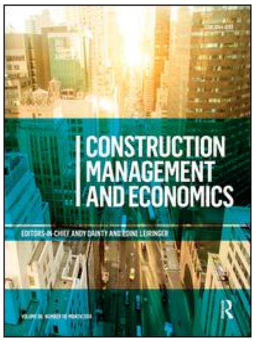

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Engaged scholarship in construction management research: the adoption of information and communications technology in construction projects

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The objective is to explore what engaged scholarship (ES) could mean for construction management research in facilitating interactions between practice and theory. ES aims to develop knowledge that advances both science and practice through engagement of scholars with practice. Three types of ES are discussed: practice research, design research and action research. These three kinds of ES are explained through their different knowledge–action relations: action theories or 'knowledge about action', design research or 'knowledge for action', and action research or 'knowledge through action'. The relevance of these three types of ES in facilitating interactions between practice and theory is clarified through elaborating on a research programme on the adoption of information and communications technology (ICT) in construction projects. First, based on grounded theory, a model is developed to understand and explain why individuals and organizations are (not) using ICT in the intended way. Second, based on this model and expert interviews, solutions are designed to potential barriers to the successful use of ICT in construction projects. Third, interventions in construction projects based on these solutions are presented. It is argued that the different kinds of ES presuppose each other and are all needed to facilitate interactions between practice and theory in construction management research.

Keywords: Action research; information and communications technology

Introduction

In construction management research, theories from different scientific disciplines seek to explain phenomena which are related to the design, production and operation of the built environment. The results of this research are also used to develop knowledge that professionals can use to design solutions for their field problems (Van Aken, 2004; Voordijk, 2009). These different kinds of research have created a continuing debate in construction management research on how to address the important relation between scientific rigour and practical relevance (Seymour and Rooke, 1995; Raftery *et al.*, 1997; Runeson, 1997; Kwong Wing *et al.*, 1998; Voordijk, 2009, 2011). In this field of research, scholars are involved in different ways to improve the relevance of their research for practice without abandoning the scientific rigour by which research is conducted.

As mentioned by Mathiassen and Nielsen (2008, p. 5) the gap between science and practice

> can to some extent be addressed by more effectively translating and communicating scientific knowledge to practicing professionals. There are, however, major differences between scientific and practical knowledge as expressed in Aristotle's distinction between episteme (basic knowledge in the pursuit of theoretical or analytical questions) and techne (applied technical knowledge of instrumental or means-end rationality); in Schön's (1983) distinction between knowing-about-practice and knowing-in-practice; and, in Polanyi's (1967) distinction between explicit and tacit knowledge.

As also mentioned by Mathiassen and Nielsen (2008, p. 5) practical knowledge is 'a distinct form of knowledge that together with scientific knowledge constitutes the foundation of a professional discipline'.

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Based on this understanding, the challenge for scholars in construction management research is not only to improve knowledge transfer from theory towards practice. More importantly, scholars in this field need to develop and exploit forms of knowledge production that facilitate interactions between practice and theory to develop scientific as well as practical knowledge. Engaged scholarship (ES) is an approach that accepts this challenge. Van de Ven (2007, p. 9) defines ES as 'a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems'. The basic assumption is that academic and professional knowledge represent different, but related domains. Moving beyond the simplistic notion that research knowledge is generated in the university and then diffused into practice, Van de Ven adopts an interactional view in which professional and research practices contribute to each other (Mathiassen and Nielsen, 2008).

ES addresses different kinds of research that can also be found in construction management research. However, a clear picture of what ES could mean for this field of research in facilitating interactions between practice and theory to develop scientific as well as practical knowledge does not exist. The overall objective of this study is to explore what can be learnt about these interactions by considering construction management research through the lens of ES. The contribution of this study is to make a conceptualization of different approaches to ES in construction management research based on the division made by Mathiassen and Nielsen (2008) and the different kinds of relations between knowledge and action of Goldkuhl (2008). Three forms of ES are presented first. Secondly, these three kinds of ES are discussed through the concept pair of knowledge and action. Next, the relevance of the different forms of ES in facilitating interactions between practice and theory in construction management research is clarified through elaboration on a research programme on the adoption of information and communications technology (ICT) in construction projects. Discussion and conclusions focus on what ES can mean for construction management research in facilitating interactions between practice and theory to develop scientific as well as practical knowledge.

Different types of engaged scholarship

Van de Ven (2007) focuses on scholars in professional schools, such as business, engineering, medicine, and law. Scholars in the field of construction management fall into that category. A central mission of scholars in professional schools is to conduct research that advances science while at the same time supporting professional practices (Mathiassen and Nielsen, 2008). However, many professionals fail to adopt relevant research findings within their discipline and much of the published research 'is not contributing in intended ways to either science or practice' (Van de Ven, 2007, p. 2). On the one hand there are concerns that academic management research has become less useful for solving practical problems (Beer, 2001). On the other hand, managers are criticized for not being aware of relevant research and not doing enough to put their practice into theory (Weick, 2001).

The aim of ES is to create knowledge that advances both science and practice through engagement of scholars with practice (Van de Ven, 2007, p. 9). ES can be practised in many different ways for addressing a variety of basic and applied research questions (see Figure 1). Researchers might engage stakeholders in a study in order to:

(1) obtain their perspectives and advice on a *basic research* question in order to describe, explain, or predict a social phenomenon;
(2) collaborate and *co-produce knowledge* entailing participation between researchers and stakeholders;
(3) carry out *design and evaluation research* focusing on normative knowledge related to design and evaluation of policies, programmes, and models for solving practical problems; or
(4) undertake *action research* applying interventions to address a problem of a specific client while at the same time contributing to academic knowledge through intervening and implementing a change to solve a client's problem.

The degree of collaboration with stakeholders is an important distinguishing feature of construction management research; however, variation in stakeholder collaboration does not have much added value in distinguishing different forms of 'basic research' in this field of research. Based on Mathiassen and Nielsen (2008), a similar, but simpler way to classify forms of ES within construction management research can therefore be based on underlying knowledge interests:

	Describe/explain	Design/control
External observer	Basic research	Design and evaluation research
Internal participant	Co-produce knowledge	Action/intervention reseach

Figure 1 Alternative forms of engaged scholarship (based on Van de Ven, 2007)

- Practice research: focuses on *understanding* construction management practices with the purpose of informing relevant stakeholders.
- Design research: focuses on *designing* various forms of artefacts with the purpose of supporting stakeholders engaged in construction management practices.
- Action research: focuses on *changing* construction management practices through problem-solving in response to specific client needs.

In the following section, this classification of three different forms of ES is further explained through the concept pair of knowledge and action. In the subsequent section, the relevance of these different forms of ES for facilitating interactions between practice and theory in construction management research is clarified through elaboration on a research programme on the adoption of ICT in construction projects.

