THE IMPACT OF A DESIGN MANAGEMENT TRAINING INITIATIVE ON PROJECT PERFORMANCE

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ABSTRACT

Over recent years there has been a significant drive away from traditional procurement routes where contractors find themselves with an increasing responsibility for the control of the design - a process they have had little experience in managing. Yet this is an area of significant opportunity for those contractors who can adapt quickly and effectively to the changing construction market. However, many current processes are insufficient to manage today's demanding and fast moving projects.

The paper reflects on the deployment of a design management training initiative to improve performance in a major UK civil and building design and construction company. It investigates the impact of the training initiative, critical practices and a suite of 25 tools on design management performance across the company. It highlights benefits delivered by the initiative as well as the practices and tools crucial to successful design management. The paper also explores the range, significance and hierarchy of implementation barriers that affect the success of design management practices and reports on strategies that have been used on a case study project to overcome such barriers. The 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, training.

1. INTRODUCTION

To reduce their risks associated with construction projects clients are increasingly adopting design and build type procurement routes in favour of traditional contracts. As a result, contractors are now expected to accept an increasing responsibility for the control of design - a process they have had little experience in managing. They now have to adapt accordingly. The learning curve is steep, not least because many projects must now be delivered fast track while co-ordinating the increasingly complex fabric (Austin *et al*, 1996) and content of buildings without a platform of accepted good practice to manage the design process. This is a major factor preventing the UK construction industry from delivering projects on time, to budget and to the specified quality.

As the target is to increase Design &Build projects to a 50% share of the UK construction market by 2008 (Egan *et al*, 2002) it is necessary to educate an increasing number of people in design management practices and tools to equip them to manage today's fast moving and demanding projects. However, many current design management tools are insufficiently developed for the industry (Bibby, *et al*, 2003b).

They are fragmented, insufficiently developed, poorly deployed and couched in abstract terms (Freire and Alarcon, 2000; Frost, 1999). Moreover, as they tend to be overly complex and force practitioners into unwanted procedures (Kanter, 2000), they are unlikely to gain wide adoption. Therefore, to improve design management in the industry, current techniques must be modified to align them with the needs of the modern design manager to manage the construction design process.

Previous research (Bibby *et al*, 2003b) has developed a training initiative to improve design management within a major design and construction company with interests in PFI, Prime Contracting, D&B as well as traditional contracting. For the past three years, through a partnership with Loughborough University and the Engineering and Physical Sciences Research Council (EPSRC), this research has been applying a new approach to design management to adapt to the changing UK construction market.

The initiative comprises a Design Management Handbook, Design Management Training, Team Support and Project Monitoring. The Design Management Handbook is the core of the training initiative. It provides guidance on critical aspects of design management practice and a suite of twenty-five tools. Training on practices and tools has been provided to approximately 600 employees across project teams throughout the company. Project teams have been supported in the implementation of the new practices and tools through Team Support to help embed new ways of working in company practice. Project Monitoring has helped establish the impact of the new practices on project performance to demonstrate that they are working and thus reinforce change.

The effectiveness of the training initiative on the company's design management performance has been explored through a combination of questionnaires, semi-structured interviews, maturity assessment and a case study. This has established which practices and tools are being used, which ones are not, as well as understanding the applicability and performance of each practice and tool. It has also identified the barriers to implementing new design management tools in the industry as well as developing and testing strategies to overcome such barriers.

While the training initiative was undertaken to suit the needs of a major D&B contractor, its development was influenced by best practice within and outside the industry, as well as common barriers identified in the literature (Bibby *et al*, 2002). Hence, lessons learned in this paper should be widely applicable to those involved in design management and the development of tools and practices to help the industry improve design management performance. Research to quantify the impacts of success factors has been limited, particularly with respect to design performance (Kuprenas, 2003). Whilst the findings are based on a single organisation, the work carried out represents a significant step forward for the industry in developing strategies to deliver improvements to design management performance.

2. RESEARCH METHODOLOGY

The research in this paper sought to establish the impact of the design management training initiative on individual and project performance. The methodology comprised a structured questionnaire, design management maturity assessment, semi-structured interviews and a case study investigation.

The structured questionnaire identified who out of 46 employees exposed to the training initiative as part of a pilot study had used the design management handbooks practices and tools. This was to identify who was to be interviewed in more detail, why others did not use the handbook and their views on the awareness training. Interviewees comprised 15 Design Managers 5 Project Planners, 8 Quantity Surveyors, 5 Project Directors, 5 Project Managers, 3 Bid Managers, 2 Systems Managers, 1 Document Controller and 2 Procurement Managers spread over 14 projects. Good practice in preparing and conducting the questionnaire was used in this research (Race, 2001; Fellows and Liu, 1997).

The maturity assessment used a Design Management Maturity Model shown in Figure 1 and conceptually based on the Capability Maturity Model (Rosenstock, Johnston, & Anderson, 2000; Skulmoski, 2001) which has widespread acceptance as a standard for assessment of organisational maturity (Crawford, 2002). It is a two dimensional matrix with the horizontal and vertical axes representing the level of maturity (between 1 and 5) and the key areas of design management respectively. The nine key design management areas and their maturity levels were defined using references to previous work (Bibby *et al*, 2002; Bibby *et al*, 2003b) and a model developed to test the maturity of design supply chains (Austin *et al*, 2001).

