A Qualitative Method for Assessing the Impact of ICT on the Architectural Design Process

Abstract

During the last thirty years or so, we have witnessed tremendous developments in information and communication technology (ICT). Computer processing power doubles each 18 months, as Gordon Moore predicted during the mid-1960s. The computer and communications world has been revolutionised by the invention of the Internet. It has changed the way of exchanging, viewing, sharing, manipulating and storing the information. Other technologies such as smartphones, wearable computers, tablets, wireless communications and satellite communications have made the adoption of ICT easier and beneficial to all its users. ICT affects the productivity, performance and the competitive advantage of a business. It also impacts on the shape of the business process and its product. In architectural design, ICT is widely used throughout the design process and its final product. The aim of this research, therefore, is to explore the key implication of using ICT in architectural design and what new changes and forms have occurred on buildings as a result of ICT developments and use by architecture practitioners. To achieve this aim, a qualitative research approach was adopted using a narrative review of ICT usage in the design of buildings. The literature found was subjected to a thematic analysis of how ICT adoption affected the architectural design process. The findings of this research indicate that there is a continuous change in the design process and its final products (buildings) as the technology evolves. The framework proposed provides a foundation for gathering evidence from case studies of the impact of ICT adoption by architectural designers. The research proposes that future empirical work has to be conducted to test and refine the relevance, importance and applicability of each of the components of the framework, in order to detect the impact of ICT on the building design process and its final product.

Keywords: architectural, design, ICT; impact, adoption, buildings

Introduction

During the last two decades or so, there have been significant improvements in ICT. These developments took two main directions (Zorkoczy & Heap, 1995): the first one, in the development of products (devices, systems) and concepts (ideas, procedures) which have a wide relevance to information; the second, in the development of the application of these products and concepts to specific areas of activities. Computers have revolutionised the way documents are generated and stored. Similarly, ICT is bound to revolutionise the way the information and documents are exchanged. Today, ICT is an essential ingredient in research, technology, education and other societal endeavours. It includes the automated capturing of data and processing of information; large-scale networking; high-end computing; high-end computation and infrastructure; high-confidence software and systems; human-computer interaction and information management; as well as theoretical studies of the nature of information and the limits of computation. Advances in supercomputers, simulations and networks are creating a new window into the natural world, making high-end computational experimentation an essential tool for pathbreaking scientific discoveries. ICT is becoming a powerful force in the world. In this millennium, a radically different world will be seen, where information, and access to it, will be one of the most important economic and social indicators (Johnston, 1999). Due to its enormous and profound socioeconomic benefits, ICT has, seemingly in a few short years, become critical to a nation's well-being and prosperity. ICT is also changing the way people live, work, learn and communicate with each other.

Competitive pressures force ICT adoption by many businesses and industries. As a result, industries have experienced significant productivity improvements as ICT has provided them with great advantages in speed of operation, consistency of data generation, accessibility and exchange of information. Construction is a traditional industry and conservative to adopt new technology unless the contribution of this technology is obvious (Li & Wang 2003), forced by clients or by regulations. The Architectural Engineering and Construction industry (AEC) has embraced ICT in order to benefit from these developments to gain or maintain a competitive advantage. Introduction of ICT in all aspects of the design and construction of facilities has been going for a few decades now.

The evaluation of the impact of ICT is a research area that has received limited attention in the construction literature in general and in the architectural literature in particular. Most of the research on the impact of ICT has focused on the evaluation of ICT from a cost-benefit perspective using several methods and techniques proposed specifically to evaluate the return of the investment on ICT. Thus, the ultimate objective of this research project is to assess the impact of ICT on architectural design process and place making.

The paper starts by describing the research methodology adopted to achieve the main aim of the research. Then a discussion of the previous works on evaluation of ICT and methods used for these evaluations. The last section of the paper discusses in detail the impact of ICT on architectural design practice and buildings.