Three different relations between knowledge and action

The division into three kinds of ES can also be made through the concept pair of knowledge and action. Goldkuhl (2008) recognizes three different kinds of relations between knowledge and action. One obvious relation is that knowledge is created and used for action. The main idea here is that knowledge should improve action. *Knowledge for action* often requires *knowledge through action*. *Knowledge through action* means that action is a source of knowledge. In order to reach knowledge, actions need to be planned, conducted and studied. This type of research is adopted in action research. Another important way of thinking is that knowledge should be about actions. This has led to the development of many theories on actions, activities and practices. This relation can be described as *knowledge about action*. These three relations between action and knowledge: knowledge about action, knowledge for action, and knowledge through action, can be seen as a basis for division into the three forms of ES.

Knowledge about action: practice research

This kind of ES is concerned with describing the world (in theories, etc.) in action-oriented ways (Goldkuhl, 2008, p. 3). This action-oriented view of reality can be related to *referential pragmatism*: 'to be understood, a society must be seen and grasped in terms of the action that comprises it' (Blumer, 1969, p. 71; see Table 1). Scientific knowledge (theories, etc.) should be explicit about actions and also their context in terms of actors and conditions for and results of actions. An action-oriented view of reality includes also acknowledging local practices and their context. Structuration theory (Giddens, 1984) and activity theory (e.g. Engeström, 2015) have influenced this type of research. There are also methodological approaches, like e.g. the action workflow approach (Kethers and Schoop, 2000) and Dynamic Essential Modelling of Organisation (DEMO) (Dietz, 2001), which build on action theories.

A well-known typology of models of action is described in Habermas' book *The Theory of Communicative Action* (Habermas, 1984, 1987). Habermas (1984) distinguishes four ideal models of social action: teleological action, normatively regulated action, dramaturgical action, and his own communicative action. These models of action have been used as a framework to analyse the actual and intended use of information systems and how these systems interact with the social system (Cecez-Kecmanovic, 2002). According to Ngwenyama and Lee (1997), in real-world communications these ideal models can only be approximated. Ngwenyama and Lyytinen (1997) stress that in complex situations all models of social action are present. They suggest, however, that '[a] specific action type will take the foreground depending on the type of group process involved and its institutional properties' (Ngwenyama and Lyytinen, 1997, p. 7). According to these researchers there needs to be a fit between social action and the technical system to avoid user rejection or failure of well-designed applications.

Knowledge for action: design research

The mission to develop knowledge that professionals can use is in line with works of classic authors in management which provided prescriptive knowledge for certain organizational problems (Voordijk, 2011). Examples are the 'scientific management' movement of Taylor (1911) and the 'administrative theory' of Fayol (1949). Fields like operations research and

Table 1 Different forms of ES, their action-knowledge relations and types of pragmatism

Forms of ES	Relation action–knowledge	Types of knowledge
Practice research	Knowledge about action	Referential
Design research	Knowledge for action	Functional
Action research	Knowledge through action	Methodological

management science (OR/MS) are also prescriptive in intent, while claiming to be sciences. This type of knowledge can be related to *functional pragmatism* (see Table 1). Functional means that knowledge should be useful and applicable in action (Goldkuhl, 2008). The mission of a design science is to develop knowledge that professionals can use to design solutions for their field problems (Hevner *et al.*, 2004; Van Aken, 2004). It is knowledge *for* action. Solution concepts, methods, or systems are the major output of this type of research.

According to March and Smith (1995) design science consists of two basic activities, build and evaluate. *Build* is the process of constructing a solution concept, method or system for a specific purpose; *evaluate* is the process of determining how well such an artefact performs. According to Van Aken (2004, p. 231) 'the design perspective on the use of knowledge intends to transcend this epistemological antithesis between the general and the contextual by saying that a general statement is actionable to the extent that it can be translated to the contextual'. Certain types of knowledge can be relevant for certain contexts and not, or less so, for others. This relevance is not a dichotomy but rather a continuum from very relevant to hardly relevant. In general, solution concepts will be more relevant, or actionable, than conceptual knowledge, but conceptual knowledge can also serve as an important input for the design of a product or process (Griffiths, 2004).

Construction management research is partly concerned with building and evaluating solution concepts, as a design science. In this field of research, solution concepts focus on performance improvement of different aspects of small and large construction projects: i.e. selection procedures (Abu Dabous and Alkass, 2008), partnering (Yeung *et al.*, 2008), design processes (Austin *et al.*, 2000), and bidding management (Dawood, 1995). Another important category includes studies focusing on performance improvement of different aspects of organizations active in the construction industry and their relations (Voordijk, 2011).

Knowledge through action: action research

Knowledge for action often requires knowledge through action. From this perspective we learn about the world through action (Kolb, 1984). *Methodological pragmatism* (see Table 1) is knowledge through action and based on the fact that knowledge is developed in a continual interaction between knowing and acting (Goldkuhl, 2008). Methodological pragmatism goes one step beyond pure observation for capture of empirical data. Knowledge is based on actions, experiences and reflections on actions. Intervention in the world with the particular intent to apply and test different solution concepts is essential in this kind of research. This involves attention to conducted actions and their effects (success and/or failure). Acting in the world is seen as a primary source of knowledge.

Methodological pragmatism builds on the idea of a planned intervention in order to gain knowledge (Dewey, 1938). Experimentation and exploration are pivotal in inquiry processes. Methodological pragmatism is adopted in action research. This type of research is based on the idea that research is made up of action processes (see also Hatchuel, 2001). One key issue in action research is the contribution to a local practice. Different solution concepts are prepared and realized in order to value their effectiveness. Action research involves an exploration of new methods and approaches and evaluation of their possible success or failure in practice. One fundamental insight in action research is that the 'true' nature of a phenomenon merely surfaces during periods of change (Goldkuhl, 2008). It is not sufficient to just observe phenomena; we need to try to change them in order to arrive at deeper knowledge of their character.

There has been a growing interest in action research in construction management research since the late 1990s (Connaughton and Weller, 2013). Construction researchers have continued to use action research in work with a focus on information systems and knowledge management. Rezgui (2007) studied the development and implementation of IT systems to support collaborative working among construction team members. Azhar *et al.* (2010) used the approach to examine improvements in construction data systems. Action research has also been used in areas such as value management (Perera *et al.*, 2011), stakeholder engagement (Gansmo, 2012) and housing experiments (Cramer *et al.*, 2015).

A research programme on the adoption of ICT

In this section, the relevance of the different forms of ES in facilitating interactions between practice and theory in construction management research is clarified through a research programme on the adoption of ICT in construction projects. In this research programme, ICT is defined as a digital coordination and collaboration tool used for communicating and sharing project information between participating organizations in a construction project (Adriaanse *et al.*, 2010b). The focus is on document management applications, workflow management applications, and product modelling applications. Document management applications are used to store, organize, and manage a collection of documents within construction projects in a digital way. Workflow management applications are used to manage the flow of documents and information and to monitor and record the progress of tasks in construction projects. Product modelling applications (e.g., 3D modelling, 4D modelling, building information modelling) are able to support interorganizational cooperation, coordination, and communication as well. These applications can be used to make a graphical model (i.e., representation) of a building object. 4D applications add a further dimension (i.e., time) to 3D applications. Product models can store both graphical and non-graphical data. After discussing the background of the research programme on the adoption of ICT in construction projects, it is illustrated how the three forms of ES were applied.

