Critical success factors (CSFs) in a multidisciplinary engineering practice

D. Koutsikouri, [1] A. R .J. Dainty, S. A. Austin

[1] CICE, Department of Civil and Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK; PH +44(0)1509 228 549; FAX +44 (0)1509 223 982; email: d.koutsikouri@lboro.ac.uk

There is increasing interest in how organisations in construction manage, organise and deliver successful projects. In the project management literature these challenges are often defined in terms of better control of timescales, budgets and resource planning. Yet these are impoverished terms for conceptualising success, which is both multi-dimensional and contextual. The aim of the paper is to explore the perceptions of critical success factors (CSFs) in a multi-disciplinary engineering practice. The findings indicate that project success is related to five dimensions of work: individuals, teams, process, project and product. Understanding these elements and their interdependence may enable managers to identify strengths and weaknesses in current work practices. An important insight provided by this research is that CSFs is a form of knowing, which needs to be articulated and communicated more effectively within the project community.

1. Introduction

Construction organisations are facing a dramatic shift in having to develop new approaches in the way projects are conceptualised and implemented to deliver success. The recent interest in the intricacies of complex project environments and attempts to apply social science methods to analyse construction management problems confirm this (Cicmil & Marshall, 2005; Bresnen, Goussevskaia & Swan, 2005). Another important driver is the emergence of a more people-centred discourse around 'team integration', 'trust' and 'respect for people', as a means of improving work relationships and boosting performance. However, the extent to which these methodologies deal with today's project complexities, the new language of positive affirmations and universal urge to move 'from good to great' www.theharcourt.com remains an area of conjecture. Research over the last four decades using the concept of critical success factors (CSFs) has made an important contribution in terms of establishing what 'must go right' for a business to reach its goals (e.g. De wit, 1988; Pinto & Slevin, 1988; Cooke-Davies, 2004). But what really constitutes project success? For the past 20 year or so textbooks have maintained that there are three critical factors are what define projects: a definite due date, a limited budget (including personnel resources), and a specified set of performance goals. However, researchers and practitioners alike now recognize that there are projects where these three items are not always clearly specified (Meredith & Mantel, 2006). In addition, there are often many implicit goals for projects, such as making a profit, not harming the reputation of the firm, extending the organization's sophistication in project management, and so on. Although the lists of success factors that may contribute to

successful projects now also include a variety of human, organisation and technical variables, there are many critics to the CSF approach (Cooke-Davis, 2004). First there are many definitions of success, which makes it fundamentally difficult to assess and measure any set of factors that research has come up with. Further, empirical research have concluded that perceptions play a strong role of a project and therefore project success should be termed 'perceived project success' (Baker, Murphy & Fisher, 1988). A particularly important finding is that the factors associated with project success are different for different industries (Baker et al, 1983) and cultures (Diallo & Thuillier, 2004). At the very least, success factors and their relative importance are idiosyncratic to the project type and the firm. Generalising a 'checklist' of factors derived from one project environment to another is therefore hardly worthwhile. The present study attempts to address this issue by focusing on CSFs in a construction design context, where current frameworks of success factors do not seem to apply. Second, recent findings overhaul the assumption that CSFs are independent of one another. Due to the complexity of the project implementation process, success factors are most likely to be dynamic, interdependent and change across time (Pinto & Prescott, 1988). Nevertheless, relationships between them are rarely explored in practice which renders them too simplistic to take account of complex construction project environments. Given the apparent drawbacks, the need for CSFs seems to remain and this has spurred new research efforts and a reconsideration of methodological issues (Cooke-Davies, 2004; Belout & Gauvreau, 2004). In this paper, the authors take the view that perceived CSFs can only be fully explored and understood in relation to one another. By understanding the interaction between the factors could provide insights into how organisations/practitioners can best meet all their CSFs (Ang, Sum & Yeo, 2002). This highlights the need to apply a more grounded CSF approach to explore CSFs in particularly complex project settings. The focus of context for the present study is a large multidisciplinary construction design practice. The daily life in an engineering practice is characterised by the uniqueness and temporality of project arrangements. The challenges that the various project participants (engineers, architects, clients, contractors) in design projects face are many and varied. For example, there is a high degree of complexity and interconnectedness of tasks, a high dependence on diverse skills and collective knowledge and little time to find out where relevant knowledge resides (Cicmil, 2004). It is suggested that teams such as these often have difficulty developing a shared project vision since they tend to create their own understandings of the project reality based on their background and world view (Dogherty, 1992). This paper aims to explore the cornerstones of successful multidisciplinary engineering projects. By capturing the perceptions of project success as experienced by the team members themselves, it is possible to make explicit the context specific CSFs that underpin consistent project success. This may be an effective framework to better understand the dynamics of project success; how different factors reinforce or impede each other during project stages. The initial findings serve as a basis for further investigation of CSFs and how they behave and function in actual construction project setting. It also responds to the expressed need for broader research methods in construction (Bresnen et al, 2005).

