

Defining an improvement plan to address design management practices within a UK construction company

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ABSTRACT | A UK based design and construction civil and building engineering company has entered into a partnership with Loughborough University and the Engineering and Physical Sciences Research Council (EPSRC) to develop and deploy design management tools capable of making significant improvements to its design management performance. Before suitable tools could be identified it was necessary to establish the current state of practices within the organisation. This paper describes the methodology, results and conclusions of this initial study. It discusses the current views and approaches to design management within the company, and identify areas where improvement is necessary. Many of these are likely to be relevant to other design organisations. The paper then puts forward a strategy capable of driving change throughout the company. This paper is likely to be of interest to those involved in design management and the development of tools and practices to help the industry improve design management performance.

KEYWORDS | construction, design, management, industry practice, process, tools

1 Introduction

In the construction industry, design is a key activity where the customer's needs and requirements are conceptualised into a physical model of procedures, drawings and technical specifications, in the process defining up to 70% of the cost of the final product [1]. The design phase also has many interfaces with other processes, such as construction and procurement, and organisations including the client, user representatives and regulatory bodies.

Historically, design was manageable with simple planning and management techniques. However, management of the design process has become increasingly complex as a result of factors such as fast tracking and the increasing complexity of the fabric and content of

buildings, requiring enormous co-ordination effort, which rarely achieves its goals [2]. It is characterised by poor communication, lack of adequate documentation, deficient or missing input information, poor information management, unbalanced resource allocation, lack of co-ordination between disciplines and erratic decision making [3, 4, 5, 6, 7].

The cause of the majority of construction delays and defects can be related to poor design performance [8, 9] frequently creating problems that are more significant than those attributed to poor workmanship and site management [10]. This scenario is very familiar to the company under investigation and has been a major driver to improving design management performance. A partnership of the company, Loughborough University and the Engineering and Physical Sciences Research Council

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(EPSRC) is supporting a research project on design management, as part of a four year Engineering Doctorate (EngD) Programme delivering changes to design management understanding and practices.

This paper discusses the methodology, results and conclusions of an initial study undertaken within the company. We discuss the current views and approaches to design management within the company, and identify areas where improvement is necessary. Many of these are likely to be relevant to other design organisations, particularly those that have evolved into design and building from traditional contracting. We then describe a strategy for driving change throughout the company.

2 Methodology

The methodology adopted to meet the research objectives was based on a previous approach [11] and comprised a literature review, review of current and recent research projects in the field, semi-structured interviews with company staff and triangulation of interview results with literature.

The review of design management literature provided an up to date understanding of the subject matter as well as helping to formulate a framework for conducting the semi-structured interviews. The triangulation stage of the investigation was used to validate interview results and identify tools and practices to address problems facing the company.

The review of current and recent research projects in the field indicated where the research could focus to provide competitive advantage to the company while ensuring it did not duplicate any existing work.

Semi-structured interviews were used to collect data from fifteen individuals (directors, project managers, construction managers, design managers and design engineers) relating to current design management practices and problems within the company. They were

preferred to structured interviews, where respondents are offered only a limited range of answers which has the risk of leading to biased views. At the other extreme unstructured interviews can produce data that are both difficult and laborious to code and analyse. Good practice in conducting interviews was used in this research [12]. The interview results were categorised and triangulated with literature as a validation exercise. Triangulation also helped to highlight underlying causes of problems identified by interviewees and potential solutions to the problems.

The interviewees identified a significant number of improvement areas to address in current design management practice. Each improvement areas was ranked based on the frequency it was raised by the interviewees. This identified the most critical issues that needed to be addressed within the company. To discover whether there were any common themes underlying these issues, the root cause for each issue were identified from literature as were potential ways of addressing each root cause (improvement mechanisms). This exercise allowed the research team to identify the improvement mechanisms that were necessary to address each issue raised by interviewees. The improvement mechanisms are:

- Structured and explicit design process
- Improved design planning
- Integrate design and construction
- Information flow management
- Understand/predict impact of design changes
- Knowledge database

To understand which improvement mechanisms would offer the greatest benefit to the company (i.e. those strategies that allows the company to address the most critical and greatest range of issues) they were ranked based an “importance weighting” calculated using Equation 1.

The weighting exercise provided a simple ranking system for the improvement mechanisms. It indicated the potential each improvement mechanism has to address the range of issues identified by interviewees. This is a

$$X_i = \frac{(A_i Y_i)}{\sum(A_i Y_i)}$$

A_i - sum for all issues the number of interviewees identifying each issue which can be solved (or part solved) by improvement mechanism "i"

Y_i - number of issues to which improvement mechanism "i" is applicable

Equation 1. Importance weighting, X_i for each improvement mechanism

measure of the importance of each improvement mechanism to the company and thus provided a clear understanding of where the research activities should focus to benefit the company.