Method

The majority of the available methods and techniques used to assess the impact of ICT were concerned with measuring financial return and benefits gained from investing in ICT. Thus, a new conceptual framework was developed and used to assess the impact of ICT on the whole field of architectural design practices, including its impact on an architectural design organisation's structure, design process, architectural design practice and design of buildings. The conceptual framework was developed at first based on literature review of similar works. The main purpose of the proposed framework was to help in the assessment of the implications of ICT adoption by building designers and it did not seek to evaluate the tangible and intangible benefits from ICT investments.

As the research was motivated by an interest in the complex nature of the relationship between the architectural design process and ICT, this work originally began as an attempt to answer these questions: how has ICT influenced the designers of buildings in developing their design? And how this influence affects the final product? In order to find an answer to these formulated questions, it was decided to embrace a narrative approach (Mays, 2005) which consists of summarising, thematically analysing and synthesising evidence from the literature. The main aim of this was to capture all of the main messages within ICT adoption in the construction industry, thereby identifying the areas which seem crucial to the architectural design process and buildings designed to integrate ICT as one of their components.

Search Strategy

The research team developed their search strategy by assessing 87 peer-reviewed articles published in reputable academic journals (e.g. Automation in Construction; ITCon) or at prestigious conferences (ARCOM; CIB) which focused on the process, practice and behaviours in the design of buildings. Most of these articles were found through a process of snowballing (i.e. references of references). They included literature reviews, opinion pieces, empirical studies and 'grey literature' such as evaluation reports. The articles described different applications of ICT in the design process, proposing new ways of doing certain tasks, proposing new design process protocols. It was difficult to assess the impact of ICT on the architectural design process without using an adequate tool. Most of the tools developed were for evaluating the investments on ICT by firms in terms of cost/benefit (Love et al., 2005; Dehlin & Olofsson, 2008; Irani, 2010); therefore, a new framework was proposed to evaluate the impact of ICT in other terms than cost/benefit analysis.

Conceptual Framework for Assessing ICT Impact

Any business consists of management; capital; stakeholders; process; and product (see Figure 1). Management is the backbone of any business that connects the other components. This can be applied to architectural design practice. The introduction of ICT by architecture practitioners aimed at improving their business efficiency and gaining a competitive edge. The use of ICT tools can be in management of the business, the process of creating a product and in the product itself.

Figure 1: Business Components

(Insert Figure 1 here)

Several frameworks have been developed to measure tangible and non-tangible benefits of ICT in the construction industry (Jonson & Clytion, 1998; Li & Wang, 2003; Stewart & Mohamed, 2001). The main difficulty in assessing the implications of embracing ICT in construction projects was the identification and measurement of benefits, and particularly intangible and other non-financial benefits; thus, these implications were often neglected and not measured (Palvalin et al., 2013). These frameworks, therefore, have serious limitations in that they could not investigate the implications of ICT on a specific task or product. They were designed only to measure the return of investment on ICT in terms of costs, benefits and risks. The proposed conceptual framework was designed to investigate the impacts of ICT tools on the architectural design process and buildings.

Farbey et al. (1993) developed an IT evaluation framework known as the three rings of evaluation "onion". The framework was designed to evaluate the investments of ICT. It expands the traditional narrow approaches of identification and quantification of benefits of an IT investment.

The proposed conceptual framework is based on the above concept and overall systematic approach to assess the implications of ICT on architectural design. The outermost layer of the proposed conceptual framework is Context, which is defined as the overall business environment in which the ICT is implemented. This process, represented in Figure 2, has some key features such as identifying ICT tools that is used in the architectural design. These tools vary according to the project type, size and budget. For small project such as houses, there is no need to utilise advanced ICT tools such as simulation for lighting or fire evacuation, whereas these tools may be required for high-rise commercial or service buildings.

Figure 2: The proposed conceptual framework.

(Insert Figure 2 here)

The second step of the assessment process is to identify the task in which a specific ICT tool is utilised. It will examine the purpose of the application of that tool. The investigation should identify what kind each task or activity is (primary design task, secondary design task, complementary design task or new design task). These tasks may vary from one project to another depending on the size of the project, budget available and its intended use. Simulation of evacuation in event of fire in a building, for example, is a task which may not be required for one building but it is essential for another. Some uses of ICT tools were only to replace many manual design tasks such as calculations or to replace conventional communication tools such as fax or telephone calls. So at this stage of the proposed framework, every task should be identified and categorised.