2. Methods

2.1. Approach

This study was analysed within a grounded theory framework. This inductive methodology enables issues relevant to the field of enquiry to emerge from the data and for theory to be generated by being grounded within the data itself. The methodology includes systematic open and axial coding (analysis), questioning of data, explanation of categories, their properties and the relationships among them (Strauss & Corbin, 1998).

2.2 Participants

Twenty two engineers and technicians (thirteen male and eight female) took part in this study, which was conducted in a UK based multidisciplinary engineering practice over a two month period. Specifically, it was located in one of the integrated business groups (IBGs), which employs more than 90 people. Since the aim was to reflect a broad spectrum of beliefs and values across the group, the sample was stratified to include individuals from different disciplines such as structural, building services and façade engineering, but also CAD-technicians. Six job levels were represented: group manager, associates, senior engineer, engineer, graduate engineer and CAD-technician. There were eight structural engineers, three façade engineers, nine building services engineers and two CAD-technicians.

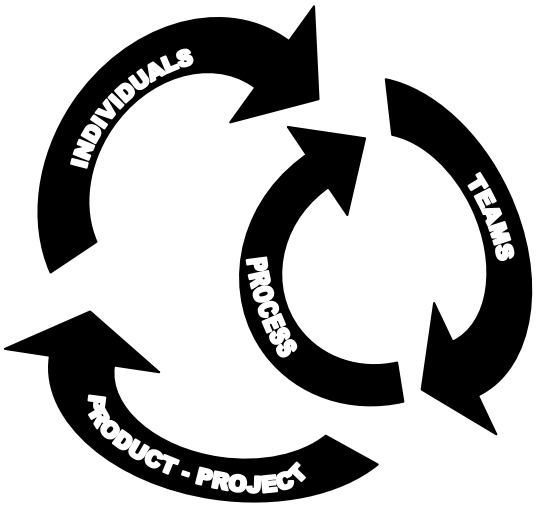
2.3 Data collection

2.3.1 Interviews

A series of semi-structured interviews were conducted with questions focusing on the informant's job role, experience of project work and examples of successful and less successful projects. The selected informants were e-mailed beforehand and asked to identify examples of a 'successful' and a 'less successful' project as the basis for discussion in the interviews. As part of the interview process, informants were asked to brainstorm critical success factors in project work. This was aimed to encourage individuals to 'make free associations' without being prompted, about factors they perceive as critical to project success. The exercise was useful because it helped to reveal two things: 1) some of the specific meanings that individuals attach to factors and, 2) their significance in context. The interviews were audio-recorded and transcribed verbatim. Categories produced by the researcher were validated through workshops, where staff from each engineering discipline including CAD-technicians, were recruited. The selected individuals were put in groups of 4-6 people according to their job level to allow data comparison across job levels. The informants were asked to group all of the initial categories (175) under larger categories so they would end up with a number of core categories. Each group was given 45 minutes to complete the task. The categorisation made by all six groups was then compared with the grounded analysis of the interview material. The analysis of the data included open coding (labelling segments of the interview material); asking questions such as 'What is going on here?' and 'What category does this incident indicate?'; axial coding to link categories and sub categories together, e.g. the category 'integration of disciplines' was placed under the larger category 'communication'; and selective coding to generate of core categories.

3. Results

Qualitative analysis of the interview material (brainstorming exercise) revealed five central constituents of project success: *individual*, *team*, *process*, *project and product*. An illustrated summary is provided in Figure 1. These core categories summarise the project team's perceptions of what is considered 'critical' in delivering successful projects or, more specifically, what needs continuous attention in day to day project implementation. Directional arrows within the model represent relationships between the categories as developed from the analysis.