The assessment was carried out in three stages. The first and second stages were carried out immediately before and after all 46 respondents received awareness training. This was to establish the change in opinion on the company's design management performance caused by the training. The final assessment took place as part of the semi-structured interview exercise and aimed to capture the change in design management maturity delivered by the training initiative. As this final assessment was carried out with those that had used design management handbook practices and tools, only these results have been used to identify the impact of the training initiative on design management maturity within the company. While it would have been preferable to capture the opinion of all 46 respondents at the final assessment stage, the results are still considered valid as the exercise captured the change in opinion of individuals on the company's design management maturity over the period of the training initiative.

	Level 1 Haven't thought about it	Level 2 Thinking of doing something about it	Level 3 Beginning to do something about it	Level 4 Doing it as normal business	Level 5 Advanced practices developed
establishing and communicating design briefs	no process to establish and communicate project design briefs	inconsistent approach to establishing and communicating project design briefs	collaboratively ensure all stakeholders needs are articulated, captured and understood before phase begins	consistently establish and communicate work scope and delivery details for whole project	consistently establish and communicate work scope and delivery details for whole project and individual disciplines
design management roles and responsibilities	no consideration given to defining the roles and responsibilities of a design manager	ad-hoc approach to defining roles and responsibilities of a design manager	roles and responsibilities of a design manager defined	roles and responsibilities of design manager and the involvement of other parties in design management defined	all parties aware of their potential contribution to and involvement in design management
selecting team members	no selection process used to identify suitable design team members	inconsistent approach to assessing and selecting potential design team members	structured means to identify and assess consultant's skills	structured means to differentiate assessed skills of consultants to select a preferred consultant	performance data used to assess consultant skills and determine selection
integrated design planning	design is planned separately from the procurement and construction processes	major design activities planned with consideration of construction requirements	major design, procurement and construction activities linked and integrated	individual design activities of all disciplines integrated with each other and construction activities	resource allocation considered on integrated project programmes
ensuring design delivery	no effort to manage the distribution of design deliverables	document management recognised as a major task that must be improved	inconsistent management of the production and issue of design deliverables	consistent management of the production and issue of design deliverables	range of approaches to manage the production and issue of design deliverables to all parties
managing information flow	design information distributed to all parties without consideration of needs	recognised overload of information flow and need to improve practices	information distributed based on issuers perception of recipient needs	information needs of each party understood with parties able to access essential information	fully co-ordinated needs expressed: specific information requirements and why each is needed.
developing the design	design development undertaken in uncontrolled manner and designers working in isolation	inconsistent design development but designers collaborating on major issues	structured approach to design development and designers collaborating on most issues	structured approach to design development and designers collaborating where necessary	design team operating within fully integrated and collaborative design environment
value consideration in design process	no consideration of value in design development process	aware that can and should be considering value in the design process	inconsistent approach using value analysis techniques in the design process	phased set of value analysis activities structured into the design process	value generation process undertaken as an intrinsic part of the design development process
managing design changes	design changes implemented by instruction	inconsistent approach to the assessment of design change proposal	consider design changes proposals by identifying and assessing significant impacts	design proposals assessed consistently using structured process to identify and assess time, cost and quality impacts	ability to quickly and effectively explore potential design change options

Figure 1: Design Management Maturity Assessment Model

Semi-structured interviews captured the impact of the practices and tools presented by the training initiative on individual and project performance as well as the difficulties people had in applying the practices and tools. The views on the Design Management Handbook, the Awareness Training and a Design Management Intranet site set up as part of the training initiative were also sought. This approach avoided the potential for bias and difficulty in coding data associated with structured interviews and unstructured interviews respectively.

The 20 interviewees comprised 14 Design Managers, a Quantity Surveyor, a Project Director, a Project Manager, a Bid Manager, a Systems Manager and a Document

Controller spread over 8 projects. Good practice in preparing and conducting interviews was used in this research (Race, 2001; Fellows and Liu, 1997).

To understand the impacts of, and the barriers to using each of the design management practices and tools, interview results were coded and analysed in four steps:

Step 1: impacts and barriers identified by interviewees for each practice and tool were categorised into 14 separate impacts (critical and supportive) and 23 separate barriers (selection, pre-application and application barriers) respectively. Critical impacts are primary project goals related to time, cost and quality, e.g. a design meeting all client requirements. Supportive impacts are precursors to achieving critical impacts; e.g. project team members are collaborating. Selection barriers will stop a user choosing to use a tool; e.g., a tool might not be appropriate for the procurement route being considered. Pre-application barriers dissuade users from applying a tool in the belief that project circumstances would prevent it from being successful. E.g., a lack of agreed project design management processes could prevent a change control process being introduced as it may not be recognised or used by other project team members. Application barriers are those barriers that affect the successful operation of a tool in use. E.g., project parties not collaborating can have a significant effect on focusing development early in the process.

Step 2: Equation 1 was used to establish the percentage (P_1) of respondents using each practice / tool that reported an impact. Equations 2, 3 and 4 were used to identify the percentage of respondents who identified the selection, pre-application and application barrier at the choice, preparation and implementation stage of each practice and tool - P_2, P_3, and P_4 respectively. These four equations helped identify the relative significance that each impact and barrier has.