Background

Although communication is highly important in construction projects, the construction industry is still confronted with great communication difficulties in sharing information among participants. Inadequate communication is seen as an important barrier to innovative, more integrated, construction processes (Adriaanse *et al.*, 2010a, 2010c). The use of ICT can offer many benefits in improving interorganizational communication, cooperation, and coordination in the context of construction projects. However, the use of ICT across organizational boundaries in construction projects is still not as effective and efficient as it could be (e.g., Adriaanse *et al.*, 2010b; Miettinen and Paavola, 2014). It seems that the use of ICT between organizations in construction projects is only beneficial under certain conditions. Insights into these conditions may ensure a more predictable, effective, and efficient use of ICT in the future. One of the most important requisites for the successful introduction of interorganizational ICT is that it is adopted and used by its potential users (Adriaanse *et al.*, 2011). Understanding the mechanisms that influence these aspects is an important step towards improving the value of ICT and, in the end, improving interorganizational cooperation, coordination and communication in future construction projects.

Since the 1970s, much research has been conducted on the adoption and use of ICT. These studies resulted in lists of factors or conditions that influenced these aspects. From the mid-1980s onwards efforts moved to the development and testing of models that could help predict ICT adoption and use (Legris *et al.*, 2003). However, existing models are criticized for their limited explanatory power and for their contradictory results across studies in the major relationships between constructs (e.g., Sun and Zhang, 2006). Studies in which the actual use of ICT is analysed (e.g., Harty, 2005) do not provide a detailed in-depth understanding of the mechanisms influencing the way ICT is used in its social and interorganizational context, and how this use is influenced over time.

Therefore, we conducted a research programme which focused in depth on mechanisms that influence the actual use of interorganizational ICT in construction projects in its social and interorganizational context. This research programme contained the three forms of ES. First, by identifying and analysing these mechanisms, a model is developed to understand and explain why individuals and organizations are not using ICT in the intended way over time. Second, based on the variables of this theoretical model, solutions to potential barriers to the successful use of interorganizational ICT in construction projects are designed. Third, it is shown based on these solutions by which interventions the implementation of interorganizational ICT on construction projects could be improved in practice. The way these three forms of ES were applied in this research programme on interorganizational ICT in construction projects is discussed in the subsequent sections.

Understanding ICT use in construction

To cope with the limitations of former studies conducted on the adoption and use of ICT, we carried out a qualitative study in which the methods of ethnography and grounded theory were followed (Adriaanse *et al.*, 2010a, 2011). Ethnographers are primarily concerned with studying, understanding and providing explanations of human behaviour and action in their social, cultural and organizational contexts (Atkinson, 1990; Harvey and Myers, 1995; Myers, 1999).

Because of the explorative nature of this research, the researchers decided to select complex design-bid-build and design-build construction projects where a document management and workflow management application was used between the client, engineering company, and contractor. These organizations used the application in the construction phase of their construction projects. The complexity of the projects increased the opportunities for looking at not only routine events, but also special, and unexpected events (Schatzman and Strauss, 1973).

Following the methods of grounded theory, we used Strauss and Corbin's (1998) analytic coding procedures in these field studies on the adoption of ICT in construction projects. First, the researchers started with *open coding* by coding the data based on a line-by-line analysis of field notes and categorized this data into concepts. Second, the researchers linked categories and subcategories to form a more precise and complete explanation of the way actors used interorganizational ICT in the construction project (i.e., *axial coding*). The researchers looked for answers to questions such as why, when, where, how, and with what consequences an actor used ICT. Finally, the researchers integrated the major categories and subcategories into a larger theoretical model (i.e., *selective coding*).

According to Strauss and Corbin (1998), the data-gathering should be finished at the point of theoretical saturation. At this point, no new information emerges during coding. After five to six months of research the researchers were convinced that the point of saturation had been reached because it was measured that the quantity of project data processed through the document management and workflow management applications was stable. It was concluded that the actors were using these ICT applications in the construction project at a level that was stable and no new concepts were being derived from the data. After the time spent in the field, the researchers took several months to go through the data again and to write down the storyline for each field study. After each researcher had finished the storyline of his field study, the draft findings were fed back to the key participants in the field. This served two purposes. First, the actors could reflect on the findings. Second, the actors could reflect on the confidentiality of the results.

Based on the field studies and the method of grounded theory, we were able to determine a preliminary framework. This framework consisted of several categories and subcategories that could be positively (driver) and/or negatively (barrier) related to the use of ICT. Connecting this grounded theory to existing theory was an important step in developing a more substantive theory containing factors explaining the actual use of interorganizational ICT in construction projects (Eisenhardt, 1989; Orlikowski, 1993; Strauss and Corbin, 1998). We related our preliminary framework to three influential models about the adoption and use of ICT (Oliveira and Martins, 2011): the unified theory of acceptance and use of technology (UTAUT), the theory of planned behaviour (TPB), and the technology acceptance model (TAM). UTAUT integrates several existing models about the individual acceptance of ICT (Venkatesh *et al.*, 2003). TPB is a general theory of human behaviour (see e.g., Ajzen, 1991) that is often applied to the adoption and use of ICT. TAM is considered to be the most influential and commonly employed theory about user acceptance of ICT (Lee *et al.*, 2003).

The three existing theoretical models share a focus on the intention of individuals to use an ICT application. This intention has a significant influence on the actual use of ICT (Ajzen, 1991). Based on this insight we included the intention to use ICT in our theoretical model as well, because it is able to fill the gap between motivational variables and the actual use of interorganizational ICT. In our model, the personal and external motivation (clustered as the intention to use ICT) influences not only the use of interorganizational ICT, but also the motivation to overcome barriers to the intended use of ICT. Thus, the intention to use ICT influences the use of interorganizational ICT as well as other subcategories in which barriers may be present. If the motivation to overcome barriers to the intended use of ICT is high an actor tries to overcome the barriers he or she is experiencing in the clarity of procedural agreements, the clarity about the operation of ICT, the alignment between ICT and working practices, and/or the availability of technical means.

Based on the results of our field studies and the comparison of our results with other models we were able to formulate the theoretical model shown in Figure 2. This model based on practice research, the first kind of ES, contained mechanisms that influence the actual use of interorganizational ICT in construction. Four major categories of drivers that influence the use of ICT are distinguished: personal motivation (PV), external motivation (EV), knowledge and skills (KS), and acting opportunities (AO) (see Table 2 column (1) Categories of drivers).

