REQUIREMENTS, INFLUENCERS AND ENABLERS FOR MODELLING THE INTEGRATION OF PROJECT MANAGEMENT FOR IMPROVING CONSTRUCTION SITE MANAGEMENT PRACTICES FOR SMALL AND MEDIUM CONSTRUCTION COMPANIES

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ABSTRACT

The need for tools to achieve a higher level of competitiveness and profitability has made management systems an important partner for construction companies. The environment in which construction projects are developed is dynamic, mainly characterized by complexity, uncertainty, interdependence, nonlinearity, ambiguity and speed. This research adopted a deductive reasoning in two phases: Literature Review and Interviews. The first phase was focused on underlying the crucial current issues that impact on Construction Site Management and the relationships among Project Management, Construction Site Management, Systems Thinking and Complexity Theory. The second phase was carried out so that practitioners validated the research result. The result of this study is a conceptual framework of requirements, influencers and enablers to support General Contractors in developing their Project Management Systems.

Keywords: Project Management Information Systems; Project Management; Construction Site Management; General Contractor.

INTRODUCTION

General contractors (GCs) have expressed concern about implementing methods, techniques and tools of the discipline of Project Management (PM) for managing their projects (Sanchez, 2017). Currently, margins are very tight and GC, mainly Small and Medium sized Enterprises (SMEs), need management systems to ensure their survival. Project Management Systems (PMSs) could support them to effectively manage their projects. The main concern is the complex reality of construction projects and the understanding of their nature to develop an appropriate system. In order to support them, this study aimed at establishing a conceptual framework that responds to the current requirements, influencers, and enablers to be considered in today Construction Site Management (CSM) practices. This contribution to knowledge could be considered a useful tool in the challenge of improving CSM practices.

LITERATURE REVIEW

The process of the literature review has been focused on the scheme illustrated in Figure 1. This scheme compiles the theoretical aspects and their relationships coming from the underlying principles and practices of PM and Systems Thinking for CSM. This scheme is in itself an underlying result from a long process of literature research.

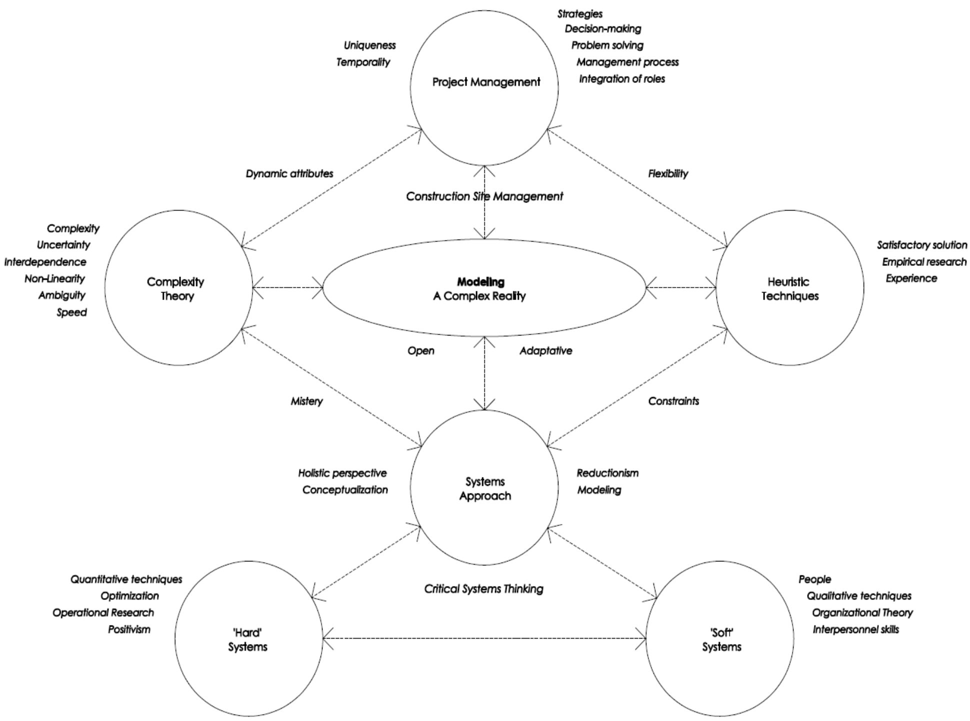

Fig.1. Theoretical scheme used in the literature review

CURRENT ISSUES AND ITS IMPACT ON SITE MANAGEMENT

Global changes in the business world do not overlook the construction industry. The construction industry has opened gradually to stronger market competitiveness. The current maturity of international PM standards advocates the need for GCs to implement PMSs for the management of their works.

