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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 is trying to improve its design management practices. It 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 understand current practices within the organisation. This paper describes the methodology, results and conclusions of this initial study. The results and conclusions discuss current design management practices within the company, identify areas where improvement is necessary and suggests a research scope 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: case study, construction, design, management, industry practice.

Introduction

In the construction industry, design is self evidently the key process [24]. It is in this phase where the customer's needs and requirements are conceptualised into a physical model of procedures, drawings and technical specifications [8], in the process defining up to 70% of the cost of the final product [19]. The design phase also has many interfaces with several other processes [7] such as the construction, procurement and the client body.

Historically, design has been manageable without the help of special planning and management techniques [3]. However, management of the design process has become increasingly complex as a result of factors such as fast tracking pressures on design [2] and increasing complexity of the fabric and content of buildings, requiring enormous co-ordination effort, which rarely achieves its goals [24]. 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, 6, 10, 20].

The cause of the majority of construction delays and defects can be traced back to poor design performance [15, 16] frequently creating problems that are more significant than those attributed to poor workmanship and site management [4]. This scenario is very familiar to the company under investigation and is a major driver to

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improving design management performance. A partnership of the company, Loughborough University and the Engineering and Physical Sciences Research Council (EPSRC) have commissioned research undertaken as part of a four year Engineering Doctorate (EngD) Programme.

This paper will discuss the methodology, results and conclusions of an initial study undertaken within the company. The results and conclusions discuss current design management practices within the company, identify and discuss the design management issues faced by the company and suggests a research scope to develop a suite of design management tools capable of driving change throughout the company.

Methodology

The methodology devised to meet the research objectives was based on a previous used approach [26] and comprised a literature review, 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 and execute the semi-structured interviews. It was also vital for the triangulation stage of the investigation, where it was used to validate interview results and identify tools and practices to address problems facing the company.

Semi-structured interviews were used to collect data from fifteen interviewees 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 potential to introduce bias. At the other extreme unstructured interviews can produce data that is both difficult and laborious to code and analyse. To mitigate research interview weaknesses, recommended training rules [5] were employed to formulate and execute the research interviews. The interview results were categorised and triangulated with literature as a validation exercise. Triangulation also highlighted underlying causes of problems identified by interviewees and potential solutions to the problems.

The interviewees identified a significant number of weaknesses associated with current design management practice. These were ranked based on the number of interviewees identifying each issue. This indicated the most important issues to address within the company. Each issue was mapped against literature to validate the interview results, understand underlying causes of the issues and identify potential solutions. The solutions identified by reference to literature were then generalised to a cluster of seven “improvement mechanisms” (structured and explicit design process, improved design planning, integrate design and construction, information flow management, understand/predict impact of design changes, knowledge database and other). Each improvement mechanism was ranked based on an “importance weighting” calculated for each using a formula devised by the author and represented by Equation 1.

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

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

Equation 1: importance weighting "X_i" for each improvement mechanism

The weighting exercise provided a simple ranking system for the improvement mechanisms. It indicated the potential of each improvement mechanism to resolve the most important and greatest range of issues identified by interviewees. This is a measure of the importance of each improvement mechanism to the company and thus provided a clear understanding of research activities should focus to benefit the company.

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 examined below.

Nature of Design

When asked to describe the process of design only a third of respondents identified the four design activities of analysis, synthesis, evaluation and dissemination as described by Markus and Arch [23] albeit using varying terminology. They described the design process within the context of a project design process. This is 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 [1] and only one respondent identified an "appraisal" [23] 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. In particular, design managers need a full understanding of the process to be able to manage the process [14] and designers with a knowledge of the general nature of the design process are better equipped to undertake the activity [22].

A structured and explicit design process may help to educate staff about the nature of the design process. A recognised benefit of a structured and explicit design process is

that it allows process participants to understand the process as a whole, their roles and responsibilities [17].

Standard design process definitions

The responses by interviewees when asked whether they were aware of any standard design process definitions are shown in Figure 1. There is a general awareness (73%) of the RIBA Plan of Work. 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".

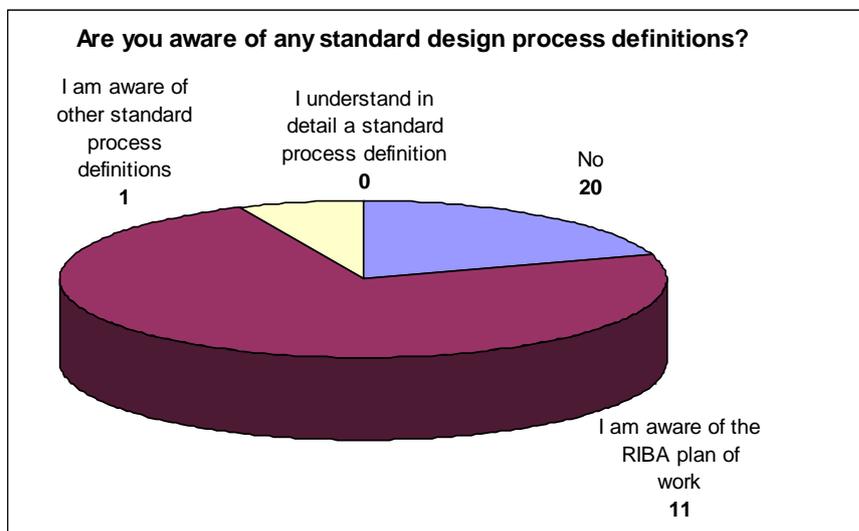


Figure 1: Knowledge of standard design process definitions

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.