Step 3: To highlight which impacts and barriers were most significant it was necessary to differentiate impacts identified by a few from those identified bythe majority. Equation 5 was developed and used to obtain a weighted score for each impact and barrier.

Step 4: The weighted scores in each category (critical and supportive impacts, selection, pre-application and application barriers) were ranked and cumulative percentage graphs of the weighted scores prepared. This identified the impacts / barriers that represented 80% of the maximum cumulative weighting score in each category and thus which can be considered the most significant.

$$P_1 = \frac{\Sigma \text{ practice / tool had positive project impact}}{\Sigma \text{ used practice / tool}} \times 100 \qquad P_3 = \frac{\Sigma \text{ pre-application barrier reported against practice / tool}}{\Sigma \text{ not had opportunity to use practice / tool}} \times 100$$

$$P_2 = \frac{\Sigma \text{ selection barrier reported against practice / tool}}{\Sigma \text{ did not need to use practice / tool}} \times 100 \qquad P_4 = \frac{\Sigma \text{ application barrier reported against practice / tool}}{\Sigma \text{ used practice / tool}} \times 100$$

Equations 1, 2, 3 and 4: Equations for calculating P_1, P_2, P_3, and P_4

$$W = 10(0.05a + 0.25b + 0.5c + 0.75d)$$

W - weighted score for impact / barrier

a - number of times impact / barrier identified by at least 5% respondents

b - number of times impact / barrier identified by at least 25% respondents

c - number of times impact / barrier identified by at least 50% respondents

d - number of times impact / barrier identified by at least 75% respondents

Equation 5: Weighted Score for Design Management Impact or Barrier

The case study was undertaken to help understand at first hand issues and barriers to deployment of design management practices and tools. The project team was supported in implementing practices and tools. The views of the project team, client and designers were sought throughout the exercise to determine the appropriate tools, how they integrated with other project processes, whether any modifications or additions were required and how to overcome the selection, pre-application and application barriers.

3. DESIGN MANAGEMENT AWARENESS TRAINING

The awareness training (where practices and tools are presented) was well received as illustrated by Table 1. Many believed it helped to appreciate design management issues by expanding and clarifying their own ideas and covered all issues in a detailed and methodical way. Interviewees liked the open forum presentation style that allowed discussion of issues by all project team members. It also helped them work with the design management team and designers by explaining the benefits of practices / tools as well as explaining designers' needs and difficulties which has helped to break down professional friction (or conflicts) that can hinder team working (Baldwin and Jarrett, 2002).

	It has helped me appreciate DM issues		**It has helped me work with DM team and designers**		**It has improved my performance**		**It has improved project performance**	
	total	**%**	**total**	**%**	**total**	**%**	**total**	**%**
strongly disagree	0	0%	0	0%	0	0%	0	0%
disagree	0	0%	1	2%	2	4%	2	4%
neutral	4	9%	7	15%	8	17%	23	50%
agree	33	72%	32	70%	31	67%	21	46%
strongly agree	9	20%	6	13%	5	11%	0	0%

Table 1: Comments on Design Management Awareness Training

Over three-quarters of interviewees consider that their personal performance was improved by attending the awareness training. Several said it helped understand the design process, its issues and potential bottlenecks in detail; showed how to prepare a good design programme and emphasised the need for the whole project team to respect the design freeze process. Almost half of interviewees said the awareness training positively affected project performance by getting the construction team to understand design management and the whole team to question and improve design management

and other project processes. Several suggested that design process improvements were difficult to identify as they were masked by the activities of other project members. For example, when a designer issued drawings early, subsequent procurement and construction activities were not ready to use the drawings - resulting in lost improvements. Also, several interviewees noted that designers were reluctant to plan the design in detail and the client was not respecting the design freeze process. Such examples illustrates the effect of departmentalising in sub-optimising the design process in line with Womack and Jones' (1996) lean thinking and reinforces the findings of earlier work (Bibby *et al*, 2003a) that design management can be significantly affected by the actions of others in the "project system".

One unanticipated comment repeated by several interviewees was that the mere presence of the researcher within the company had a positive impact on design management performance. By being a persistent champion for design management it has raised the awareness of design management and acted as an impetus for change across the company. It may have also addressed a key problem of training noted by (Beer *et al*, 1993) that employees often become frustrated when their new skills go unused in an organisation where nothing else has changed – thus undermining commitment to change. However, as the presence of the researcher has maintained the momentum of the change programme this has helped to address such barriers.

Several conclusions can be drawn from these observations. The awareness training has been successful by getting the project team to understand design management, to work with design management / design teams and has improved their personal performances. Also, the presence of the researcher within the organisation has acted as an impetus for change. However, process improvements can be hidden by other project operations. Therefore, future projects should include the design team and client in awareness training, delivered at each project start up and involve the agreement of project design management processes. This helps ensure a consistent process (Kagioglou *et al*, 1998) and allows genuine involvement which is essential for introducing new ways of working (White, 1979). It is therefore a good strategy for addressing pre-application barriers. On the case study project all parties commented on and agreed design management processes, which has helped to embed the practices and tools in the project processes.