Current issues that impact on CSM practices were identified in the literature review. Some of them are new management approaches and others seem to be permanent in time.

Profitability and productivity are two critical success factors for GCs. Success is understood as completing projects on time and price with the required quality, zero accidents and minimal construction waste generation, with emphasis on client satisfaction for the provided service and product executed by GCs. Profitability means that the work produces at least the initially estimated benefit. Improving productivity is a major concern of any organization as it represents the effective and efficient conversion of resources into commercial products and enables the determination of business profitability (Olomailaye et al., 1998; Minks and Johnston, 2011).

During the construction phase of a project, design information defects are frequently made evident (Alarcon and Mardones, 1998). The quality of design information is to be strongly considered for project success. Projects are planned and scheduled in relation with the design information provided by designers. Half of the scope changes, rework, cost overrun, extensions of time and delays on schedule, contractual disputes and requests for information are due to deficiencies in design information (Tilley et al., 2000). The main factors influencing cost overruns and delays are due to modifications to the initial scope of work, incorrect and incomplete design information and delays in authority approvals (Love et al., 2008).

The construction industry is full of projects suffering from cost overruns and delays regarding the contractual price and time. (Love et al., 2005). These cost overruns and delays are a major cause of disputes (Waldron, 2006). GCs undertake to execute a project according to an agreed economical sum and time by entering into a construction contract. One of the most significant risks of construction contracts is a breach in the contractual execution period caused by the delay in critical activities (Thorpe and Karan, 2008). Cost overruns and delays are often treated as major factors contributing to the high cost of construction (Charles and Andrew, 1990). That is to say that the client's objectives can be achieved through a disciplined management effort recognizing the interrelation between price, time and quality (Bowen et al., 2002).

The competitive nature and contractual complexity inherent to the construction process exacerbate the incidence of disputes (Sinha and Wayal, 2012). In the construction industry, activities are associated with legal responsibilities as they are carried out through contracts within which claims, conflicts and disputes can end up in litigation if they are not properly managed (Khekale y Futane, 2013; Muir, 2005; Busby and Hughes, 2004). While construction projects are increasingly complex, so are their contracts and by affinity conflicts and disputes may arise (Khekale and Futane, 2013). The main cause of conflict is due to subjective interpretation of construction contracts by contracting parties (Mitkus and Mitkus, 2014).

Problems associated with construction projects should be resolved quickly and effectively to avoid additional costs, requiring collaboration between staff, both inside and outside projects (Miah et al., 1998). 65% of constructor rework is attributed to inadequate, contradictory or lack of information (Newton, 1998). The production of useful and quality data and information enables problem solving and communication during construction (Minks and Johnston, 2011). Information and communication are closely related to the effective management of works, not only within the organisation but also among the different stakeholders involved.

Weather conditions are risk factors and may impact on project objectives (Minks and Johnston, 2011; Sears et al., 2008; Thorpe and Karan, 2008). The bidding time of construction contracts is best suited to provide estimates for delays resulting from weather information. Analysis of different scenarios, based on historical records of weather data for planning and scheduling in time management, is also part of risk management and results in consideration in estimating the duration of construction activities, distributing weather effect in a realistic way in project schedules (Sears et al., 2008)

IT tools facilitate the ability of communication between stakeholders and people, both inside and outside GCs. New technologies allow team members to work effectively, improving teamwork spirit, sharing data and information and encouraging collaboration. There are many tools related to the PM, sometimes too expensive for SMEs. Top management of GCs is responsible for linking their PMSs with their Project Management Information Systems (PMISs). PMISs are data software for effective information management (PMBOK, 2013).

Knowledge management is an essential function in CSM, as construction projects provide an important body of knowledge to companies (Ribeiro, 2008). Knowledge management is related to personal experiences, lessons learned and best practices recording.