The aim of the third stage of the conceptual framework is to envisage how a specific design task or activity is conducted after applying an appropriately selected ICT tool. Each task will be, at this stage, studied carefully to identify how it was carried before the introduction of ICT.

The fourth stage involves an evaluation of the impacts resulting from changes to specific design related activity. Then these impacts can be classified into two main different groups (impacts on process and impacts on product).

Related Research Works

The evaluation of ICT is defined by, for example, Farbey et al. as ‘‘a process, or parallel processes, which take place at different points in time or continuously, for searching for and making explicit, quantitatively or qualitatively, all the impacts of an IT project and programme and strategy of which it is a part” (1999, p. 190). There have been a myriad of academic and technical literature discussing costs and benefits of ICT in the construction industry (Andresen, 2001; Marsh & Flanagan, 2000; Naaranoja, 1999; Moreau & Back, 2000). Other studies looked at the impacts of ICT on specific tasks such as facility management (Fisher & Kunz, 2003), whereas several looked at the impact of specific tool such as VR on the design process (Dorta & Lalande, 1998). However, most of the research considered evaluation as an external judgement in isolation from its human and organisational components and effects (Serafeimidis & Smothson, 2000).

The issues of development of an ICT evaluation method have generated interest among researchers and practitioners. Previous research works on ICT evaluation in the construction industry were mainly concerned with the measuring the performance of ICT systems (Li, 1996; Chen & Zhu, 2004);, cost and benefit assessment (Anderson, 2001; Marsh & Flanagan, 2000; Naaranoja, 1999); justification of techniques for evaluating the potential benefits of ICT (Andresen et al., 2000; Love et al., 2001; Stewart & Sherif, 2001; Li & Wang, 2003). These studies focused on the direct benefits in return of an investment by an organisation and did not investigate what the impacts (either positive or negative) of these investments might be on the construction industry in general and the architectural design process in particular. Their key message is that the future ICT evaluation is difficult to predict but there is a trend indicating that evaluating the cost of technology will be less important (as costs of hardware and software are decreasing), whereas the assessment of implications of ICT on the design and construction process will be articulated.

The evolution of Architecture as a profession

Architecture simply stands for the act of making places for habitable use; it was one of the earliest human necessities (Kostof, 1985). Today, architecture is a representation of all past construction cultures, an evolution of building practices (Miller & Burr, 2002). Throughout history, architectural design has been subject to change as any new material or tool is introduced to the profession. These changes took two directions: the first is on the building forms and the second is on the building profession. During the early days of human settlements, the master builder carried out all the design, engineering and construction tasks. The advent of reinforced concrete in France towards the middle of the 1800s and its rapid use all over the world have affected architecture, and new shapes and structures were designed and built that had not been possible using concrete only. The industrial revolution resulted in a series of inventions and increased the technical knowledge in all fields including building and construction. It became difficult for the master builder to control these huge amounts of information. This led to specialisation in the construction industry and new professionals came on board to join the construction team, previously the master builder himself and labourers helping him in carrying out his job.

The development of concrete by the Romans enabled architects to think of architecture in terms radically differed from those used by earlier builders. This invention radicalised Roman architecture and it became architecture of space rather than of sheer mass. The use of iron and glass has shaken up traditional construction. During the late nineteenth century, new building shapes were created that they were not possible using reinforced concrete. Skyscrapers, high-rise buildings and high towers have become as a key feature of many cities in different countries, such as USA, Singapore, Malaysia and France. Advances in technology complexity in the construction process required specialisation that resulted in generation of a huge amount of information and the need for information exchanges between specialists in the design and construction process in a short time. ICT is introduced to the construction industry to fulfil this need.