4. DESIGN MANAGEMENT HANDBOOK, PRACTICES AND TOOLS

4.1 Use of the Handbook

The overwhelming majority (14/15) of design managers did use the handbook with only one unable to do so because of lack of time and supporting resources to prepare tools for his project. Encouragingly 6 non-design managers also used the Design Management Handbook practices and tools. The remaining 26 interviewees did not use the practices and tools: 12 did not need to use it as part of their work and 14 did not have the opportunity to use the practices and tools. This was due to one of the following:

- the practice or tool being introduced too late for use in the project process;
- current processes not written to suit application of the tools; or
- that interviewees lacked the time or resources to put the tool into place.

However, some said they would use the Handbook in future if processes were mandatory, if all project operations were involved in defining project design management processes, and if more project time was allowed to develop processes.

The first two barriers were addressed on the case study project by involving all project disciplines in the selection of design management processes and their definition in a mandatory Project Design Management Plan (PDMP). As a lack of time is a common design phase problem (Austin *et al*, 1996), it is unlikely that more will be available to develop processes. However, the case study comments suggest that using a model PDMP will require less time to define processes.

The Handbook tools were taken by the company and included in its Integrated Management System (IMS) available through the company Intranet. Few interviewees used it as it did not provide anything in addition to the Handbook, there were some initial access problems and many considered the format made it difficult to navigate the IMS.

In conclusion, design managers are clearly using the Handbook and other project disciplines are also starting to adopt it. Case study experience has shown that the deployment of a PDMP can help overcome implementation barriers.

4.2 Handbook Content and Format

Table 2 shows interviewees comments on the Handbook. An overwhelming majority considered that the handbook had a clear and logical format, which was also easy to read and understand. Many also liked the standalone format of each section containing all guidance for that subject area and directed users to the associated tools. The majority believed that the handbook provided a good understanding of the subject and showed how to manage the design process by providing good practice that can be applied relatively easily and explaining how to overcome typical design management problems.

	Has a clear and logical format		**Is easy to read and understand**		**Gives me a good understanding of subject**		**Shows how to manage the design**	
	total	**%**	**total**	**%**	**total**	**%**	**total**	**%**
strongly disagree	0	0%	0	0%	0	0%	0	0%
disagree	0	0%	1	5%	1	5%	2	10%
neutral	1	5%	4	20%	5	25%	1	5%
agree	16	80%	11	55%	10	50%	15	75%
strongly agree	3	15%	4	20%	4	20%	2	10%

Table 2: Comments on the Design Management Handbook

Table 3 shows that there were no problems reported related to the content and style of any practice or tool, therefore, the Handbook appear to be a useful tool to diffuse design management practices and tools throughout the company.

4.3 Use of Design Management Practices and Tools

There is an interesting picture of use and success of design management practices and tools amongst interviewees, principally illustrated in Tables 3, 4 and 5. Table 3 shows

the level of use of design management practices and tools amongst interviewees. The values shown are the percentages of interviewees who agreed with the statements in the table against each practice and tool. Table 4 shows the critical and supportive impacts that were provided by each practice and tool. The values shown are the percentages of the interviewees that had used a practice / tool that reported a positive impact delivered by the practice or tool. Table 5 illustrates the selection, pre-application and application barriers that affected the performance of each design management practice and tool. For selection barriers the values represent the percentages of interviewees that did not need to use a practice / tool as part of their work and reported that a selection barrier caused them not to use it. For pre-application barriers the values represent the percentages of interviewees that did not have the opportunity to use a practice / tool and stated that this was caused by a pre-application. For application barriers the value represents the percentages of interviewees that used a practice / tool stating that an application barrier affected the performance. Values in all tables recorded as 0% have been omitted for clarity. The cells in the tables have also been shaded following the key shown by each table for clarity.

Generally, interviewees have used the design management practices and tools with many reporting positive personal and project performance impacts. All practices, apart from Rigorous Team Selection provided between three and five critical project impacts. Therefore, they are crucial to effective design management. The following practices delivered significant levels of critical and supportive impacts and as such are the foundations of design management: capturing, clarifying and owning stakeholder requirements; progressive freezing of design details; be more specific with design scope of works; involve parties at the right time in the process; monitor all design deliverables; control issues of deliverables and information.

As few interviewees undertook Rigorous Team Selection or used associated tools P07 Consultant Benchmarking, and P08 Consultant Interviews, it is difficult to establish their importance to effective design management. This activity is typically the responsibility of the company's senior management. Comments suggested they did not carry out design team selections in the rigorous and structured manner suggested by the Handbook. However, many believed that it is an important design management task and that the company should do it more rigorously. From this, it would appear that senior management have not taken the opportunity to take the lead to apply new design management processes.

Table 4 shows the practices against which users reported a low instance of positive impacts. These practices are: allowing adequate design time, planning the design in detail and collaboratively, managing interfaces, investigating and controlling potential design changes, and focusing development effort early in the process. This appears to be the affect of a combination of barriers at pre-application and application stages. The pre-application stage barrier affecting all practices is the lack of leadership from senior management. However, during application there are four common barriers affecting the practices: lack of leadership from senior management, construction team ignoring design freeze / change control, client ignoring design freeze / change control and parties not collaborating.