The main goal of Just In Time is to achieve zero inventories throughout the supply chain between suppliers, clients, and companies. Their contribution in CSM is for achieving a more efficient execution process, better management of construction materials, machinery and auxiliary equipment, and better management of temporary works (Pheng and Hui, 1999). The main obstacles for implementing Just In Time in CSM are the lack of confidence and discipline between contractors and suppliers. That is why some improvement in communication and people management is vital (Akintoye, 1995). Akintoye's statement is still a reality many years after.

Lean Construction is a proven managerial approach for effective CSM performance nowadays. As LCI (2015) stated Lean Construction is a production management-based approach to project delivery, that is, a new way to design and build capital facilities. This management approach for construction projects pursues continuous improvement, minimizes costs and maximizes the value of the final products defined by clients (SGLC, 2015). Lean Construction main technique is the Last Planner System that is highly focused on coordinating workflow interconnections at operational level by fostering confidence, accomplishment and frequent meetings on site.

Business Processes Reengineering is a systematic methodology for helping firms to make significant progress in how their business processes operate (Harrington, 1991). It involves rethinking and redesigning business processes to improve performance indicators such as cost, quality, service and speed (Betts and Harper, 1994). In the execution process, Business Process Reengineering tries to make construction activities add value to the process (Griffith and Watson, 2004). Support from top management and department management is required for its implementation.

Concurrent Engineering intends to optimize design and construction processes to reduce delivery time and cost, and improve quality, coordinating design, manufacture and construction, and maximizing competition and collaboration among the parties involved (Evbuomwan and Anumba, 1998).

A Building Information Model (BIM model) is a powerful 'shared knowledge' tool with reliable information about the building, useful for making decisions throughout the life cycle of a project (CMAA, 2010). The construction industry worldwide is currently addressing BIM impact. The positive potential of BIM in the field of management is unquestionable. CSM requires information for planning, monitoring and control for construction and decision-making processes.

Any approach for an effective CSM implies to consider the accomplishment of Standards and Industry Regulation. Enterprise Management Systems (EMSs) provide business prestige and competitiveness assurance. The implementation of a PMS is easier if companies have already implemented other EMSs. UNE-ISO 21500 (2013) and PMBOK (2013) are standards for PM and provide a set of useful processes, which have been analyzed in this study. Both are similar in nature and reflect a systems approach, which is focused on a processes-orientated viewpoint, while being ideal to be integrated or at least coordinated with other EMSs (Resource, Financing, Accounting, Quality, Safety, Environment and so on).

In this competitive environment where clients and final users are more informed than ever and more demanding, dictating the highest standards of quality, safety and environmental management (Baccarini 1996; Dulaimi and Langford, 1999; Fryer, 2004; Gidado, 1996;), it is now seemed to be the time to focus PM principles and practices on CSM practices.

PROJECT MANAGEMENT AND ITS INFLUENCE IN MANAGING CONSTRUCTION SITES

PM is primarily characterized as a function for the integration (CMAA, 2010) of the many disciplines it covers, thus responding to managerial processes, product and people involved. PM is an effective process used in many contexts (Fewings, 2013). Academics and experts discussed the concept of PM from different viewpoints. These viewpoints are:

- A process of integration, coordination, decision making and problem solving (Fewings, 2013)
- A process with a managerial approach (Meredith and Mantel, 2012)
- A method based on oriented processes, similar to traditional methods as PMBOK (2013) or UNE-ISO 21500 (2013) (Kerzner, 2006)
- A process with a people-oriented approach (Morris, 1997)

- A process with a strategic approach (Stacey, 2007)

PM literature review revealed three crucial aspects of PM; thinking ahead, communication, and evaluation of the results. In the construction phase, there are two key elements, decision-making and communication, which are mandatory for tasks/projects for successful performance (Koskela and Howell, 2002). All of these crucial key aspects are essential for CSM.

A project has two genetic features; uniqueness, while the result is unique, regardless of the presence of repetitive elements, and temporary, in that it has a finite duration (Cleland and King, 2007; Echeverria, 2011; Guerra et al., 2002; Lewis, 1995). A project is a temporary effort undertaken to create a product, service or result (PMI, 2015 a). Construction projects are very complicated businesses because of their singular features with high levels of complexity, uncertainty and uniqueness (CIOB, 2014).