Architectural Design Process Evolution

The architectural design process is a set procedure used by designers or architects to identify a physical form that will achieve certain functional and behavioural objectives in a particular context. This procedure is used to prepare a set of plans and specifications that guide other stakeholders in the design and construction process – such as structural engineers, mechanical engineers, masons, electricians, plumbers, painters and many other skilled workers – in the completion of their work. The design process, therefore, can be described as an interactive and cyclic activity involving analysis, synthesis, appraisal and decision, applicable to a number of stages in a sequential design morphology (Maver, 1970). Process mapping is widely recognised to be an important management tool for how value is delivered to customers (Winch & Carr, 2001). There have, therefore, been several attempts to represent maps or models of the design process. Since the origination of the design methods movement in the early 1960s, there have been numerous attempts to model design and construction process (Macmillan et al., 2001). The building process contains a vast range of activities, which may be justified with respect to various design and construction disciplines.

There are two main groups of process models in AEC industry. The first group includes general process models for the whole construction process, and the second group is specific. The first group includes the most widely used model for design and construction process, the RIBA Plan of Work (RIBA, 1995). RIBA Plan of Work consisted of twelve stages that a project should go through. It set out the details of work to be carried out by each profession during each stage of the design and construction process, but did not show links of information activities to indicate how particular tasks could be related (Austin et al., 1999). RIBA Plan of Work amended in 2007 was similar to the 1995 model but only reduced the number of stages to eleven. The latest attempt by RIBA was the 2013 plan of work, which suggested integrating latest developments in ICT into the design and construction process. It is too early to comment on this work plan as it has just been released.

British Airports Authority developed a process model for its project planning and development for construction and IT solutions (BAA, 1995). It identified a seven-stage project process which construction solutions progress through. At Salford University, a group of researchers, with the collaboration of a number of industry organisations, have developed a design and construction process model called Process Protocol (Kagioglou et al., 2000). The new protocol was developed by analysing current practices in the construction industry and comparing construction process with similar practices in the manufacturing industry. It proposed a nine-stage project process that the design and construction process should go through. A key feature of the Process Protocol is the identification of ICT tools which may be used to support the design and construction process, and at which stages they can be used. It sets out the details of work to be done by each profession during each stage of the whole construction process. However, these models attempted either simply to describe the sequence of activities that typically occur in designing or to prescribe a more appropriate pattern of activities. Nevertheless, construction design process models should be dynamic and adaptable rather than fixed (Jeng and Eastman, 1999).

None the less, the design process is complex and grows continuously in complexity because of the increase in specialist knowledge. As a result, many new professionals join the design team of a project from a wide variety of organisations with different knowledge, objectives and information. This makes architectural design processes consist of a continual exchange and refinement of information and knowledge. Even the most experienced architectural design teams can fail to manage this complex process and this may lead to serious problems, such as supplying information at the wrong time, and of the wrong quality, to related people.

Discussion

There is no doubt that ICT has brought about many changes to the architectural design process and its final product. These impacts are continuously taking place. On the design process side, clients are appointing a specialist who sets up an ICT plan and provides information and consultation. This specialist joins the design team to carry out the ICT client's requirements analysis and set up solutions for their needs. ICT became one of client's key requirement items, especially the networks and space provision. The design process has not been affected by the introduction of ICT, but ICT has changed the way of carrying out the design tasks. Needless to say, the drawing board is now replaced with a PC and technicians are no longer needed for drafting and production documentation. This results in senior designers having higher employment chances than juniors, as design tasks requiring an input from less experienced hands are fewer than before the introduction of ICT in the design process.

Communication by using ICT tools has improved the way design participants communicate and has led to more collaboration between them. The Internet allows designers to access latest codes of practice, specifications and building materials information. This causes smaller amendments to design and a shorter time for the process. It also has a great impact on the quality of design and has produced improved buildings.

Architects need to prepare for the next generation of ICT. This may involve adapting a new model of design practice in their profession and re-conceptualisation of current design process to meet practical production and organisation needs (Jeng & Eastman, 1999). The new design process should not be limited to managing and controlling a small suite of applications, and it therefore requires a more complex structure than the existing one. It is anticipated that there would be a range of applications for a series of design requirements, such as standard programmes like particular structural steel, cladding system, etc. Each application should pass its results to other programmes that use its data. This necessitates the integration of these applications to CAD drawings, spreadsheets and other programmes such as thermal analysis. As the design process is iterative, it sometimes requires reverse flows of information, such as propagating data values from spreadsheet tables back to CAD drawings for budget control. Most execution flows of existing applications are static, implicit and cannot be reversed. The requirement reveals a demand for a unified, extensible ICT applications framework that provides an integrated design environment for smooth exchange of design information and coordination of all design and construction activities.