INDIVIDUALS
Motivation, Values, Skills and competence, Leadership

TEAMS
Communication, Trust and mutual understanding, Respect, Wellbeing of project community, Culture, Clear roles and responsibilities, Relationships

PROCESS
Technology, Listening and feedback, Physical work environment, Supportive management, Resources and planning, Work process.

PROJECT – PRODUCT
Clear goals and project mission, Commercial awareness, Challenging project/task

Figure 1. The dynamics of five CSFs and their sub-categories

From a managerial point of view the project organisation need to have skilled, motivated and passionate individuals to carry out the task or the challenge; these individuals have to work together as a team to accomplish collaborative design that satisfy the client; the individuals and the teams need appropriate technology (tools and workspace), effective project management (planning, support and definition of roles and responsibilities) to operate in a structured way; and all these influence the central outcome of the *project*, the *product* itself. The model shows that project success relies heavily on the ability and behaviour of team members to work well together, but also how these relationships may be reinforced or impeded by other factors such as planning, availability of resources and style of leadership. Inherent in this way of thinking is the recursive interplay between the actors, e.g. project members, and the structure, e.g. organisational hierarchy and prevailing culture, which offers some important insight into how to understand project success. The interviews formed the basis for developing a preliminary hypothesis of core CSFs, which could be mapped onto the core categories created in the workshops. It is important to point out that these two sets of data are based on the open coded factors (175) elicited from the initial brainstorming exercise. In both instances, the primary task was to cluster the open coded CSFs into higher level categories and label them.

The initial set of high level categories, created by the researchers, comprised more detailed categories than those emerging from the workshops. Variations were also reflected in the number of core categories created, language used to label them and under which category each item would belong to. This can be explained as a consequence of *time*, *professional group* and *job role*. The researchers spent an unlimited time on categorising the 175 initial factors into a number of high level themes, whereas the workshop participants were given limited time. However, familiarity with the coded factors (e.g. 'effective project management', 'communication between disciplines', 'quality of contractor' etc) and an understanding what the words and sentences facilitated this task. Further, interpretation of text and talk is often influenced by background and professional discipline. For example: technicians created a high level group called 'satisfaction' and talked about it as part of being motivated, whereas managers talked about 'motivation' in terms of being motivated by the project itself. This emphasises the role of professional culture in an organisation (Kunda, 1992). In a similar vein, job role also seemed to influence the categorisation of factors. Associates talked about 'team factors' whereas senior engineers mentioned 'dynamics' which may not reflect a real difference between these two groups in terms of what they are trying to articulate. Rather, it seems that they had to make a quick negotiation amongst themselves and decide what to go for. In this way, each group constructed CSFs through discussions, debate and negotiation around the high levels categories that the CFS would fall into. Based on these observations CSFs are taken to be socially constructed and socially recognised phenomena. The analysis of the workshop outcomes can be summarised as follows:

- Project success is seen as a *process* rather than an end-state across group levels.
- There is a preference to view success factors as *interrelated* and *mutually interdependent*; 'they cannot exist without each other'.
- Project success is seen as dependent on appreciating what lies beneath the exterior of the so called golden triangle, 'cost, time and to specification'.
- Success factors relating to *leadership/management*, *team work* and *competency/skills* were common to all groups.
- There is a high degree of consensus across groups on factors such as *communication, motivation* and *culture.* Communication which is usually seen as a top success factors in other studies, is not a consistent factor across the groups. Instead it was talked about as an overall important factor. For example, technicians talk about communication seemed to be related to being more integrated in the project process. The senior engineers across all disciplines summarised it as follows: 'communication is the catalyst in all good project work'.
- Communication is *the success factor* that influences work relationships and acts as a 'catalyst in good project work'.
- Variations between the groups appear to be a consequence of job roles rather than professional disciplines, indicating that junior levels (e.g. graduate engineers) perceive supportive as more critical than resource planning. Similarly, senior levels seem to place more focus on having the right people and manage the different and sometimes conflicting project demands rather than 'time to play

with ideas'. Contrary to recent studies of CSFs in project work, client focus does not emerge as a consistent factor across the groups. There was little reference to 'the client', 'client satisfaction' or 'end-user'

The most striking observations indicate that project participants, regardless of background or role, hold an inward looking attitude of project success; mainly focusing on their own concerns such as timetables, their contribution to the project and so forth. This reflects the continuous regime of 'getting things done', or what has been termed the 'tyranny of projects'; a mentality that govern much of the work in the construction industry (Koch, 2004). One senior, male building services engineer expressed an important part of this condition: *'You just work, work, work, busy, busy, busy you know. I can organise my time but then somebody throws something in…something is coming from nowhere, which should not happen really'*. The situation is further complicated by the difficulty in juggling the demands of being involved in many projects which is common in consulting engineering (Koch & Bendixen, 2005). This presents a challenge that goes beyond time management; it is a matter of knowing where to direct attention.