Designing solutions to potential barriers

Based on the four categories of drivers as distinguished in the theoretical model, we were able to design solutions to potential barriers to the successful use of interorganizational ICT in construction projects and the purpose of these solutions (Adriaanse *et al.*, 2010b). Interviews were conducted with experts from the United States construction industry. In total 20 experts from 10 companies were involved in this study. The main criteria for selecting these organizations and experts were: (1) their experiences: they needed to be involved in several construction projects in which interorganizational ICT was used, and (2) the type of organization they work for: client, designer (architect, engineer), or contractor. Thus we focused on representatives of the main actors in the construction process. Since our focus was on mechanisms and solutions, we selected frontrunners rather than selecting a random sample of users. These experts could better reflect on possible solutions to potential barriers based on their experiences. The experts interviewed were project leaders, project directors, persons

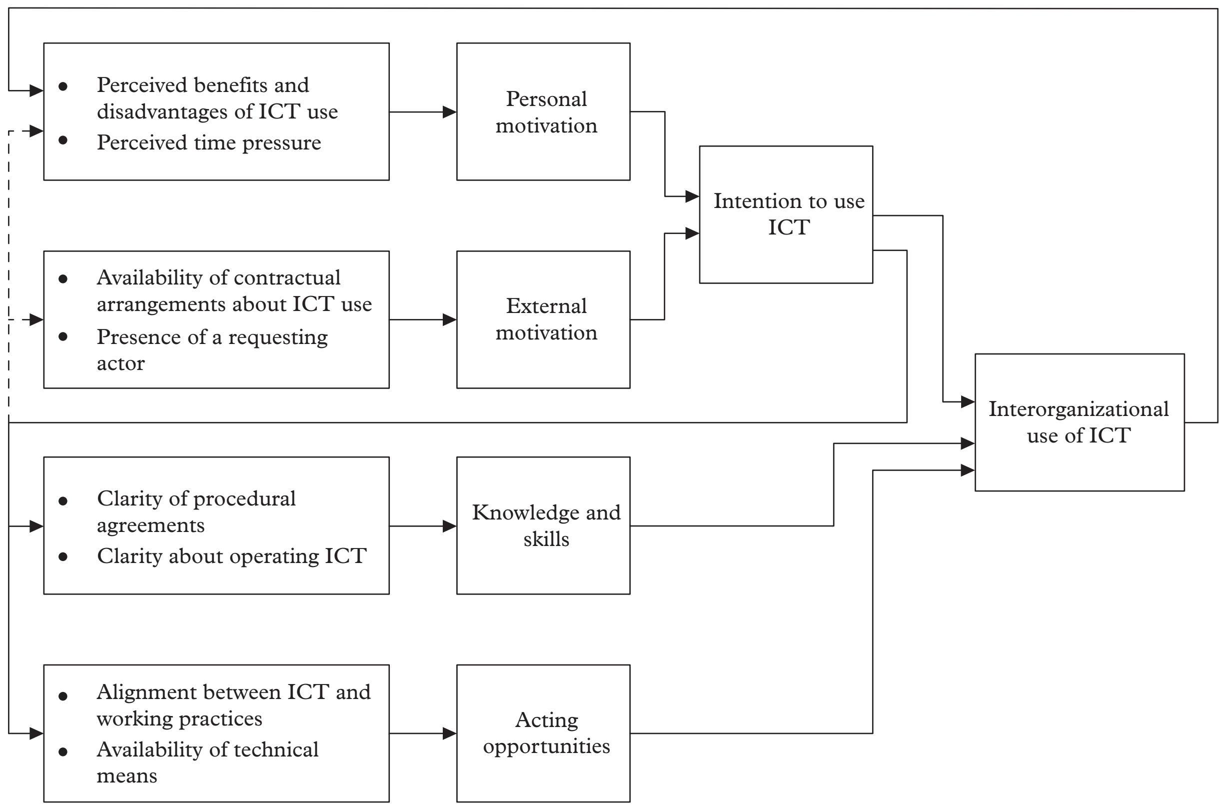

Figure 2 Theoretical model (Adriaanse *et al.*, 2010a)

responsible for the implementation of the ICT applications, and users of ICT. Each interview focused on differences between types of applications, differences in experiences between projects, and solutions to potential barriers. When the experts identified a barrier they were asked to suggest potential solutions to these barriers. In addition, the researcher added additional questions based on understanding that evolved from carrying out the interviews.

Table 2 shows in columns (1) the major categories of drivers these solutions are related to, (2) the solutions designed, and (3) the purpose of these solutions. The solutions are connected in a structured way to mechanisms influencing the use of interorganizational ICT. The solutions focus on stimulating the personal motivation to use ICT, the external motivation to use this technology, and facilitating conditions in terms of knowledge and skills and acting on opportunities to use ICT. In Table 2 the focus is on solutions that could be implemented at a *project level*. These solutions were important entry points for developing directions for solutions at organizational and industry levels. Our research already showed some (obvious) directions for solutions at these levels: (1) develop standard digital working practices at an organizational level, (2) use ICT within long-term relationships between organizations, (3) develop an industry standard for exchanging information, and (4) make legislation fit with digital working practices.

Changing construction practice

On the introduction of ICT in construction projects to support interorganizational communication, cooperation, and coordination an interorganizational IT innovation perspective becomes important (Harty, 2005). The IT innovation perspective considers the introduction and use of ICT in its social and interorganizational context (e.g., Cooper and Zmud, 1990; Swanson and Ramiller, 2004). It is viewed as a process within which various stages may be distinguished: comprehension, adoption, implementation, and assimilation. The stages and the considerations and decisions that need to be made in each of these stages are discussed below from an organization perspective (Adriaanse *et al.*, 2009).

In the *comprehension stage*, individuals or other decision-making units gather and evaluate information and scan (1) organizational challenges and opportunities, and (2) IT solutions and its benefits to find a match

Table 2 Three forms of ES in the research programme

Practice research				Design research			Action research
(1) Categories of drivers				(2) Solutions	(3) Purpose of solutions	(4) Stage	(5) Interventions
PM	EM	KS	AO			(1, 2, 3)	
PM				Educate the actors involved about (1) the ICT application, (2) how this ICT can be used, and (3) the potential benefits, disadvantages and risks (and provide solutions to these).	Reduce distorted perceptions about benefits, disadvantages, risks, and possible solutions.	1, 2, 3	• Steps 2 (analyse the implementability) and 4 (create management support) of the comprehension and adoption stages. • Risks can be limited by a (temporary) fallback option to traditional practices or by limiting the scope of the idea. • Show the benefits of the idea as soon as possible after the application is started.
PM				Be clear to the actors involved about the necessary investment, so organizations can include this in their cost estimates.	Reduce resistance caused by unforeseen investment.	1, 2	• Step 3 of the adoption stage: develop an implementation plan. • In the comprehension stage an initial estimation of necessary investments can be provided.
PM				Decrease the investment of other organizations by paying for the use of ICT (application, training, etc.), or convince the client to do so.	Reduce an important disadvantage, that is, the necessary investment.	1, 2, 3	• There is a budget from the parent organization; implementation costs are not charged on the project. • One business unit may use a software application of another business unit. • The client is willing to pay for the ICT system.
PM		KS	AO	Customize the application and make agreements about the use of the application based on the purposes, needs, and working practices of the actors involved.	Make all participating organizations benefit from the use of ICT.	1, 2, 3	• Take benefits of the use of ICT into account at step 1 (work out the idea) of the comprehension and adoption stages and in the detailed implementation and optimization of the idea in the implementation and assimilation stages.
PM				Use incentives to the use of ICT (e.g., divide savings between participating organizations, link payments to ICT use).	Build in financial drivers to encourage the use of ICT, so actors become more motivated to use ICT.	1, 2	• Suppliers give builders discounts when they work according to a certain ICT system.