Key

75-100

50-74

25-49

0-24

		Yes					No					
		I have tried to implement the practice / tool	It had a positive effect on my performance	It had a positive effect on project performance	Barriers affected the success of the practice / tool	I modified the practice to suit my needs	Do not need to use it as part of work	Not had opportunity to try practice / tool as yet	Did not understand handbook / training content	Did not like handbook / training style	Practice / tool does not help to manage the design process	Practice / tool does not fit with the project's procurement route
design management practices												
Rigorous team selection based on range of criteria		15	15	15	75	5	75	10				
Capturing, clarifying and owning stakeholder requirements		80	80	60	35			20				
Understanding the process of design in detail		95	85	65	35			5				
Allow adequate design time		65	35	25	80			35				
Plan the design in detail and collaboratively		80	65	55	50			20				
Integrate design, procurement and construction activities		85	70	70	40			15				
Progressive freezing of design details		80	65	65	50			20				
Be more specific with design team scope of works		90	85	70	30			10				
Control issue of deliverables and information		90	80	65	45			10				
Manage interfaces		75	65	55	65			25				
Investigate and control potential design changes		65	55	40	75			35				
Focus development effort early in the process		80	55	55	75			20				
Involve parties at the right time in the process		80	80	80	30			20				
Monitor all design tasks and deliverables		80	75	80	25			20				
planning tools												
P01	brief document	80	80	70	15	25		20				
P02	concept design stage kick-off meeting	15	15	15	75	5	75	10				70
P03	tender design stage kick-off meeting	25	25	25	60	15		75				
P04	detailed design stage kick-off meeting	15	15	15	60	10	55	25				50
P05	design change workshop	35	30	30	60			65				
P06	master design programme	65	65	50	55		15	20				
P07	consultant benchmarking	5	5	5	90		85	10				
P08	consultant interviews	5	5	5	95		85	10				
P09	discipline design programme	65	65	65	30		10	25				
P10	job description	5	5		55		95				30	
co-ordination tools												
C01	information transfer schedule	85	85	75	15	35		15				
C02	work package control document	75	75	70	5	35		25				
C03	co-ordination meeting	95	90	80	20	30		5				
C04	design workshop	65	65	65	10	15		35				
C05	staged information delivery	40	40	35	10	5	5	55				
C06	fix information	40	40	30	30	15	5	55				
C07	interface schedule	40	40	30	30	15	5	55				
development tools												
D01	value analysis	45	45	45	50	5		55				
D02	brainstorming	65	65	60		10	15	20			10	
D03	decision matrix	5	5	5	55		60	35			60	
D04	task force meeting				40		50	50			40	
D05	design review document	30	30	30	10	20	15	55				
D06	design proposal document	30	30	30	30	20	15	55				

Table 3: Use of Design Management Practices and Tools

Key

75-100

50-74

25-49

0-24

		Used the practice / tool	Do not need to use it as part of work	Not had opportunity to try the practice / tool as yet	critical impacts: Design delivered on time/early	Design met all client requirements	Delivered co-ordinated design	Fewer late design changes	Cost certainty of design	supportive impacts: All parties clear of their responsibilities	Helps identify / solve potential difficulties	Monitors and controls progress	Helps assess impacts of potential decisions	Got project parties collaborating	Provides audit of decisions made	Identified design interdependencies	Better design programmes	Incorporates needs of all stakeholders
design management practices																		
Rigorous team selection based on range of criteria		15	75	10							65				35			
Capturing, clarifying and ownership of stakeholder requirements		80		20	50	55	5	25	30	30	5			5				
Understanding the process of design in detail		95		5	5		20	10			35			30		45		
Allow adequate design time		65		35	15	10	10		10		15					10	15	
Plan the design in detail and collaboratively		80		20	30		45			25	25		15	45		20	20	
Integrate design, procurement and construction activities		85		15	45		45	5		20	10		5	35		5	5	
Progressive freezing of design details		80		20	75		30	55	5					15				
Be more specific with design team scope of works		90		10	50	50		50		45	5	5		5				
Control issue of deliverables and information		90		10	60	40	5	10		55								
Manage interfaces		75		25	5		15	5		55				5		45		
Investigate and control potential design changes		65		35	25			30	10	15			60	10				
Focus development effort early in the process		80		20	55	15	5	5	40		5							
Involve parties at the right time in the process		80		20	90	50	40	55	30		65			40				
Monitor all design tasks and deliverables		80		20	50					45	45	70						
planning tools																		
P01	brief document	80		20	50	55		45	15	70				15				
P02	concept design stage kick-off meeting	15	75	10						100								
P03	tender design stage kick-off meeting	25		75						100								
P04	detailed design stage kick-off meeting	15	55	25						100								
P05	design change workshop	35		65				30	15				70	30				
P06	master design programme	65	15	20	40		30			30				40		55	25	
P07	consultant benchmarking	5	85	10									100		100			
P08	consultant interviews	5	85	10								100	100					
P09	discipline design programme	65	10	25	55		40			45	25	10		15		25	90	
P10	job description	5	95															
co-ordination tools																		
C01	information transfer schedule	85		15	60	5	25			60		55				10	10	
C02	work package control document	75		25	65	55	5	25	5	45		15		20	5			
C03	co-ordination meeting	95		5			75	5		35	10			10				
C04	design workshop	65		35	25		30	15	10		75			60				
C05	staged information delivery	40	5	55	75	15		50	15					15	15			
C06	fix information	40	5	55	50			50	15					15				
C07	interface schedule	40	5	55			25			65				15				
development tools																		
D01	value analysis	45		55	45	65			55		35							
D02	brainstorming	65	15	20	15	15				10	85			15				
D03	decision matrix	5	60	35											100			100
D04	task force meeting		50	50														
D05	design review document	30	15	55	50	100		15	35			15						
D06	design proposal document	30	15	55	85	65		35	35									
monitoring tools																		
M01	progress report	75		25	55		55			20	45	60						
M02	progress meeting	80		20	65		50			40	50	75						
cumulative weighted % of times impact identified against all practices and tools																		
weighted score					33	6	5	4	2	14	7	5	4	3	3	1	1	1
cumulative weighted percentage score					66	78	88	95	100	71	80	86	91	94	96	98	99	100