3 Research results and discussion

Semi-structured interview results provided a clear understanding of design management practices within the company and where the major challenges lie for improving performance. Several aspects of design management practice were discussed during the interviews. The results of this exercise and the triangulation with literature sources are presented below.

3.1 Nature of design

When asked to describe the process of design only a third of respondents identified the four design main activities of analysis, synthesis, evaluation and dissemination as described by Markus and Arch [13] albeit using varying terminology. They described the design process within the context of a project process. This would be expected, considering that it is the terminology they are comfortable with and use in the work environment. However, no respondent identified the iterative nature of design [14] and only one respondent identified an "appraisal" [13] activity as part of the design process.

Some interview comments suggested that company employees with a contracting background do not understand the process of design. Two interviewees with such

a background were unable to provide an answer to the question. However, a similar inability was demonstrated by an interviewee with design experience.

The analysis of interview results suggests that there is a need to improve the understanding of the very nature of the design process throughout the company. This is considered necessary by literature to be able to successfully achieve project objectives [15] and undertake the activity of design [16].

A structured and explicit design process may help to educate staff about the nature of the design process. The benefit is that it allows process participants to understand the process as a whole, their roles and responsibilities [17].

3.2 Standard design process definitions

The responses by interviewees when asked whether they were aware of any standard design process definitions are shown in Table 1. There is a general awareness (73%) of the RIBA Plan of Work [18]. This is to be expected as it has been available since the mid 1960's and therefore it is likely that many within the industry would be aware of it. Only one interviewee stated an awareness of another standard design process definition, a project process map produced by a project management group and believed it to be a "very effective way of representing the project".

No interviewee was able to provide a detailed description of any standard design process definition such as the various stages of the RIBA Plan of Work.

Table 1. Knowledge of standard design process definitions

response	number	percentage
No	3	20%
I am aware of RIBA plan of work	11	73%
I am aware of other standard process definitions	1	7%
I understand in detail a standard process definition	0	0%

This line of questioning has highlighted that the company uses no consistent process for approaching the design phase of a project. It is claimed [19] that to be able to manage a process effectively it must be repeatable. The inconsistent way in which design is approached from project to project will therefore make management of the process difficult.

The provision of a structured and explicit design process within the company would provide the potential to establish a consistent approach to project design and also to reduce ambiguity in the scope of tasks to be undertaken [20].

3.3 Project design stages

Interviewees were asked to identify the stages of a project’s design process and define when each started and finished including the activities that occur during each stage. Responses were mapped against four high-level design process definitions: The Process Protocol [17], the RIBA Plan of Work [18], the BAA Project Process [21] and the AMEC Project Process [22]. This mapping of interviewee responses is shown by Figure 1. Only seven of the fifteen interviewees felt able to answer this question. Those that provided answers omitted some stages completely or described them using varying terminology. There also were inconsistent descriptions by interviewees of the activities to be undertaken at each stage.

Concept and scheme design stages were not identified by all interviewees and were sometimes described by different terms: tender and preliminary design were used to describe the scheme design stage, whilst scheme development was sometimes referred to

instead of concept design. Detailed design was the only phase described consistently.

Currently, employees across the company describe project stages using varying terminology and do not have a common perception of the activities undertaken during each project stage. Without a common language, there is no hope of generating common aims and objectives within the process [23] as verbal communication can neither create sufficient understanding of a process between various parties nor define issues unambiguously [20]. It has been suggested [24] that if the activities that constitute design are not understood, it is not possible to manage design successfully.

An ordered approach to the design process is clearly essential if people are to work together effectively towards common goals [25]. A structured and explicit design process provides such an ordered approach with a common language and unambiguous description of tasks. This improved understanding of the design process will enable project teams to make more rational decisions at the right time and with a full understanding of the implications [24].