(*Continued*)

Table 2 (Continued)

Practice research				Design research			Action research
(1) Categories of drivers				(2) Solutions	(3) Purpose of solutions	(4) Stage	(5) Interventions
PM	EM	KS	AO			(1, 2, 3)	
PM	EM	KS	AO	Customize the ICT application in scope and used functionalities to the specific project based on the mechanisms shown in the theoretical model.	Reduce the risk of malfunctioning of ICT, which eliminates its potential benefits.	1, 2	• Steps 1 (work out the idea) and 2 (analyse the implementability) of the comprehension and adoption stages.
PM				Evaluate the realized benefits of the use of ICT regularly and intervene quickly if the intended benefits are not realized.	Reduce the risks of frustrated users, a lack of confidence in ICT, and user rejection as a result of malfunctioning of ICT.	3	• Step 2 (evaluate the interventions and use of ICT) of the implementation and assimilation stages.
PM		KS		Let actors use their current applications when using interorganizational ICT or implement ICT that works in a similar way to the applications participants already use.	Reduce the novelty of ICT and, therefore, the required time investment to learn to use ICT, and the perceived risks of using ICT.	1, 2	• In step 2 (working out the idea) of the comprehension and adoption stages this is taken into account.
PM		KS	AO	Pre-qualify organizations and persons regarding their ICT capabilities.	Reduce the risk of selecting organizations that are not able to use ICT.	2, 3	• Set up a project team based on the present support and the available ICT knowledge to these persons.
PM		KS		Provide user support to potential users (e.g., training, user manuals, support on site) to let them understand the application, and the way it needs to be used.	Reduce the time investment needed to learn to use ICT, the perceived risks of using ICT, and any frustration as a result of wrong use.	2, 3	• Giving training to new users. • Provide support by external persons (consultants, software vendors, experts from other companies). • Provide user manuals. • Link experienced users to new users.
PM		KS	AO	Select ICT that is easy to use, that prevents users from making mistakes, and that has features built in that reduce risks (e.g., notification features). Propagate this user-friendliness towards potential users.	Reduce the required time investment to learn to use ICT, the perceived risks of using ICT, and any frustration as a result of wrong use.	3	• One party made a 3D model based on 2D drawings from another party, because that other party can't yet model in 3D.
			AO	Test the ICT application (e.g., alignment between ICT and working practices, functionalities, bugs) carefully before ICT is introduced in the project.	Prevent situations in which ICT is not able to support the actions of the actors involved. This reduces the risks of frustrated users, a lack of confidence, and user rejection.	2, 3	• Test risky parts of the new digital method in the adoption stage. Testing not risky parts can also happen in the implementation stage.

EM		Mandate the use of ICT in the contract or convince the client to do so.	Force actors to use ICT.	1, 2, 3	• The client prescribes the use of a certain ICT system.
EM		Convince other actors (e.g., client, management of organization) about the benefits of the use of ICT so they start to request its use.	Force actors to use ICT.	1, 2	• Step 4 of the comprehension and adoption stage.
EM		Do not allow users to bypass ICT.	Prevent situations in which actors do not use ICT.	3	• Encourage players not to use the fallback option to traditional practices. • Set clear priorities from the project management.
	AO	Educate the people and organizations involved on (1) the ICT application, (2) how this ICT can be used and aligned to their working practices, and (3) the importance of aligning their working practices to each other and to ICT.	Reduce distorted perceptions about the need for alignment and the opportunities to align ICT and working practices.	1, 2, 3	• When performing step 1 of the comprehension and adoption stage pay attention to the alignment of practices of actors and ICT. For example, agreements can be made about: scope, structure, detail and accuracy level of modelling activities, to use software applications, exchange formats, methods of operation (who does what when, etc.), version management, revision management and approval procedures. • Detailed coordination takes place in the implementation stage. When those involved are in one room coordination can easily take place.
	AO	Give electronic communication legal status, for example, by making use of electronic signatures or by approving statements of electronic communication formally in meetings.	Give electronic communication legal status.	2, 3	• Digital messages are formally approved in a building meeting.
	AO	Develop a project standard for exchanging information (i.e., all actors use the same application, or use applications that are able to exchange information).	Eliminate interoperability problems.	1, 2	• Various ICT applications can exchange data on a sufficient level in order to obtain the objectives. • The same ICT applications are used so that data can be exchanged well.
	AO	Educate participating organizations about the technical needs.	Reduce distorted perceptions about technical needs.	1, 2	• One party advises the other about the applications, the required capacity of the internet connections on the construction site, etc.

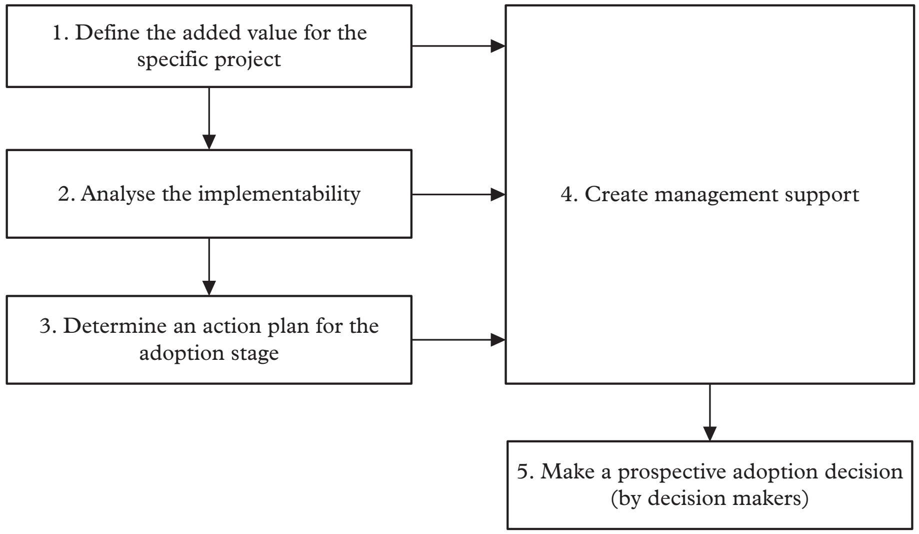

Figure 3 Steps of the comprehension stage (stage 1) (Adriaanse *et al.*, 2009)

between IT solutions and the firm's own circumstances. Through the sensemaking efforts (e.g., demonstrations, site visits, and experimental prototyping) they learn more about the IT innovation and develop an attitude or stance towards it (Swanson and Ramiller, 2004). Based on these efforts they may decide to become a prospective adopter. The steps taken in the project to successfully complete the comprehension stage are shown in Figure 3.

In the *adoption stage* both the business value of the IT innovation and the challenges presented by the prospective change are likely to be weighed before the organization decides whether to proceed and commit resources to the innovation. This stage ends with a decision to adopt, reject or defer the adoption of the IT innovation. The steps taken in the project to successfully complete the adoption stage are shown in Figure 4.

Implementation is the critical gateway between the decision to adopt the IT innovation and the routine use of the innovation within an organization (Klein and Sorra, 1996). In the *implementation stage* the IT innovation is developed and/or tailored to the firm-specific context, installed, and maintained, the organizational procedures are revised and developed, organizational members are trained both in the new procedures and in the IT application (i.e., adaptation). At the end of this stage the IT innovation is implemented and users are committed to its use.