Table 4: Impacts Delivered by Design Management Practices and Tools

Key

- 75-100
- 50-74
- 25-49
- 0-24

	selection barriers			pre-application barriers								application barriers										
	Responsibility of other management function	Does not help manage the design process	Not suited to D&B procurement route	Lack of leadership from senior management	No agreed project design management process	Client ignoring design freeze / change control	Inflexible construction programme	Commercial decisions / lack of decisions affecting design	Construction team ignoring design freeze / change control	Inflexible client programme	Parties not collaborating	Lack of leadership from senior management	Construction team ignoring design freeze / change control	Client ignoring design freeze / change control	Parties not collaborating	No agreed project design management process	Inflexible construction programme	Insufficient design resources	Commercial decisions / lack of decisions affecting design	Insufficient design management resources	Designers lacking required skills	Inflexible client programme
design management practices																						
Rigorous team selection based on range of criteria	100			100																		
Capturing, clarifying and ownership of stakeholder requirements				25	25			25					5	15	20							
Understanding the process of design in detail												10			20		10	10	5		5	
Allow adequate design time				15		15	30			30		25	25	10	40		25	15	25	10		15
Plan the design in detail and collaboratively				50	25		25	25				20	5	5	30	5	5	15		5	5	
Integrate design, procurement and construction activities				35			35					20	10	5	10	10	5	10	5	5	10	
Progressive freezing of design details				25								25	40	40	5	15						
Be more specific with design team scope of works				50								10				15		5	10	5	5	
Control issue of deliverables and information				50								15		10	10	15		20		5		
Manage interfaces				40	60							15	15	5	35	15	5	5		5		
Investigate and control potential design changes				30	15	30			15		15	40	40	40	15	25		10				
Focus development effort early in the process				25	50	25			25			25	30	25	30	15	5	5	20	5		
Involve parties at the right time in the process				25	50								5		15				15			
Monitor all design tasks and deliverables				25	25							15						5	5		5	
planning tools																						
P01 brief document				25	75															5		
P02 concept design stage kick-off meeting			100																			
P03 tender design stage kick-off meeting				40	35						5	40				20						
P04 detailed design stage kick-off meeting	10		90	20	20											35						
P05 design change workshop				15	25	40						15	45	30								
P06 master design programme	100			25	25							10		15	10		25	15	10	10		
P07 consultant benchmarking	100			50	50																	
P08 consultant interviews	100			50	50																	
P09 discipline design programme				20	20							25	10		15		10	25				
P10 job description		60																				
co-ordination tools																						
C01 information transfer schedule												5			10			5				
C02 work package control document												5										
C03 co-ordination meeting												15	5		10					5		
C04 design workshop												10										
C05 staged information delivery							10															
C06 fix information	100			10	10							15	25	25								
C07 interface schedule					45	10			10			15	15	15								
development tools																						
D01 value analysis				10	55	10						20	10		10	45						
D02 brainstorming		65																				
D03 decision matrix		100																				
D04 task force meeting		80																				
D05 design review document					20																	
D06 design proposal document					45											15						
monitoring tools																						
M01 progress report					20											5						
M02 progress meeting					25																	
cumulative weighted % of times impact identified against all practices and tools																						
weighted score	11	4	2	7.7	7.7	1.1	1.0	0.6	0.4	0.3	0.1	2.6	2.3	1.9	1.8	1.4	0.9	0.9	0.7	0.5	0.3	0.1
cumulative weighted percentage score	63	88	100	41	82	87	93	96	98	99	100	20	37	51	65	75	82	89	94	98	100	100

Table 5:Barriers Experienced by Design Management Practices and Tools

P01 Brief document, P06 Master design programme, P09 Discipline design programme were effective planning tools, positively affecting the performance of over half interviewees and delivering critical and supportive project impacts. P06 could perhaps have been more successful but was affected at the pre-application stage by the lack of leadership and agreed design management processes to get project teams to prepare and buy into detailed design planning. The application of P03 Tender Kick-off Meeting and P05 Design Change Workshop had some success. However, use and impact was limited with the former providing a supportive impact and the latter three critical impacts. P03 was affected by the lack of leadership and agreed design management processes at pre-application and application stages. Practitioners were dissuaded from using P05 through a lack of agreed design management process framework on which to base the tool and the client issued changes by instruction, thus ignoring design freeze and change control.

Few interviewees used P02 and P04 concept and detailed design kick-off meeting. It appears that they do not fit in with the company's role within the D&B procurement route. The company is rarely involved early enough in a project to use P02. In Design and Build project interviewees noted no clear step between tender and detailed design thus P04 was unnecessary and P03 Tender design kick-off meeting was sufficient.