Structure of design process: As mentioned earlier, the design process was divided into several stages. The design concept was usually developed by an architect, then he/she passed it to the constructor to be worked out and materialised; afterwards to the contractor to transfer it to reality. There was a manager who led this process. Architectural design became more complex as new sophisticated technologies were introduced to buildings, which led to increase in the number of designers participating in the design of a building. A large amount of information is generated from these different participants, each of whom brings his own specialised information. The design process is changing from a sequential process to more a networked type which is more often known as concurrent design. ICT enable design professionals to develop design concurrently and there is no need to wait until others finish their tasks.

Change in decision-making procedure: Design is a premeditated activity controlled by rules. These governing rules and the properties required in the final solution are subject to enduring review, alterations and refinement. Any decision taken at one area affects the configuration of the process as a whole; therefore, any sequential solution approach can be regarded as inadequate. Decision making activity requires the adoption of a tool that incorporates all potentially relevant issues. With the use of ICT, the amount of information and the number of factors that should be considered are increased, as is and the manager's anxiety about decision-making. This new technology provides better information about project requirements from clients' points of view. This may also assist designers in understanding and managing the architectural design process; this can involve decisions in design analysis and selecting best design solutions. ICT tools impact the decisions made during the design process in a number of ways. The methods and order of design activities are changes, e.g. new simulation tasks are added, such as lighting simulation, simulation of evacuation of buildings in the event of fire. Therefore, bad decisions will be less easily excused by senior managers because crucial variables can be identified by ICT tools. The use of ICT tools in decision making has increased the speed of taking the right decision. These tools are also able to make information readily available at any time, anywhere, and can be organised in any required format. These have brought fundamental changes to the hierarchy of decision making.

Organisational shift: What has been the impact of ICT on the organisation's structure of design practices in construction firms and how may this affect the architectural design process? Is using ICT for handling data leading to a reduced need for middle management by making wider spans of control possible for senior management? ICT may flatten out the pyramid of management hierarchy. The role of ICT is changing in the design and construction firms. ICT departments will have to develop new structures to service their clients better. Introduction of ICT may help in managing this huge amount of information. How can design managers handle this information and mange it between the participants in the design team? In addition, how can they coordinate the exchange of information within the design team? These issues contribute to highlight the key requirements that have recently emerged for the proper management of ICT and design and construction process. It is indeed hard to predict where an organisation is heading, because one has to deal with much uncertainty, competitiveness and with rapidly changing technology. The rapid changes in ICT have great impact on the business environment. These changes not only necessitate modifying the way to run a business but also required modification of the business models. The construction industry has not been exempted from this revolution. The critical element today is making the link between the technology questions on one side and the strategy issue on the other side. A disconnect between these two elements may lead to serious misunderstanding between the organisation's top management and the ICT manager. The key requirement to proper management of the design and construction process is a definition of the general governance model.

This might lead to modifying or changing the existing design and construction process models with new models built around ICT tools. The other change that might result from the use of ICT in the construction industry is the way in which participants in the design and construction process interact with each other. By making the design process more open, more public and more systematic, ICT tools allow several brains to collaborate effectively. This has required modification of the existing models of communication to suit the new forms of collaboration to include new participants in the design and construction process. The Internet has destroyed time as well as location. Design teams can be assembled in physically remote locations yet have immediate access to common computer models. It was predicated that current Third World countries such as India and Pakistan might leap a generation in development to offer such service design or drafting facilities to European or US companies (Bridges, 1997). Design information was increasingly generated electronically; therefore, traditional paper storage has been substituted with digital storage. The other change was that standard letters have been substituted with e-mail and web based white boards.