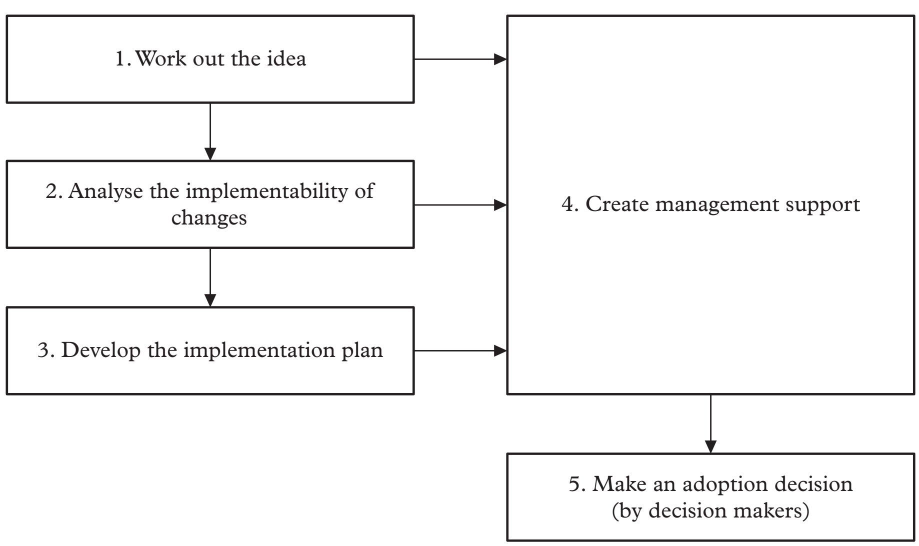

Figure 4 Steps of the adoption stage (stage 2) (Adriaanse *et al.*, 2009)

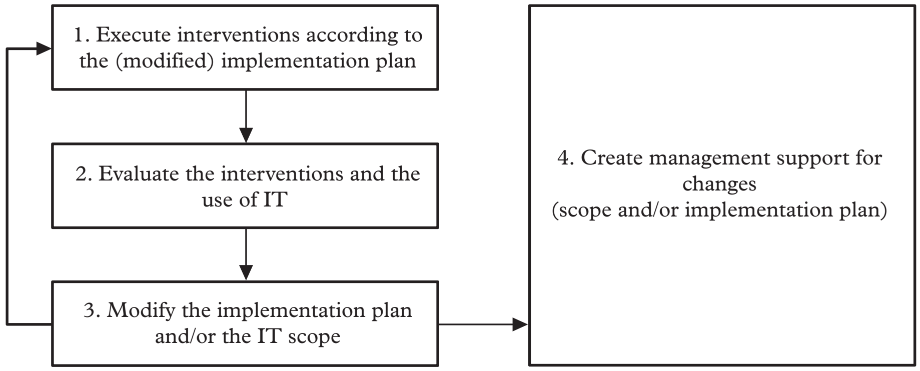

Figure 5 Steps of the implementation and assimilation stages (stages 3 and 4) (Adriaanse *et al.*, 2009)

In the *assimilation stage*, the IT innovation diffuses across the organization and becomes routinized in the activities of the organization (Purvis *et al.*, 2001). It becomes absorbed into the work life of the firm and demonstrates its usefulness. The steps taken in the implementation and assimilation stages are shown in Figure 5.

In the field studies we drew on the principles of action research and intervened in and analysed in depth the introduction of ICT across organizational boundaries in a number of construction projects. During each field study, first a researcher actively spent most of the time observing participants during the daily routine and in meetings and informally talking to them (Adriaanse *et al.*, 2009). The researcher had complete access to all internal project meetings within the engineering company and the contractor. Second, the researcher conducted many informal and semi-structured interviews to capture participants' perceptions and understanding. The researcher tried to see the world from the participants' point of view. The researcher studied the effects of the introduction of ICT applications too by examining documents such as contract documents, minutes of meetings, and procedures from the quality management system. The researcher followed a project for seven months.

The stages and steps provided guidance to people responsible for implementing ICT in construction projects on the question 'whether, when, and how to innovate with information technology' (Swanson and Ramiller, 2004). These interventions focused on a particular stage and were based on the solutions designed in our research programme on ICT adoption in construction projects (see Table 2 columns (4) Stage and (5) Interventions). It was concluded that when introducing ICT in construction projects it is important to show and to take into account benefits of the use of ICT in all stages discussed. Analysing the implementability of a new ICT application and creating management support are also necessary actions to be taken. It is important too to align the practices of actors involved and the new ICT application. Risks can be limited by a (temporary) fallback option to traditional practices or by limiting the scope of the idea. During all stages detailed coordination between major actors involved is a necessary precondition for success.

Discussion

The overall objective of this study is to explore what ES could mean for construction management research in facilitating interactions between practice and theory to develop scientific as well as practical knowledge. ES aims to create knowledge that advances both science and practice through engagement of scholars with practice. Three types of ES have been discussed: practice research, design research and action research. The relevance of these three types of ES in facilitating interactions between practice and theory is first clarified by focusing on the interaction between theory and practice in the research programme on the adoption of ICT in construction projects. Second, this interaction is discussed from the ES perspective.

Interaction in the research programme

The objective of the research programme studied was to develop guidelines for the successful introduction of ICT across organizations in a construction project. In this programme, the focus was first on the key mechanisms that influence the way actors use interorganizational ICT. The results of our study were compared with other theoretical models. Based on this comparison a theoretical model was presented that was able to explain and predict the use of interorganizational ICT. The model showed that the use of interorganizational ICT is embedded in a web of (social) actions. The way one actor acts influences the way another actor acts and the benefits this actor can attain from the use of ICT. In addition, ICT is only one of the means that actors can use to communicate. To gain a better understanding of the way actors act in their social and interorganizational context and how their acts are affected by social relationships, the theoretical model needs to be confronted with social theories. This suggestion for future scientific research, relating the theoretical model developed to other social theories, is an important step in developing a more substantive theory (Eisenhardt, 1989; Orlikowski, 1993; Strauss and Corbin, 1998).

The theoretical model developed did have relevance for practice as well. Based on the major variables of this model, solutions to potential barriers to the successful use of ICT in the context of construction projects were designed. The model gives managers insight into the barriers and drivers of the use of ICT. It helps project managers or people responsible for implementing interorganizational ICT to identify the technical and non-technical risks of introducing and using ICT in construction projects. Based on this risk analysis, they can formulate and implement measures to overcome these risks or choose to limit the scope of the application (e.g., limit the scope to some organizations or to some communication processes). Based on the mechanisms shown in the theoretical model, strategies and protocols can be developed and tested, which facilitate the successful implementation of interorganizational ICT. In addition, the framework could be used as an analytic tool to evaluate the status quo of an underutilized application in a construction project and to formulate and implement improvements.

Interaction from the ES perspective

In this research programme, the three kinds of ES could be distinguished. First, to develop understanding of mechanisms that influence the way actors use interorganizational ICT researchers had to understand practice. Secondly, to build new knowledge that could support practice by solving potential barriers to the successful use of ICT researchers had to design solutions and guidelines. Third, to learn what it takes to actually communicate through the use of ICT researchers had to engage in different forms of intervention helping project managers to implement ICT.