Discussion

As was discussed above, the aim of this study was to explore project success as perceived by engineers and technicians in a multidisciplinary engineering practice. It is part of a number of research outputs regarding the social dynamics of construction team work. The study presents an ideal opportunity to make comparisons with existing success factors drawn from other project settings. Five core success factors emerged from the interview data: individuals, teams, processes, project and product. Analysis of these factors shows that they both reinforce and impede each other in an iterative manner during the project life cycle. These findings add a number of dimensions to the current findings in the project management literature, which go beyond the short term goals of the manager, 'on time, on budget and to specification'. Specifically, suggested model implies that human as well as contextual factors contribute to the perception of project success. Another observation is that CSFs appear to be socially constructed among individuals as well as socially recognised phenomenon. In this way, project success is taken to be a process rather than a static concept. This way of conceptualising success is part of the new generation of research stating that project organisations should be studied as social arrangements in terms of locating what is working and what is not working in them (Bresnen et al, 2005; Cicmil et al, 2005). Another important observation in the study was that when given the freedom to state any success factor the majority of them emphasised variables relating to internal characteristics of the project process such as maintaining good relationships, passion for the project, and a clear understanding of their role. External characteristics of the product or service itself such as customer focus or product performance were not emerging as critical. This pattern of responses occurred in the subsequent workshop where the participants where asked to group the success factors derived from interviews with engineers and CAD-technicians. This is surprising considering the many published articles and books on the importance of the client in project success (e.g. Meredith et al, 2006),

and brings attention to the somewhat inward-looking attitude of CSFs in project work. Assessment of these observations suggest two concurrent events: 1) engineers and technicians are more focused on getting the design right than focusing on product performance which can only be measured when the building is ready to use, and 2) the naturalised culture in construction seem to emphasise 'getting things done' rather than reflecting on what is getting done. These observations are to a great extent in line with conclusions based on a number of different project environments and industries (e.g. Baker et al, 1983; Slevin & Pinto, 2004). While the pressure to deliver on time and on budget are still dominant within the project organisation, team members themselves are more interested in whether a project is worthwhile doing, satisfying and is a good learning experience (i.e. they are focused on psycho-social outcomes). The workshops demonstrate that the differences in perception of project success, is a result of job role, rather than what professional group one belongs to. This was an expected outcome, but worth investigating since professionals cultures seems to be seen as major problem in multidisciplinary work (Dougherty, 1992). An important insight provided by this research is that CSFs is a form of knowing, which is not commonly articulated within the project community. At the same time CSFs must be made explicit in an organisation to have any effect on performance. This is reflected in the study, where communication was singled out as being the 'catalyst' for all CSFs. The constraint lies in the nature of design work; the involvement of architects and other subcontractor that represent organisations that operate outside of the engineering consultancy. Construction project work is communication based; efficient collaboration relies on effective diffusion of information throughout the project (Baiden, Price & Dainty, 2006, in press; Winch, 2001). What is required is a radical change in the way CSFs are conceptualised and measured for them to be useful for practitioners looking for ways to improve current project performance.

Conclusions

Project success depends on a range of human, organisational and technical variables. Yet there is no agreement in the literature what factors exactly contribute to success. Despite this, CSFs continue to be an important method of improving performance in project work. The main conclusions from this study are that: 1) project success appears to be related to the opportunities and constraints of organisational behaviour, existing work processes and structures, causing an inward-looking view of success among project participants 2) CSFs are interrelated and mutually dependant and are likely to change across time, and 3) project success is a process rather than a static concept which relies on effective communication between individuals at all levels. Despite this, it is impossible to claim that all dimensions of project success in a multi-disciplinary project environment have been captured. Further empirical studies are needed to evaluate and further develop the presented intermediate model as basis for appropriate support to practitioners in the construction industry. An in-depth understanding of each project participant's influence and perception of project success is also beneficial.

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