Within the scope of this study, a construction project is defined as “A set of processes, consisting of coordinated and controlled activities with starting and ending dates, which requires people and other resources (capital, information, services, materials, machinery and auxiliary equipment), gathered in a temporary organization for producing a unique result (the building).” A construction project is a transformation process of an investment decision into an operationally effective physical reality, and that physical reality is what should ensure profitability for the construction firm.

PM is the application of knowledge, skills, tools and techniques to project activities to meet product requirements (PMI, 2015 b). Construction projects lend themselves to PM because of their temporary and unique nature (Fewings, 2013). One of the most significant features of PM is that it allows for isolating the management of a project out of the overall management of a company in order to separately manage the particular project investment and strengthening team synergy.

In this study, the term PM has a discipline approach, which integrates all necessary functions for managing the construction process. A strong relationship among the concepts of PM, CSM, project, construction works, project manager and construction site manager is suggested, perceiving PM as a multi-disciplinary management method applicable to construction projects within GCs (SMEs).

CRITICAL REVIEW ON THE BENEFITS OF APPLYING A PMS IN CONSTRUCTION PROJECTS

A PMS for SM should be based on three key components: people, process and product. In fact, some authors stated that knowledge required for CSM practices comes mainly from these three areas (Egbu et al., 2005; Robinson et al., 2001). Customer satisfaction has to cover both service and product, and only people make it possible. A construction project is mainly a process of managing people (Fewings, 2013), a highly transient human system where social interaction has prominence (Antoniadis, 2012). Competencies and skills people need for using a PMS should be taken into account, being in this case the construction site manager the person responsible for what happens in site. CSM could be viewed as a management meta-process and should be addressed with management processes as part of GCs organizational structure. These management processes could be compatible with other enterprise management systems processes (quality, safety and environment). The result is an operationally effective final product (the building).

Analysing necessary knowledge in CSM practices in a structured and systematic way is crucial. However, the nature and problems associated with CSM present challenges for the integration of PM processes in the context of CSM. These problems can be addressed through the development of an effective framework for the integration of relevant knowledge to CSM practices. This knowledge is not easy to determine because, in the field of construction, knowledge is tacit rather than implicit.

The integration of knowledge might not completely solve current problems of CSM but should minimize the number of problems associated with CSM.

COMPLEXITY THEORY

Construction projects are complex in nature (Bertelsen, 2003a; Bertelsen, 2003b). Complexity theory is gaining prominence as it has considerable room to give a view of the systemic nature of managing complex projects (Note and Aiello, 2014).

Construction projects are characterized by its dynamic nature (Sanchez, 2017). Complexity, interdependence, nonlinearity, uncertainty, ambiguity and speed are inherent to this process (Sanchez, 2017). Many of these dynamic features are associated with complex systems featured in Lucas (2000). Construction projects are organizationally and technologically complex, and this fact is related to differentiation, which refers to the number of different elements, and interdependence or degree of interrelationship between these elements (Baccarini, 1996). Interdependence has to do with the intensity of interactions and behaviours within an organization, and helps to understand how the various departments and units within an organization depend on the performance of others (Thomson, 1967). These factors argue in coordinating the process locally rather than centrally. Non-linearity is due to the dynamic and ever-changing project environment (Bertelsen, 2004). Uncertainty is associated with lack of information and risks, and it is the result of an increasingly customer-orientated market, in the effort to achieve client satisfaction for the service and product offered. Ambiguity is related to the multiple and contradictory interpretations, cause of the relationships within a group of people, which is linked to confusion and lack of clarity (Thiry, 2002). Speed increases every mentioned dynamic attribute. Deadline is always a restriction, and thus time is a limited resource, so solving problems and making decisions associated to CSM always require a quick response. Thomas and Mengel (2008) suggested for project managers to deal with complexity and this statement can be fully apply in construction projects and construction site managers' ability for managing complexity.

SYSTEMS THINKING

Systems approach is an enabler for developing a system-model for SM, while recognizing the interdependence and cause-effect relationship between system elements. Systems theory provides a framework for understanding the best way projects have to be carried out in their environments (Walker, 2002). System thinking is a process that allows us to understand how things influence one another from a broader perspective (Flanagan, 2014).