From our research programme we learnt that the different forms of ES also presuppose each other and are all needed to facilitate interactions between practice and theory in construction management research. Understanding practice is needed to design useful solutions. The interventions in practice also increased our understanding of mechanisms influencing the introduction and use of ICT in construction projects: to reach a deeper understanding of practice it is necessary to change it. The solutions to potential barriers to the successful use of ICT were applied in the context of construction projects through a number of decisions that needed to be made. Interpretations of practice (ES 1) and solutions (ES 2) were ultimately tested through attempts to improve practice (ES 3).

From our study it follows that there may be no clear distinction among the different types of ES. It seems to be more a question of how far the researcher is engaged in the different phases. From a positivist perspective, researchers provide neutral interpretations of some field of human activity and try to discover cause–effect relationships (Cecez-Kecmanovic, 2005, p. 21). Design and intervention research require, however, intensive engagement of the researcher. This intensive engagement of researchers means that researchers adopt more an action perspective and include subjective and intersubjective meanings of human beings (Orlikowski and Robey, 1991). Researchers try to explain and understand in depth the way actors act in their social context (Ngwenyama and Lee, 1997). Design and action research as part of the ES perspective can in this way be interpreted as an addition to the positivist perspective on research. The different kinds of ES can also be related to elements in organizational learning: learning requires appreciation of the situation, inventing new options, and changing the situation. We find these elements in different forms and relations within theories of the field of learning (e.g. Argyris and Schön, 1978).

Conclusions

It was investigated what ES could mean for construction management research in facilitating interactions between practice and theory to develop scientific as well as practical knowledge. The formulation of the three kinds of ES has been made through reflections on construction management research based on the concept pair of knowledge and action. The relevance of each kind of ES for the field of construction management was discussed and illustrated through elaborating on a research programme on the adoption of ICT in construction projects applying the different forms of engaged scholarship. It was shown that the different kinds of ES presuppose each other: to reach a deeper understanding of practice it is necessary to change it; understanding practice is needed to design useful propositions; and the propositions and interpretations of practice are ultimately tested through attempts to improve practice. Therefore this study could be interpreted as a call for fully engaged scholarship: to facilitate interactions between practice and theory in construction management research all three kinds of ES in construction management research have to be applied and combined.

First of all, researchers in the field of construction management research have to describe, explain and theorize on actions in local practices (referential pragmatism). Collecting primary data already means that a researcher is engaged. However, research in the field of construction management endeavours to produce not only general knowledge, but also knowledge of how to improve construction practice, and how to get better building objects and processes in particular. In other words, construction management is also a design science. General knowledge becomes relevant when it can be translated into, and tested in, this specific context. In this vision knowledge has also a prescriptive character. Prescriptive knowledge is often formulated with a clear reference to proposed types of actions improving local and general practice (functional pragmatism).

Construction management also requires active participation in testing and exploring new ways of working (methodological pragmatism). Construction management research is like medical science: both fields of research deal with improvement problems, i.e. with designing treatments to improve the well-being of patients or to improve building processes and objects. Such treatments are interventions in a given 'system': the interventions are designed and applied to change existing operational processes of this system in order to realize improvements. In future construction management research it will be interesting to observe how both researchers and practitioners act in the different forms of ES and how it will facilitate and improve interactions between practice and theory in future.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abu Dabous, S. and Alkass, S. (2008) Decision support method for multi-criteria selection of bridge rehabilitation strategy. *Construction Management and Economics*, **26**(8), 881–91.

Adriaanse, A., Voordijk, H., and Dewulf, G. (2009) The introduction of building information modelling in construction projects: An IT innovation perspective, *Proceedings of the 9th International Conference on Construction Applications of Virtual Reality,* Sydney, 5-6 November.

Adriaanse, A., Voordijk, H. and Dewulf, G. (2010a) The adoption and use of interorganisational ICT in a Dutch construction project. *Journal of Construction and Engineering Management*, **136**(9), 1003–14.

Adriaanse, A., Voordijk, H. and Dewulf, G. (2010b) The use of interorganizational ICT in United States construction projects. *Automation in Construction*, **19**(1), 73–83.

Adriaanse, A., Voordijk, H. and Dewulf, G. (2010c) The use of interorganizational ICT in construction: A critical perspective. *Construction Innovation*, **10**(2), 223–37.

Adriaanse, A., Voordijk, H. and Dewulf, G. (2011) Interorganizational ICT in projects: A critical interpretation. *International Journal of Information Systems and Change Management*, **5**(1), 36–53.

Ajzen, I. (1991) The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, **50**(2), 179–211.

Argyris, C. and Schön, D.A. (1978) *Organizational Learning*, Reading, PA: Addison-Wesley.

Atkinson, P. (1990) *The Ethnographic Imagination: Textual Construction of Reality*, London: Routledge.

Austin, S., Baldwin, A., Li, B. and Waskett, P. (2000) Analytical design planning technique (ADePT): A dependency structure matrix tool to schedule the building design process. *Construction Management and Economics*, **18**(2), 173–82.

Azhar, S., Ahmad, I. and Sein, M. (2010) Action research as a proactive research method for construction engineering and management. *Journal of Construction Engineering and Management*, **136**(1), 87–98.

Beer, M. (2001) Why Management research findings are unimplementable: An action science perspective. *Reflections*, **2**(3), 58–65.

Blumer, H. (1969) *Symbolic Interactionism: Perspective and Method*, Berkeley: University of California Press.

Cecez-Kecmanovic, D. (2002) The rationality framework for a critical study of information systems. *Journal of Information Technology*, **17**(4), 215–27.

Cecez-Kecmanovic, D. (2005) Basic assumptions of the critical research perspectives in information systems, in Howcroft, D. and Trauth, E.M. (eds.) *Handbook of Critical Information Systems Research*, Cheltenham, UK: Edward Elgar, 19–46.

Connaughton, J. and Weller, S. (2013) Improving collaboration in construction: an opportunity for action research. In: Smith, S.D., and Ahiaga-Dagbui, D.D. (Eds) *Proceedings 29th Annual ARCOM Conference*, Reading, 2-4 September 2013, Association of Researchers in Construction Management, 1125–34.

Cooper, R.B. and Zmud, R.W. (1990) Information technology implementation research: A technological diffusion approach. *Management Science*, **36**(2), 123–39.

Cramer, H., Dewulf, G. and Voordijk, H. (2015) Lessons learnt from applying action research to support strategy formation processes in long-term care networks. *Action Learning: Research and Practice*, **12**(2), 166–94.

Dawood, N.N. (1995) An integrated bidding management expert system for the make-to-order precast industry. *Construction Management and Economics*, **13**(2), 115–25.

Dewey, J. (1938) *Logic: The Theory of Inquiry*, New York: Henry Holt.

Dietz, J.L.G. (2001) DEMO: Towards a discipline of organisation engineering. *European Journal of Operational Research*, **128**(2), 351–63.

Eisenhardt, K.M. (1989) Building theories from case study research. *The Academy of Management Review*, **14**(4), 532–50.