Many did not use P10 Job Description, D03 Decision Matrix and D04 Task Force Meeting saying they did not help to manage the design process. Interviewees could not see any real application for D03 and D04 the tools in their work. P10 was considered too structured for the varied and fluid role of the design manager. Several respondents stated the Design Management Handbook itself provided sufficient guidance while allowing them to use professional judgement to respond to the project needs.

All co-ordination tools delivered critical and supportive impacts - illustrating their importance to effective design management, the tools providing the most critical impacts were C05 Staged Information Delivery, C02 Work Package Control Document and C03 Co-ordination Meeting. This establishes them as crucial co-ordination tools. Barriers affected few tools, with only C06 Fix Information significantly affected by the construction team and client ignoring design freeze / change control during application. C05 Staged Information Delivery, C06 Fix Information and C07 Interface Schedule were used by less than half of interviewees, even though they were effective tools. The lack of agreed design management processes did not provide the framework in which to apply C07. No major barriers were reported for C05 and C06. The only explanation interviewees offered is that while they are useful tools, they are not likely to be used as much as say P06 Master Design Programme or B01 Brief Document.

Development tools that can be considered crucial because they provided critical impacts were D01 Value analysis, D02 Brainstorming, D05 and D06 Design review and proposal documents. They helped deliver the design on time, meet all client and budget requirements. However, less than a third of respondents used D05 Design review document and D06 Design proposal document. While no significant barriers affected D05, interviewees suggested that while useful the tool is not one that would be used as much as P06 master design programme or P01 brief document. The only significant barrier affecting D06 was the lack of agreed project design management process to make the project team buy into its use. This barrier also affected the use of D01, value analysis at both pre-application and application stages.

The majority of interviewees used M01 and M02 monitoring tools. They help deliver the design on time and ensure it is co-ordinated – marking them as essential tools.

In conclusion, all design management practices apart from Rigorous Team Selection, planning tools - P01, P05, P06, P09, all co-ordination tools, development tools - D01, D02, D05, D06 and all monitoring tools - M01, M02, provided critical impacts and therefore are critical to design management.

Adequate design time, planning the design in detail and collaboratively, managing interfaces, investigating and controlling potential design changes and focusing development effort early in the process were affected by one principal barrier at the pre-application stage and four barriers in application. P02 and P04 concept and detailed design kick-off meeting are not suited to D&B procurement route. P10 Job Description, D03 Decision Matrix, D04 Task Force Meeting do not help to manage the process. P05 Design change workshop, D01 Value Analysis, C07 Interface schedule are affected by the lack of agreed processes.

4.4 Critical Impacts Delivered

Figure 2 illustrates the most frequently identified critical impacts that the practices and tools have delivered. The 80% cumulative weighted score shows that a timely delivered designs and a design meeting client requirements are the most frequently delivered critical impacts. By considering the cumulative impact reported by 75% or more of the respondents, then 80% of responses also ensure a co-ordinated design and fewer late design changes. Therefore, critical impacts delivered by the practices and tools are a timely delivered design, a design meeting client requirements, a co-ordinated design and fewer late design changes.

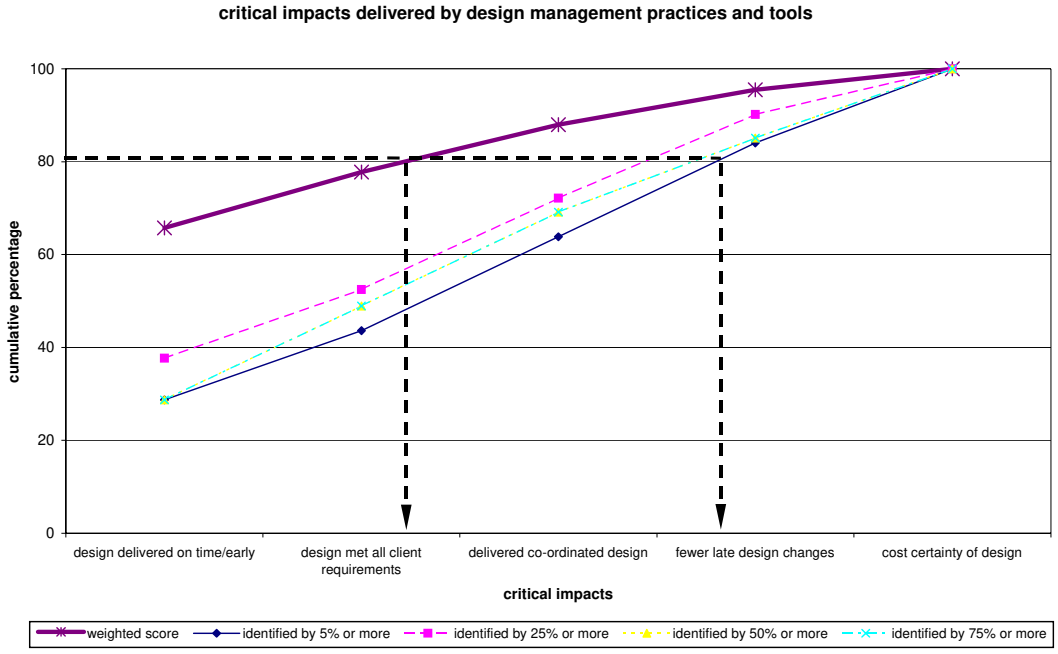

Figure 2: Critical impacts delivered by design management practices and tools

It is concerning that few practices and tools helped provide cost certainty of design, as it is such a crucial aspect of any project. However, this can be tempered by the fact that cost control is seen as a commercial team task rather than belonging to the design manager. This is supported by the case study findings that the commercial team needed to modify commercial processes and their cost plan to align with the new design management processes.