System thinking allows construction site managers to gain a holistic view of the project during the execution phase, contributing to a more effective CSM, by involving client's objectives to contractor's objectives as well as the requirements coming from codes, standards and directives. The process of managing construction projects amounts to a Complex Adaptative System (Sanchez, 2017).

BASIC PROJECT MANAGEMENT SYSTEMS (PMS)

A PMS for CSM is essential for making decisions. A PMS is frequently linked to a PMIS, generally associated with a software tool. A PMS produce the information businesses need to make decisions, control operations, analyse problems and create new products or services (Laudon and Laudon, 2002). Feedback is output returned to the appropriate people or activities in the organization to evaluate and refine inputs (Laudon and Laudon, 2002). External agents to the firms, such as clients, suppliers, competitors, shareholders and regulatory agencies interact with companies and their Information Systems (Laudon and Laudon, 2002). Data and information gathering, sharing and analysis during the process are vital and are inputs for many management system processes.

PM guidelines, such as UNE-ISO 21.500 (2013), PMBOK (2013) or ICB (2006), although imply recognition of a discipline that has been in place for over 40 years are not concrete enough and difficult to implement directly to construction projects. GCs (SMEs) should address the management of their projects through Project Management Systems (PMS). A PMS is a set of policies, processes, techniques and tools that companies use to manage their projects (PMBOK, 2013).

A PMS for CSM requires covering sixteen management functions; integration, stakeholders, people, scope, time, resources, costs, financing, quality, safety, waste, information, purchasing and subcontracting, risks, knowledge, and claims (disputes/conflicts) (Nestcher, 2014; CMAA, 2010; CMPMBOK, 2008; PMBOK, 2013; UNE-ISO 21500, 2013; CIOB, 2013).

Management processes related to these functions are to be structured in such a way that responds to Deming’s cycle (plan, do, check, and act), incorporating two new dimensions, initiation and closure, because of the temporal dimension of a project/work.

Techniques for CSM should be both quantitative and qualitative. Quantitative techniques are related to Operations Management and enable the supervision of the activities associated with the project, and qualitative techniques are associated with interpersonal relationships. Such PM techniques, which help to achieve the objectives, are related to management organization, leadership, problem solving, reporting and computerized register, planning and scheduling, cost control, quality management, safety, contract compliance (Minks and Johnston, 2011) and waste management.

HARD AND SOFT SYSTEMS THINKING

Systems approach, although it forces a holistic analysis, its reductionism for interpreting individual parts implies leaving behind many of the characteristics inherent to this complex reality. Heuristics, based on empirical knowledge and experience, brings flexibility to the modelling process, contrary to the restrictions of the Systems Approach. Analysis should be critical and based on the effective combination of hard and soft systems thinking.

Pollack (2007) stated that the academic literature confirms strong links between the hard paradigm and Project Management and a growing acceptance of the soft paradigm because of the demonstrated existence of undercurrents in the literature.

The terms 'Hard' and 'Soft' are widely used in PM literature review. 'Hard' is vaguely associated to tangible goods and tasks, and 'Soft' is related to people and intangible goods (Crawford and Pollack, 2004). In managing complexity, soft techniques are essential for successful CSM and for people management. For Site Managers to achieve successful CSM, hard and soft competencies are essential.

RESEARCH METHODOLOGY

Research methodology is a system of explicit rules and procedures in which an investigation is based to assess knowledge (Saunders, 2016). This study adopted a deductive reasoning. Deductive reasoning implies developing a conceptual and theoretical framework before conducting an empirical examination. In the first phase, an exhaustive literature review was conducted, and in the second phase, interviews with open-ended questions allowed interviewees to express what they really thought about the topic and framework with enough freedom. Literature review allowed finding what is already known on the topic. Interviews were undertaken to gain the perceptions and opinions from practitioners in the field. Reliability, validity, bias and ethical issues during the research process were taken into account, assuring anonymity of those interviewed professionals.

RESULT AND DISCUSSION

The result of this research is a conceptual framework (Figure 2) that considers the findings of the literature review and interviewees' perceptions and opinions. The literature review underlined the current issues that impact on CSM and the complex nature of the construction process.

