winch, 1998:275). As a result, the implementation of system changing ideas is hampered.

Institutional leadership

Implementing and institutionalizing innovation is not an individual activity. “Instead, it is a network-building effort that aims for the creation, adoption, and sustained implementation of a set of ideas among people who, through transactions, become sufficiently committed to these ideas to transform them into “good currency.” (Van de Ven, 1986:601) Institutional leadership is concerned with the creation of a context, both intra- and inter-organizational, in which innovation can prosper. This context includes laws, government regulations, distributions of knowledge and resources, and the structure of industry in which the innovation is located.

Nam and Tatum (1997) have identified the client as main institutional leader in fostering the implementation of construction innovation. Ling (2003) has shown the importance of senior management involvement in creating a climate supportive of implementing innovation in construction projects. However, Keegan and Rodney Turner (2002) have pointed out that construction and engineering firms have a low desire for innovations. The traditional methods of project management seem to stifle efforts in developing and implementing construction innovation. In addition, regulatory and procurement policies have a strong influence on the direction of innovation processes in construction (Gann and Salter, 2000). Detailed contractual agreements and undifferentiated usage of regulations constrain a firm’s possibilities of finding new solutions.

The literature review seems to indicate several problems in the management of technology development and implementation in construction. In the following, we describe and discuss two case studies of innovation processes in construction in terms of the four problems identified by Van de Ven.

3. THE DEVELOPMENT OF A THERMAL CONVERSION UNIT TO REMOVE COAL TAR FROM RECYCLED ASPHALT

Case description

In 1992, the use of coal tar in new road constructions was prohibited, because coal tar has a high degree of polycyclic aromatic hydrocarbons. The use of recycled coal tar containing material was still permitted, although this was a temporary situation. In anticipation of a future prohibition of the use of all coal tar containing material, four road construction firms (Alliance) developed a technology in the mid-1990s to remove coal tar from recycled asphalt. The development started as a promising opportunity because there were no competing technologies or competitors and government agencies were committed. However, the technology never delivered. The aim of the case study is to determine the factors leading to this failure. The case study is based on semi-structured interviews and document analysis. Key managers in the technology development project were interviewed, and historical documents (reports, professional papers) were analyzed. The interview protocols evolved from open to semi-structured. The questions relate to the individual's version of how this technology development process evolved. Probing questions were asked to establish why decisions were made and what – in hindsight – could have been done better

The technology is derived from a combustion process used for the processing of minerals, food, and chemicals. Initial tests took place in early 1998 on a small-scale thermal conversion unit (TCU). Based on these test results, Alliance decided to build a full-scale TCU. This full-scale TCU would be built on an existing asphalt production plant, in which the TCU could support the furnace of the asphalt production plant. This had several advantages:

- Efficient use of energy, enabling a substantial reduction in fuel consumption
- Re-use of cleaned material as aggregate in new asphalt
- Combined use of existing facilities, such as filter installation for flue gases, personnel, and equipment

Before the construction of the test facility commenced in 1999, Alliance convinced the Ministry of Spatial Planning, Housing and the Environment (SPHE) and Directorate-General for Public Works and Water Management (DG) of the feasibility of the TCU. The SPHE agreed on a prohibition of the use of coal tar containing asphalt by January 1, 2001. The DG would supply a sufficient amount of coal tar containing asphalt, if the processing costs were acceptable. A small engineering firm, licensee of the combustion process, did the design, engineering and construction of the TCU. A project group of innovation managers of Alliance managed this engineering firm. In addition, a group of asphalt production managers from Alliance assisted the engineering firm in the integration of the TCU and asphalt production plant for the pilot runs, which started in late 2000 and continued to 2004. In this period, there were recurring problems in the transfer of the coal tar containing material through the TCU, because of design flaws.

Furthermore, the discontinuous nature of asphalt production limited the optimal use of the TCU.

Case discussion

The first case describes the development of a technology to deal with an environmental problem, coal tar. The TCU, which is a technology that leaves only clean asphalt minerals, is a technically sound idea. However, a sound technology is not enough to bring it into operational acceptance and general deployment. This case illustrates the importance of institutional leadership. Institutional leadership involves inter- and extra-organizational contexts. Both of these contexts were managed poorly. Alliance did not secure a sufficient amount of support “from its larger community” (Van de Ven, 1986:601). The SPHE did not provide enough safeguards to prevent inexpensive alternatives. For example, the SPHE allowed temporary storage of coal tar containing material without demanding a bank guarantee. This resulted in low rates for the cleansing of coal tar containing material and influenced the feasibility of the TCU. Moreover, since competing technologies emerged during 2001, the SPHE had no need to provide additional guarantees and safeguards to stimulate the development of technologies. Alliance itself also failed in providing a supportive intra-organizational context. They did not develop clear joint goals, strategies and procedures and failed to become a “vehicle of group integrity” (Van de Ven, 1986:601). This is illustrated by increasing internal conflict among the four road contractors and accusations towards the supplier of the TCU about the technical problems. Furthermore, the personnel of the asphalt plant was not convinced of the added value of the TCU, and some of them saw the TCU as an intrusion. Their primary concern was to produce asphalt. Van den Ven recognizes that “top management’s critical contribution consists in strategic recognition rather than planning” (1986:603). In this case senior management failed to provide strategic recognition.

This lack of shared vision and commitment was not a problem in the early development stages when there were no competing technologies and Alliance thought the SPHE was willing to protect their market. In 2001 the development of the TCU became increasingly problematic and competing technologies arose. The absence of a shared vision and commitment started to show. Two of the road contractors pulled back their share in Alliance and were unwilling to invest more resources. The absence of a supportive culture with shared values and rituals seriously limited the ability of Alliance to “transform the structure and practices” of their environment (Van de Ven, 1986:605).