Engeström, Y. (2015) *Learning by Expanding: An Activity-Theoretical Approach to Developmental Research*, 2nd edn, New York: Cambridge University Press.

Fayol, H. (1949) *General and Industrial Management*, London: Pitman.

Gansmo, H.J. (2012) Municipal planning of a sustainable neighbourhood: Action research and stakeholder dialogue. *Building Research and Information*, **40**(4), 493–503.

Giddens, A. (1984) *The Constitution of Society: Outline of the Theory of Structuration*, Cambridge: Polity Press.

Goldkuhl, G. (2008) *What kind of pragmatism in information systems research*. AIS SIG Prag Inaugural meeting, 3-8, Paris, 14 December 2008.

Griffiths, R. (2004) Knowledge production and the research-teaching nexus: The case of the built environment disciplines. *Studies in Higher Education*, **29**(6), 710–26.

Habermas, J. (1984) *The Theory of Communicative Action*, Vol. One, Boston, MA: Beacon Press.

Habermas, J. (1987) *The Theory of Communicative Action*, Vol. Two, Boston, MA: Beacon Press.

Harty, C. (2005) Innovation in construction: A sociology of technology approach. *Building Research & Information*, **33** (6), 512–22.

Harvey, L. and Myers, M.D. (1995) Scholarship and practice: The contribution of ethnographic research methods to bridging the gap. *Information Technology & People*, **8** (3), 13–27.

Hatchuel, A. (2001) The two pillars of new management research. *British Journal of Management*, **12**(special issue), 33–9.

Hevner, A.R., March, S.T. and Park, J. (2004) Design science in information systems research. *MIS Quarterly*, **28**(1), 75–105.

Kethers, S., and Schoop, M. (2000) Reassessment of the action workflow approach: Empirical results. *Proceedings of the Fifth International Workshop on the Language-Action Perspective on Communication Modelling (LAP 2000),* Aachen, Germany, 14-16 September 2000.

Klein, K.J. and Sorra, J.S. (1996) The challenge of innovation implementation. *Academy of management review*, **21**(4), 1055–80.

Kolb, D.A. (1984) *Experiential Learning. Experience as the Source of Learning and Development*, Englewood Cliffs, NJ: Prentice Hall.

Kwong Wing, C., Raftery, J. and Walker, A. (1998) The baby and the bathwater: Research methods in construction management. *Construction Management Economics*, **16**(1), 99–104.

Lee, Y., Kozar, K.A. and Larsen, K.R.T. (2003) The technology acceptance model: Past, present, and future. *Communications of the Association for Information Systems*, **12**, 752–80.

Legris, P., Ingham, J. and Collerette, P. (2003) Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, **40**(3), 191–204.

March, S.T. and Smith, G.F. (1995) Design and natural science research on information technology. *Decision Support Systems*, **15**(4), 251–66.

Mathiassen, L. and Nielsen, P.A. (2008) Engaged scholarship in IS research: The scandinavian case. *Scandinavian Journal of Information Systems*, **20**(2), 3–20.

Miettinen, R. and Paavola, S. (2014) Beyond the BIM utopia: Approaches to the development and implementation of building information modeling. *Automation in Construction*, **43**, 84–91.

Myers, M. (1999) Investigating information systems with ethnographic research. *Communications of the AIS*, **2**(4), 1–20.

Ngwenyama, and Lee, A.S. (1997) Communication richness in electronic mail: Critical social theory and the contextuality of meaning. *MIS Quarterly*, **21**(2), 145–67.

Ngwenyama, O.K. and Lyytinen, K.J. (1997) Groupware environments as action constitutive resources: A social action framework for analyzing groupware technologies. *Computer Supported Cooperative Work*, **6**(1), 71–93.

Oliveira, T. and Martins, M.F. (2011) Literature review of information technology adoption models at firm level. *Electronic Journal of Information Systems Evaluation*, **14**(1), 110–21.

Orlikowski, W.J. (1993) CASE tools as organizational change: Investigating incremental and radical changes in systems development. *MIS Quarterly*, **17**(3), 309–40.

Orlikowski, W.J. and Robey, D. (1991) Information technology and the structuring of organizations. *Information Systems Research*, **2**(2), 143–69.

Perera, S., Davis, S. and Marosszeky, M. (2011) Head contractor role in construction value-based management: Australian building industry experience. *Journal of Financial Management of Property and Construction*, **16**(1), 31–41.

Polanyi, M. (1967) *The Tacit Dimension*, New York: Doubleday.

Purvis, R.L., Sambamurthy, V. and Zmud, R.W. (2001) The assimilation of knowledge platforms in organizations: An empirical investigation. *Organization Science*, **12**(2), 117–35.

Raftery, J., McGeorge, D. and Walters, M. (1997) Breaking up methodological monopolies: A multi-paradigm approach to construction management research. *Construction Management Economics*, **15**(3), 291–7.

Rezgui, Y. (2007) Knowledge systems and value creation: An action research investigation. *Industrial Management & Data Systems*, **107**(2), 166–82.

Runeson, G. (1997) The role of theory in construction management research: Comment. *Construction Management Economics*, **15**(3), 299–302.

Schatzman, L. and Strauss, A.L. (1973) *Field Research: Strategies for a Natural Sociology*, Englewood Cliffs, NJ: Prentice-Hall.

Schön, D.A. (1983) *The Reflective Practitioner: How Professionals Think in Action*, New York: Basic Books.

Seymour, D. and Rooke, J. (1995) The culture of the industry and the culture of research. *Construction Management Economics*, **13**(6), 511–23.

Strauss, A.L. and Corbin, J.M. (1998) *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, Thousand Oaks: Sage.

Sun, H. and Zhang, P. (2006) The role of moderating factors in user technology acceptance. *International Journal of Human-Computer Studies*, **64**(2), 53–78.

Swanson, E.B. and Ramiller, N.C. (2004) Innovating mindfully with information technology. *MIS Quarterly*, **28**(4), 553–83.

Taylor, F.W. (1911) *The Principles of Scientific Management*, New York: Harper.

Van Aken, J.E. (2004) management research based on the paradigm of the design sciences: The quest for field-tested and grounded technological rules. *Journal of Management Studies*, **41**(2), 219–46.

Van de Ven, A.H. (2007) *Engaged Scholarship: A Guide for Organizational and Social Research*, Oxford: Oxford University Press.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003) User acceptance of information technology: Toward a unified view. *MIS Quarterly*, **27**(3), 425–78.

Voordijk, J.T. (2009) Construction engineering and management: The epistemology of a multidisciplinary design science. *Construction Management and Economics*, **27**(8), 713–20.

Voordijk, H. (2011) Construction management research at the interface of design and explanatory science. *Engineering Construction and Architectural Management*, **18**(4), 334–42.

Weick, K. (2001) Gapping the relevance bridge. *Fashions meet fundamental in management research. British Journal of Management*, **12** (Special Issue), S71–5.

Yeung, J., Chan, A. and Chan, D. (2008) Establishing quantitative indicators for measuring the partnering performance of construction projects in Hong Kong. *Construction Management and Economics*, **26**(3), 277–301.