Ten experienced interviewees validated this conceptual framework. These construction practitioners considered this conceptual framework a good tool to support the modelling process of PMSs for CSM for GCs.

As illustrated in Figure 2, the proposed conceptual framework consists of seven key components: 1) knowledge sources, 2) attributes, 3) requirements, 4) influencers, 5) enablers, 6) compliance with code and standards, and 7) managerial functions.

The paragraphs below provide a brief discussion of the concepts illustrated in Figure 2.

Overview

The framework objective is to be useful in the process of modelling a PMS for the management of construction works. The difficulty is that the framework must respond to a reality considered complex. Authors' original intention was to achieve a satisfactory solution, neither perfect nor optimal because of the inherent complexity in managing construction works.

Complexity, uncertainty, nonlinearity, ambiguity and speed are inherent to construction works. All these aspects suggest for their PMSs to consider the need of dynamic processes and procedures advocating flexibility, adaptability and integration of functions and tasks because of the occurring situations in an ever-changing process. A PMS for CSM for GCs should consider these dynamic attributes. This sort of PMSs must have the capability to learn and evolve by adapting to changes, and survive in this way by processing information based on people' experience. That is the reason why a pragmatic approach is encouraged to be used by construction thinkers in their processes for modelling a PMS for CSM.

Sources of knowledge

Chaos, disruption and disorder are inherent to the construction industry. Knowledge in construction is more tacit than implicit so the ability for continuous learning and change adoption is crucial. The need for interpersonal skills is vital to coordinate the requirements coming from the managerial meta-process, people involved and product in execution.

Attributes

For analysing CSM, characteristics of the environment where construction works take place, competencies or skills required for construction site managers, as well as essential issues in relation to data and information, PM processes, techniques and tools have to be taken into account.

A process based-approach for CSM is vital for competitive advantage and easy compliance with codes and standards. A process based-approach for performing the managerial CSM functions needed is been demanding by most clients nowadays

CSM lends to PM and PM makes sure the integration of resources and managerial techniques. Data and information are vital in CSM practices. To implement adequate PM processes and techniques is an important progress in performing CSM.

To manage the complexity of the construction process, current construction site managers require competencies in both construction technologies and PM, including technical, behavioural and contextual skills, and thus gaining a holistic perspective for integrating and coordinating multi-disciplinary and multi-departmental functions inside and outside of the organisation.

Requirements

Requirements focus on key project objectives such as profitability and productivity (related to time and costs), quality (compliance with technical specifications), safety (zero accidents) and waste (generating minimum construction waste in favour of environmental sustainability). For that reason, management processes related to time, costs, resources, scope, quality, safety and recycling prevail to ensure the profitability and productivity of construction works.

Influencers

The main influencers are climatology, the quality of design information, restrictions of price and time and legal issues. Climatology should be considered in time and risk management. The quality of design information is to be strongly considered for project success and that is the reason why a comprehensive review of design information is a critical task in CSM for establishing proper planning, monitoring and control of constructions works. Price and time restrictions are usual in construction projects. Furthermore, if conflicts are not properly managed, they quickly become disputes and these are one of the main factors influencing contractual time accomplishment. Claims handling is necessary for GCs to play a central role in preventing and resolving them.

Enablers

Some findings are related to the enablers in developing a precise approach for a modern CSM. IT tools are key enablers in managing projects, and that´s why today, any system for CSM performance requires a PMIS. Knowledge management is of great importance for continuous improvement and an essential function to be incorporated in CSM practices. JIT premises are essential in current CSM, and for that reason, Lean Construction assumptions are needed for improving CSM performance. Additionally, GCs should be prepared to work in a multidisciplinary way, eliminating functional and departmental barriers, using Business Process Re-engineering. Furthermore, the incorporation of techniques related to Concurrent Engineering could make CSM more effective, as well as BIM philosophy and related tools improve construction site managers' performance and their team's.

Compliance with codes and standards

The development of a PMS is better to be focused on a processes-orientated approach for enabling compatibility with other enterprise management systems.