3.4 Design management activities and processes

Activities that interviewees believed were part of the design management function are shown in Table 2. The interviewees identified many of the design management issues and activities that are considered significant [3, 4, 5, 6, 7]. It can therefore be concluded that the company understands the fundamental activities necessary to successfully address design management issues and problems, which may be attributed to experience of common difficulties during design. This tri-

Process Protocol	RIBA (plan of work)	BAA Project Process	AMEC Project Process	Interviewee responses
Demonstrating the Need	Pre-Agreement	Inception		
Conception of Need	Inception			Design brief Client brief stage Understand and evaluate client business needs
Outline Feasibility	Feasibility	Feasibility	Feasibility	Feasibility study
Substantive Feasibility				
Outline Conceptual Design	Outline Proposals	Concept Design	Concept Design	Concept stage Concept design Scheme development Develop options
Full Conceptual Design	Scheme Design			
Co-ordinated Design, Procurement and Full Financial Authority		Detailed Design	Detailed Design	Detailed design
Production Information	Production Information/BoQ	Production Information	Production Information	
	Tender Action			
	Project Planning			
Construction	Operations on site Completion	Construction	Construction	
Operation and Maintenance		Operations and Maintenance		As built design
	Feedback			

Figure 1. Interviewees view of the project process compared to standard project process

angulation also gives confidence in the knowledge of the company staff involved in the research and therefore the validity of the findings.

3.5 Design management tools

The tools used by interviewees to manage the design process are shown in Figure 2. They range from meetings to financial control schedules. Other tools include information release schedules and milestone delivery dates. A programme of project design activities is the second most popular tool used by interviewees to manage the design but this only represented a third of the sample.

Figure 2 provides a picture of the range of techniques deployed. Thirteen out of the fifteen interviewees used

some structured method, but only five help manage design with a combination of three or more of the tools and a further five use only one. Other than interviewees G, H and N, interviewees use few and differing tools to manage the design process. This indicates the company has no defined approach to design management, which may be hampering its design management performance.

The company needs a structured approach to design management incorporating tools to help manage the design process. There are tools, many already used in the construction industry, that can be adopted by the company. However, employees must be motivated to use any new technique otherwise its deployment is likely to fail. To generate enthusiasm users need to be

Table 2. Interviewee’s perceived design management activities compared against literature

rank	activity	number	problem factors and roles identified in literature
1	design change management	12	change control process
2	design team leadership	12	erratic decision making/inadequacies in designers’ technical knowledge
3	design planning	12	low confidence in preplanning design/unbalanced resource allocation
4	information flow	11	deficient or missing input information/information management
5	standard processes / framework	11	
6	programme / progress monitoring	10	manage progress and budget/manage approval process
7	client briefing/requirements capture	8	poor briefing
8	integrating design and construction	8	intergrated design and construction/feedback from site to design
9	interface management	8	lack of co-ordination between disciplines/interface management
10	project team structure	8	
11	value management	6	value management
12	risk management	5	risk analysis
13	buildability	5	buildability
14	design development / control	4	design development
15	tools and training	4	
16	decision control	2	lack of adequate documentation/design decision control
17	cultural issues	2	
18	CDM / Health and Safety	2	
19	team building	1	team building

rank	tool	interviewee reference													number			
		J	M	A	B	K	D	L	E	F	C	I	O	N		G	H	
1	meetings			x		x			x	x				x	x	x	x	8
2	project programme				x		x				x						x	5
3	information release schedule										x			x	x	x	x	5
4	electronic document management												x	x	x	x	x	5
5	design deliverable schedules							x							x	x	x	4
6	milestone dates								x	x			x					3
7	financial control schedule												x					1
	total number of interviewees	0	0	1	1	1	1	1	2	2	2	3	3	4	5	5		

Figure 2. Matrix of design management tools used by interviewees

trained and educated about the benefits, how and when to use it and how to overcome barriers (cultural, organisational, process and technical) to uptake. How we focused on the tools appropriate for the company is explained in the methodology and the approach that is being used to encourage tools is discussed in the current research strategy section.

3.6 Design management strengths

Interviewees were asked to comment on design management activities they believed the company did well. The strengths identified were predominantly (83%) based on their technical skills (good technical design skills, create buildable solutions and understanding contractor needs) associated with the company’s

design consultant role. It is worth noting that two interviewees believed that no design management activities were carried out well. Generally, interviewees expressed a belief that design management practice within the company could improve significantly.

3.7 Design management improvement areas

Interviewees identified thirty-five separate design management issues they felt the company often had experienced. When triangulated with literature it became apparent that many of these issues were not attributable to just one cause but rather are the result of several effects. Therefore, the issues require a combination of techniques to address. For example, while the implementation of a structured and explicit design

process is critical to addressing many of these, its application in isolation would not solve a single problem identified by interviewees. Only when it is used in combination with other techniques will the company be able to overcome the design management difficulties it faces.

Table 3 indicates the relative importance to the company of implementing each improvement mechanism. The chart shows each improvement mechanism with an associated “importance weighting”. The weighting of each improvement mechanism is explained in the methodology section.