4. THE DEVELOPMENT OF A SPRAYABLE WATERPROOFING MEMBRANE FOR TUNNELING

Case description

The second case concerns an innovation process which aimed to overcome the disadvantages of conventional sealings in tunneling such as leakiness, complicated corrections of imperfections and intricate applications. This could be attained by developing a sprayable, elastic membrane which connects the inner and outer shells of the tunnel and, thereby, creates a bonded system. That is, the membrane changes the constructive relations of the inner and outer shells. Single-shell constructions are possible with significant savings of material. Moreover, since the membrane is sprayable, automatic application of it becomes possible, which may improve the efficiency of the construction process. However, the product entry on the market was two years behind the

schedule. The case study aimed at determining the influences that lead to this delay. The innovation process took place within a Swiss supplier of construction material. Interviews were conducted with the head of the R&D department, the project manager and the marketing manager. The different views of these persons on the course of the project revealed the main problems and factors responsible for the delay. Documents (product specifications and project reports) were analyzed to support the findings from the interviews. With the help of group discussions at the beginning and the end of the research involving the interviewed persons, individual experiences were reconstructed and validated.

The innovation process can be described as a typical R&D process including three phases. Basic research represented the first phase. Through experimental and theoretical work, new knowledge about sealings was gained without any orientation towards a specific application. That is, a first product profile was built up which fulfilled the requirements of tunneling only partly. The second phase covered applied research. Here, tunneling as the field of application was defined. Requirements on the product resulting from this choice could be defined. With the help of laboratory tests, it was examined whether the product met these requirements. The third phase comprised the development of a marketable product. Here, the product was tested under real conditions during ongoing tunnel constructions. These field tests provided further requirements necessary to ensure the applicability of the membrane. However, in the transition from basic to applied research, crucial effects of the product on the tunnel structure and the construction process were neglected, and a very incomplete product profile was generated. This partial product profile in turn caused field and lab tests with a poorly conceived product. As a result, the product composition changed several times, product features already tested had to be verified again, and trade-offs between product features occurred. Consequently, important product requirements could only be recognized during the tests, which led to numerous product modifications and knowledge gaps regarding the verification of product characteristics. Additional and unscheduled development work was the result, accompanied by irritated internal and external customers confronted with a continually changing product. Finally, this need of additional resources could be met only insufficiently, which caused a two-year delay.

Case discussion

The development process described above revealed that the management of part-whole relationships was the main problem causing the significant delay.

The idea of a sprayable waterproofing membrane for tunneling not only changed the existing way of protecting the tunnel against water, but also altered the way of constructing the tunnel. That is, the initial idea led to a complex set of interdependent requirements that had to be fulfilled to develop and implement the innovation successfully. These requirements concerned, on the one hand, the membrane itself and, on the other hand, the whole tunnel construction and the construction process. For example, at the beginning it was thought that the membrane need not be fire resistant, because it is situated between two concrete shells. However, the field tests revealed that due to the application process, the inner tunnel shell is not covered by the membrane for a rather long time. Fire resistance became an important demand, which was followed by an essential product modification. Furthermore, the connection of inner and outer tunnel shells through the membrane modified the static behavior of the construction completely. Normally both shells are regarded as separate systems, whereas the membrane creates a bonded system that shows very different mechanical characteristics.

Concentrating on the membrane alone and neglecting the interdependences to the whole tunneling system led to several extensive loops of modifying and testing. Although running through feedback loops is intrinsic to innovation, these part-whole relations call for an organizing approach that integrates “all essential functions, organizational units, and resources needed to manage an innovation from the beginning to the end” (Van de Ven, 1986:599). The innovation process of the investigated case lacked this consistency of “iterations of inseparable and simultaneously-coupled stages (or functions) linked by a major ongoing transition process” (Van de Ven, 1986:599). Particularly, the involvement of application knowledge only took place after much effort had already been put into building up a product profile. Finally, crucial characteristics were missing and other characteristic were redundant. Besides the late inclusion of application knowledge, the spread of this knowledge over several autonomous parties of the construction process was neglected. Moreover, the fact that for the success of the innovation the membrane had to be implemented first during an ongoing construction project was disregarded. That is, the first usage of the membrane required innovative engineering bureaus, contractors and clients that were willing to take the risks associated with an application without prototyping. Thus, the early detection of these lead users and their involvement in the innovation process at the transition from basic to applied research may reduce unexpected delays and errors in certain development phases that complicate further errors and rework in subsequent phases. It is obvious that not all requirements can be determined in advance. However, an early provision for application knowledge (e.g. through workshops) and supportive measures (e.g. Quality Function Deployment) may stimulate discussion about the essential parts of the innovation while not losing view of the whole technical and social system in which the innovation is embedded. Especially in construction, this may remove conservative behavior preventing a faster diffusion of new ideas.

5. CONCLUSION

This paper presented the results of two case studies concerning innovation processes in construction. Both cases showed that successful construction innovations not only require an appropriate management of their implementation, but also need an adequate management of the generation and development phase. Moreover, through the initial phases of the innovation process, conditions must be provided that allow an effective and efficient implementation. Based on the four central problems of managing innovation provided by Van de Ven, we could find that the creation of institutional leadership and the management of part-whole relationships have a great influence on these conditions. Institutional leadership is necessary to ensure the commitment and culture necessary to implement innovations. The management of part-whole relationships ensures that the effects of an innovative idea on the technical and social system the innovation is part of can be recognized in time and more accurately.

It is obvious that two single cases can only to certain extent shed light on the problems related to innovation processes in construction. More research with a comprehensive view on construction innovation is needed. Especially the early phases of innovation processes should be considered more deliberately.

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