Improved buildings: Conventional CAD systems are utilised for saving manpower rather than improving the quality of the output (buildings) of the design process. There is a longstanding debate about the use of CAD as a drafting tool or design aid tool. The use of a paper drawing is still the main form of communicating graphical design information. Electronic formats may be used for informal communication. The question here is: has ICT removed some limitations of manual design procedures, presumably resulting in better buildings? E-commerce might considerably improve the component selection procedure. Computerised procedures have encouraged designers to be experimental and wide-ranging, and might permit them to be more rational in their selection procedures. These changes could result in our expecting better buildings. The difficulty here lies in the fact that we are uncertain what 'better building' means. This raises two questions: whether ICT could allow designers to produce better designs, which were not possible using traditional tools; and does the adoption of ICT affect the form of buildings? Introducing ICT during the ideas-generation stage could improve the process. That might help the designers to generate new ideas not possible using a pencil and a piece of paper or a physical model.

Visualisation tools, such as 3D, VR and VRML, might help the designer to develop his/her ideas and elicit feedback from clients and prospective users of a proposed facility. Most research work in applications of ICT in the construction industry have been towards using its tools to carry out non-standard design tasks which would improve building performance. Advanced natural ventilation, for example, was designed using computer simulation models to avoid the need for air-conditioning. These tasks were usually those time-consuming and tedious computations, such as day lighting, acoustics and energy-saving calculations, which designers usually ignored on the assumption that traditional solutions were usually adequate to these problems. Design is sometimes problem solving. Knowledge management systems may help in solving design problems by benefiting from others' experiences.

Collaboration: Currently, collaboration between different participants in the design process is restricted severely by the discrete way in which each specialist tries to integrate the opinions, suggestions and findings of all other professionals into his own part of design. Traditionally, the method of working was to have joint discussions about the design project as it proceeds, after which specialists returned to their hiding places where each tried to do his/her best to modify his proportion of the design to integrate to the whole design. Most CAD systems support collaboration between participants and emphasise that the computer is the medium through which this collaboration is effected. Integration of specialist contributions to the design would be made by ICT, with each individual having immediate evaluation of the implications of any modifications to his/her contribution.

Skills: Anecdotal evidence suggests that the ratio of drafting personnel to engineers has declined as CAD use has increased. This has led to predictions that the designer would carry out the duties of two experts, designer and drafting personnel, in future. CAD standards libraries would support repetition and standardisation within and across project designs. Repetition would encourage use of robotics in field and in factory environments for module production.

Major Design Changes caused by Intelligent Buildings: Raised floors were the feature of intelligent buildings that had the greatest implications for architectural design. This feature distinguished intelligent buildings structure from conventional buildings. Raised floors provided space for various building services to be placed, such as electrical wiring, LANs and air supply. The other important feature was the occupants' amenity. In buildings that utilised this concept, all aspects of building design, ranging from outdoor landscaping to building environment systems and interior furniture design, were approached in consideration of occupants' well-being. As a way of increasing occupants' amenity, for instance, the air distribution systems of some buildings inject perfume into conditioned supply air. Intelligent buildings generally consume 20-50% more energy than conventional buildings (Kim, 1996). The main cause of this increase was that these buildings were equipped with more electric appliances, including computers, televisions, fax machines and other automation equipment. This equipment not only consumed more electric energy but also increased the heat in buildings, which required cooling equipment. The thermal design of many intelligent buildings required additional study during the design stage. It was often found that preoccupation with technological solutions has caused designers to neglect simple architectural considerations, such as proper building orientation, shading, natural ventilation, day lighting and use of native technologies (Kim, 1996).

Conclusion

This paper has presented some of the results from an on-going study that aims to investigate the impact of ICT on architectural design process; it reveals that there are continuous changes in the design and construction processes due to several forces, one of which is ICT. The architectural design process has also gone through some changes as a result of introduction of new materials, environmental constraints and embracing of ICT by architects and designers. The influence of ICT on architectural design is substantial and continuous. The design process models have not been modified to embrace ICT properly, as other industries have done. Most ICT tools are used to automate tasks or to carry out tasks that are impossible to conduct manually, such as simulation calculations. ICT might have changed the way clients participate in architectural design and how stakeholders collaborate, but the sequence of the design process has not been affected.