Table 3. Weighted improvement mechanisms

improvement mechanism	importance weighting
structured and explicit design process	36
design planning	26
knowledge database	14
integrate design and construction	13
information flow management	7
understand/predict impact of change	2
others	2

The cluster of improvement mechanisms that can help the company address the majority of design management challenges it faces are:

1. **Structured and explicit design process** - provide the team with a clear and explicit description of all the activities that will be carried out during a project, including their order, any dependencies and who should be involved.
2. **Design planning** - help the team plan a robust design in greater detail
3. **Integrate design and construction** - help design and construction team work together more effectively
4. **Information flow management** - help the team manage to create a focus on design information rather than simply design deliverables
5. **Understand/predict impact of change** - allow teams to understand and predict the impact of a potential design change

6. **Knowledge database** - provide historical information to support the needs of other improvement mechanisms.

Focusing research on these six mechanisms would allow the company to successfully address twenty eight (80%) of the issues identified by interviewees and make significant contributions to the resolution of five (14%) further issues. A structured and explicit design process and improved design are the critical success factors that should be complemented by the other measures to deliver targeted improvement.

The seven issues contained within the “others” category in Table 3 have a collective importance weighting of 2. They do not represent core issues challenging the successful implementation of design management within the company and therefore will not be investigated further.

4 Current Research Strategy

The research is now focusing on delivering advancements to the company in five of the improvement areas described above, namely:

- Structured and explicit design process
- Improved design planning
- Integrate design and construction
- Information flow management
- Understand/predict impact of design changes

The development of a knowledge database was also identified in the earlier research as a potential improvement mechanism. However, this was considered to be outside the scope of the research and it is likely that the provision of a knowledge database will be pursued centrally by the organisation in the near future.

We are now addressing the improvement strategy by launching a design management education and training initiative. This involves a series of workshops which examine critical aspects of the management of design

and provide appropriate tools. A handbook has been developed containing training material including discussions on the barriers to effective design management, how to overcome them and a suite of twenty-five design management techniques. The latter were identified in the literature and research reviews and relate to the key improvement mechanisms shown above. They are grouped into four distinct yet inter-dependent categories:

- Planning- to help plan the project to satisfy all stakeholder requirements
- Co-ordination -to help co-ordinate design tasks and information
- Development - to help develop a design satisfying all stakeholder requirements
- Measurement - to help select project partners and monitor their progress

Workshop attendees are provided with an opportunity to discuss issues in the handbook as well as become familiar with the tools through worked examples and exercises. Project team support and a design management intranet site are being provided to ensure that the tools and practices are fully adopted within the company. Dissemination of good practice, on its own, is not sufficient to drive through change [26]. We will also gather feedback on the tools themselves and the impact of their application on projects.

We are currently monitoring the deployment of these tools and supporting training material on a pilot project. We are also gathering information on how individuals perceive each tool; the supporting training material and the effect of each tool on individual and project performance. The findings from this exercise will be used to refine the design management handbook and inform research understanding of design management within the construction industry.

From the deployment and testing of the tools and supporting implementation strategies we anticipate considerable company benefits and research learning. The main benefits are:

- suite of design management tools supported by training material
- company staff introduced to new ideas and tools
- company staff using new ideas and tools on projects
- improved project management (increasing efficiency and effectiveness)
- design management intranet site for support and organisational learning
- understanding the impact of tools on design management practices
- identifying the barriers to introduction and adoption of tools
- developing appropriate implementation strategies
- identifying improvements to existing techniques

5 Conclusions

The investigation to establish current practice of design management within a UK design and construction company has lead to several conclusions.:

Currently the company design process is unstructured, which has lead to the use of varying terminology to describe stages and tasks in the process. The benefits of structuring the design process are that it provides a common language to describe the process and an understanding of the tasks and responsibilities of each project party. From this it can be concluded that a structured design process would benefit the organisation and should be deployed.

Employees are aware of the difficulties they need to overcome to successfully manage the design process, yet the company experiences great difficulties in trying to manage the process. From this situation it can be concluded that the employees need to develop their skills and knowledge so that they can overcome the barriers to managing the design process.

For the company to improve its design management performance the understanding of the very nature of the design process must be improved and employees

should use more of the tools that are available to manage the design process. As we know the type of tools (improvement mechanisms) that employees should use to address the issues facing company we understand where it needs to focus to improve its design management performance. We have been able to devise a structured approach to design management that will benefit the organisation. This is currently being deployed in the form of a design management education and training initiative. It aims to disseminate an understanding of the nature of the design process and provide tools focused on the key needs of the organisation.

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