Managerial functions

A modern construction site manager should exercise leadership and mature interpersonal skills. In CSM, leadership influences very significantly on profitability, since the business results of a construction project reflect the ability to lead teams of people. In addition to leadership and interpersonal skills, some managerial functions to be considered in CSM practices are: Integration, stakeholders, people, scope, cost, time, resources (materials and equipment), quality, safety, waste, risk, purchasing, information, financing, knowledge, and claim management.

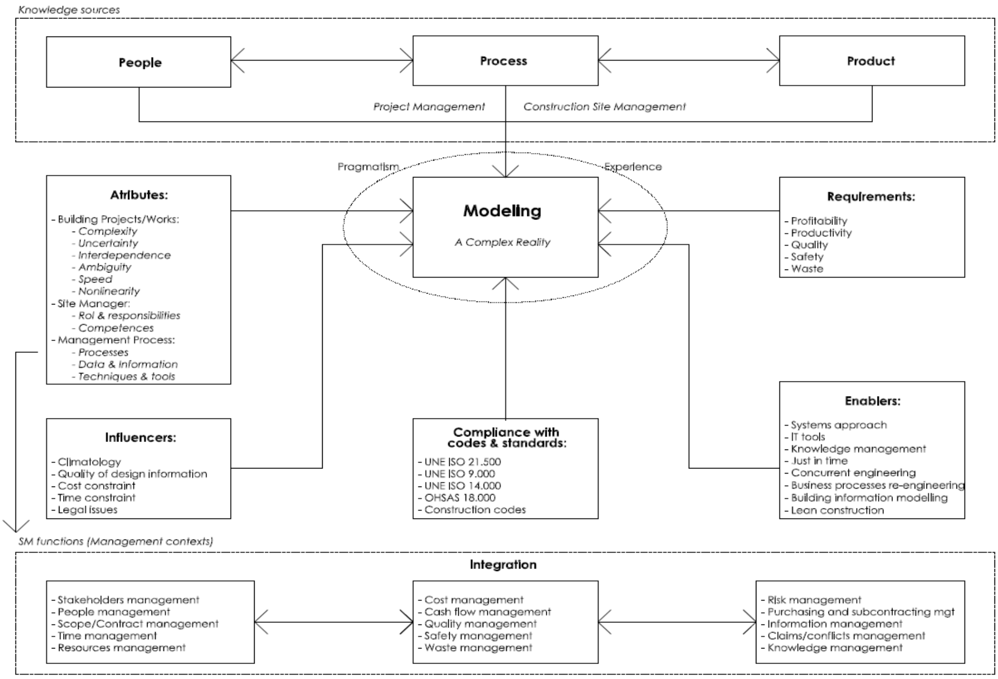

Fig. 2. Conceptual Framework

CONCLUSIONS

The determining factor why the proposed conceptual framework is a contribution to knowledge is the need for supporting construction thinkers in their modelling process for PMSs for CSM for GCs (SMEs).

The activity in the construction industry has a number of characteristics resulting in special features for management systems for GCs. The first revealed conclusion is that complexity, uncertainty, non-linearity, ambiguity and speed are attributes inherent to CSM. For that reason, traditional PM systems do not fit well enough to CSM. Systems Thinking facilitates to achieve a holistic perspective of the phenomenon, but its reductionism approach for the understanding of its multiple parts takes many features of this complex reality out in the modelling analysis. For a PMS to be successful in construction the capacity for flexibility, adaptability and integration of processes and functions is required; that is, a rigid model is invalid to such a complex phenomenon.

The proposed conceptual framework comes together every concerns and issues to be in consideration in the modelling process for PMS for CSM. The interviews conducted with construction professionals made evident the need for improving CSM practices, and an adequate PMS is a crucial tool for this challenge. Interviewees validated the proposed conceptual framework as a good tool to support the modelling process for PMSs for CSM for GCs. They also stated the complex reality CSM is and the need for improving CSM practices by using a flexible PM approach.

Authors' main recommendation for the industry focuses on the need for the current Construction Site Managers to have both competences in building techniques, and skills in general management and project management. The current education Construction Site Managers have is very good at construction skills but poor in general and project management skills.

Thus, to be more effective in managing the complexity of construction works, hard and soft PM techniques in a flexible, adaptive and integrated approach are essential for current CSM practices.

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