A number of researchers and professional bodies representing the architecture discipline have tried to modify existing design and construction processes or to develop new ones to integrate ICT tools to the processes; however, these attempts are still quite limited and do not provide an adequate solution due to the advances in ICT and computer power which allows for sophisticated programmes to do complex tasks.

The introduction of ICT has not only affected the design and construction process but it has also impacted on the final product (buildings) of the processes. A new kind of buildings was produced, called intelligent buildings. Building materials used in intelligent buildings are the same as used in conventional buildings, but intelligent buildings have new features such as the raise of the floor to provide space for services and extra space for cables. ICT has also led to many otherwise overlooked design tasks being done. These, e.g. daylight and acoustics calculations, were time consuming and tedious computation, and architects usually ignored them on the assumption that traditional solutions to these problems were adequate. Many new design tasks emerging from the introduction of ICT need to be investigated further.

Studying the influence of ICT on the architectural design process should be conducted from time to time. Development of Building Information Modelling and Cloud will have an impact on the buildings and their design process. This impact shall be evaluated and assessed using the proposed framework and case studies.

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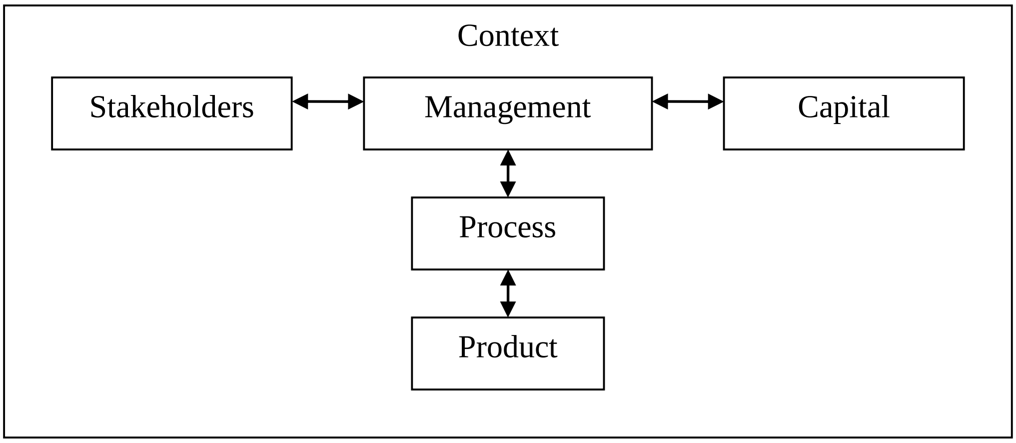

Figure 1: Business Components

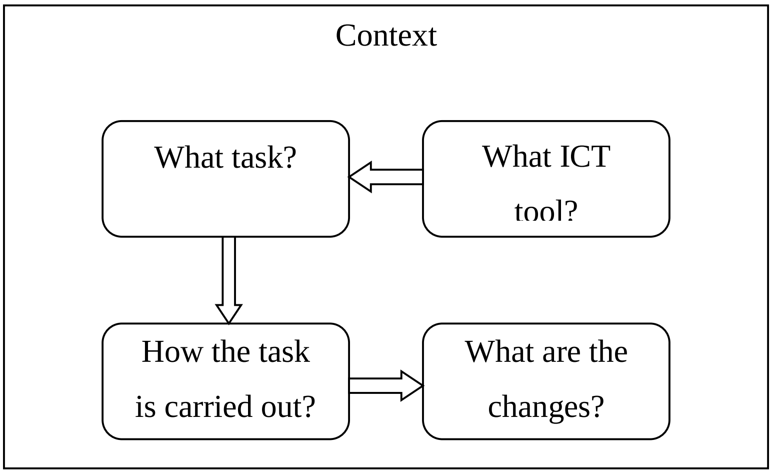

Figure 2: The proposed conceptual framework