This line of questioning has highlighted that the company uses no consistent process for approaching the design phase of a project. It is claimed [13] 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 provides the potential to establish a consistent approach to project design and also [18] to reduce ambiguity in the scope of tasks to be undertaken.

Project Design Stages

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Interviewees were asked to identify the stages of a project design process and define when each started and finished by identifying the activities that occur during each stage. Responses were mapped against four standard high-level design process definitions: The Process Protocol, the RIBA Plan of Work, the BAA Project Process and the AMEC Project Process. 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 were inconsistent descriptions of the activities to be undertaken at each stage.

Concept and Scheme Design stages were not identified by all interviewees and were sometimes described using varying terminology. Tender, Scheme and Preliminary Design were used to describe the Scheme Design stage of the design process. Scheme Development and Concept Design were terms used to describe the Concept Design Stage. Detailed design was the only phase described consistently.

Currently individuals across the company describe project stages with varying terminology and do not have a common perception of the activities undertaken during each project stage. Without common meanings and the value of a common language, there is no hope of generating common aims and objectives within the process [25] as verbal communication can neither create sufficient understanding of a process between various parties nor define issues unambiguously [18]. Therefore it has been suggested [12] that if the many activities that constitute design are not understood, then 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 [27]. 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 [12].

Design management activities and processes

Activities that interviewees believed were part of the design management function are shown in Figure 2. These activities correlate well with the most significant design management problems identified in literature [6, 3, 20]. Therefore it can be concluded that the company understands the fundamental activities necessary to successfully address design management issues and problems. This may be attributed to experience of typical difficulties during the project design phase. The contribution of company staff to the research can therefore be considered valid.

Rank	Activity	Number (n=15)	Problem Factors and Roles Identified in Literature [6, 3, 18, 19]
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	lack of confidence in preplanning for design work/unbalanced resource allocation
4	information flow	11	deficient or missing input information/information management/poor communication
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 process
9	interface management	8	lack of co-ordination between disciplines/interface management
10	project team structure / development	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

Figure 2 Interviewee perceived design management activities compared against literature sources

Design management tools

The tools used by interviewees to manage the design process are shown in Table 1. They range from “meetings” to “financial control schedules”. Other typical tools used 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 only a third of interviewees said that they use it to manage design.

Rank	Tool	Interviewee Reference											Number (n=15)						
		J	M	A	B	D	K	L	C	E	F	I		O	N	G	H		
1	meetings			x			x			x	x			x	x	x	x	8	
2	project programme				x	x			x								x	x	5
3	information release schedule								x							x	x	x	5
4	electronic document management															x	x	x	5
5	design deliverable schedules								x								x	x	4
6	milestone dates																x	x	3
7	financial control schedule																x		1
Total number of tools used		0	0	1	1	1	1	1	2	2	2	3	3	4	5	5			

Table 1 Matrix of design management tools used by interviewees

The matrix on Table 1 provides detailed information of the tools used. A cross marks where a particular interviewee uses one of the tools identified and the shaded area shows tools identified that are not used by that interviewee. Thirteen out of the fifteen interviewees responded positively to this answer, but only five use a combination of three or more of the tools. Five interviewees use only one of the seven tools identified. Other than interviewees G, H and N, there is an ad-hoc approach to the type and

number of tools used to manage the design process. This indicates a lack of a consistent approach to design management, which is likely to produce an inconsistent level of performance across the company.

The company does not use many tools to manage the design process, the tools they use are relatively simple and there is an ad-hoc approach to their use throughout the organisation. Design managers need better tools and techniques to help them manage the design process [4]. There needs to be a more consistent application of tools that are appropriate to managing the design process. In particular, design planning and monitoring tools used should aim to account for the iterative nature of the design process and focus on design information rather than simply design deliverables.

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.

Design management weaknesses

Interviewees identified thirty-five separate design management issues they felt the company often had problems with. 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 resolve. For example, while the implementation of a structured and explicit design process is critical to solving many of the issues, 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 address the design management issues it faces.

Figure 3 indicates the relative importance to the company of implementing each improvement area. The chart shows each improvement area with an associated "importance weighting" based on the number and importance of the issues it can help in solving. The weighting of each improvement area is explained in the methodology section.

The cluster of improvement areas where the company can address the major and majority of design management challenges it faces is:

- **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.
- **Design planning**
help the team plan a robust design in greater detail
- **Integrate design and construction**
help design and construction team work together more effectively
- **Information flow management**
help the team manage the create a focus on design information rather than simply design deliverables
- **Understand/predict impact of change**
allow teams to understand and predict the impact of a potential design change
- **Knowledge database**
provide historical information to support the needs of other improvement mechanisms.

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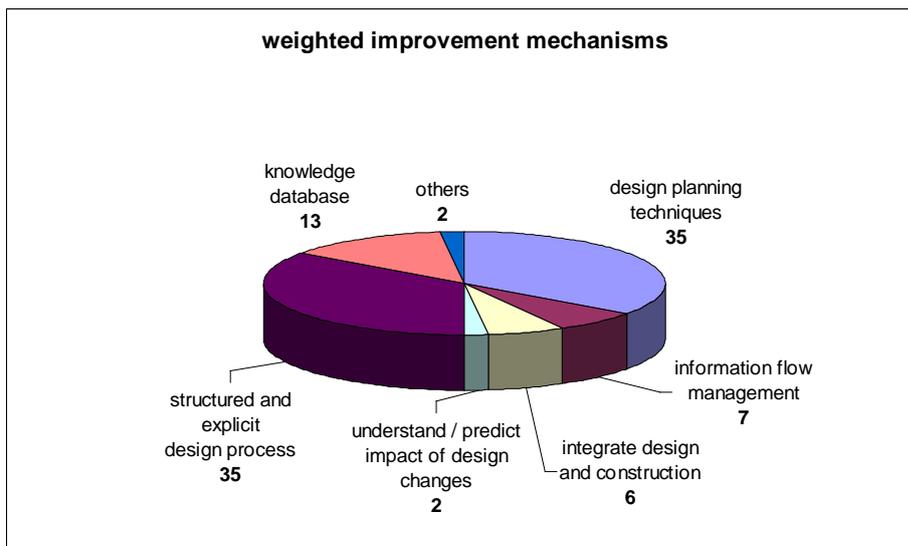


Figure 3 Weighted Improvement Mechanisms

Focusing research and improvements on these six areas would allow the company to successfully address 28 (80%) of issues identified by interviewees and make significant contributions to the resolution of 5 (14%) further issues. A structured and explicit design process and improved design and project planning 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 on Figure 3 have a collective importance weighting of 2. They do not constitute the core issues challenging the

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successful implementation of design management within the company and therefore will not be investigated further.

Current Research Strategy

The cluster of improvement areas where the research is now focusing on delivering advancements to the company is:

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

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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 areas by launching a design management handbook containing educational material discussing the barriers to effective design management, how to overcome them and a suite of twenty-one design management tools. The tools were identified in the literature review and address the key improvement areas 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

To ensure that the operation of each tool is transparent [11] the handbook is being supported through a series of workshops. Workshop attendees are provided with opportunity to discuss ideas 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 also being provided to ensure that the tools and ideas are fully adopted into the company. It has been suggested that providing support for tools is important in getting the tools adopted in industry [9].

We are currently monitoring the deployment of these tools and supporting educational material on a pilot project. We are gathering information on how individuals perceive each tool, the supporting educational materials 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. They will be reported in due course.

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

Company Benefits

- Suite of design management tools supported educational material
- Company staff educated about new ideas and tools
- Company staff using new ideas and tools on projects
- design management intranet site

Research Learning

- understand impact of tools on design management practices
- understand the barriers to introducing and using tools
- understand necessary components of implementation strategies
- understand similarities and differences between similar research

The exact details of the anticipated benefits will be reported on in due course.

Conclusions

The investigation to establish the quality of design management practice within a UK design and construction company has identified several issues.

A structured and explicit approach to the design phase of a project should be applied throughout the company. It should aim to promote an understanding of the nature of the design process and the use of a common language to describe the construction design process and its many activities. The adoption of a company-wide design process model is suggested to address these issues.

The company has an understanding of the fundamental design management activities that should be implemented in practice to successfully manage the process. However, the tools used are relatively simple and applied on an ad-hoc basis throughout the company, indicating a lack of consistent approach to design management. In particular, design planning should be undertaken using tools appropriate to plan and control an information driven, iterative and ill-defined process such as construction design.

Current design management strengths are associated with practitioners' traditional design consultant role.

Design management issues and problems are often not the results of one single factor. Rather, they are the result of a combination of factors and require a range of improvement mechanisms for their successful resolution. Also, it appears that a single improvement mechanism can be applied to assist in resolving several design management issues.

Research is now focusing on delivering improvements in design management performance by launching a design management handbook containing tools and educational material discussing the barriers to effective design management and how to overcome them. The tools that are being launched are grouped into four distinct yet inter-related categories:

- Planning
- Co-ordination
- Development
- Measurement

The handbook is being supported through a series of workshops where the educational material and tools are presented. Project team support and a design management intranet site are also being provided to ensure that the tools and ideas are fully adopted into the company. Deployment of these tools and educational support is currently being monitored on a pilot project, the results of which will be reported in due course.

The strategy we have adopted allows the tools and ideas to be introduced into the company while providing the opportunity for innovative research. The results of the research will be published in due course as the project progresses.

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