5. BARRIERS TO IMPLEMETING PRACTICES AND TOOLS

5.1 Selection Barriers

Selection barriers are clearly significant when experienced as they prevent high proportions of users from using practices and tools in the first place. However, they do not occur in the frequencies of pre-application and application barriers, with only 11 significant occurrences of selection barriers affecting 11 practices and tools. Pre-application and application barriers had 43 and 21 significant instances where they affected the performance of 23 and 13 practices and tools respectively. Therefore, while selection barriers are very disruptive when encountered, they are not often a problem for design management practices and tools.

5.2 Pre-application and Application Barriers

Pre-application barriers accounting for 80% of the cumulative weighted score (Table 5) are a lack of leadership from senior management and no agreed design management processes. Therefore, these are the critical pre-application barriers preventing the majority of users trying to implement new design management processes.

Application barriers accounting for 80% of the cumulative weighted score (Table 5) are a lack of leadership from senior management, construction team and client ignoring design freeze / change control, parties not collaborating, no agreed design management processes and inflexible construction programme. Therefore, these are the critical application barriers affecting the operation of design management processes and mainly affect practices and planning tools.

When pre-application and application barriers are considered in combination (Figure 3), the key barriers accounting for 80% of the cumulative weighted score represent the critical barriers affecting the practices and tools throughout the design process. They are:

- a lack of leadership from senior management;
- no agreed project design management process;
- client ignoring design freeze / change control; and
- construction team ignoring design freeze / change control.

However, the only two barriers apparent at both pre-application and application stages were a lack of leadership from senior management, and agreed design management process. Therefore, they are the key barriers affecting the use of design management practices and tools throughout the design process.

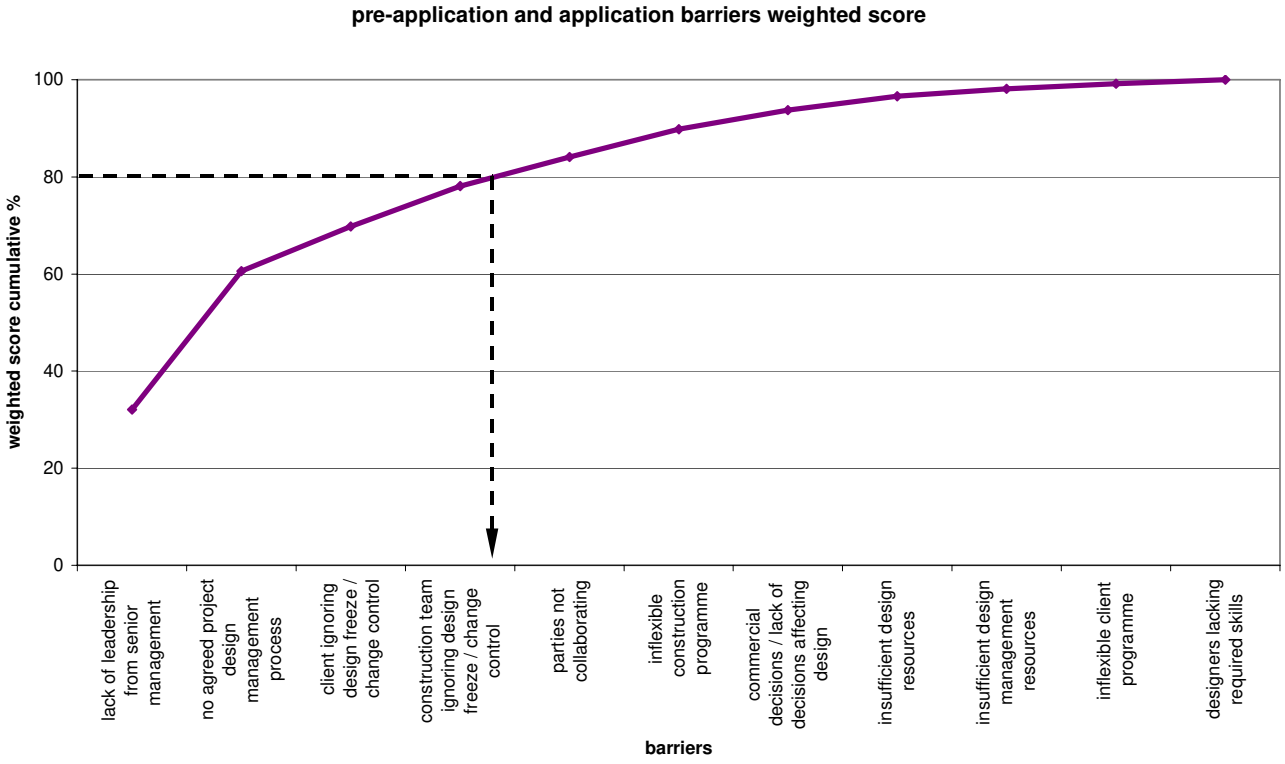

Figure 3: Pre-application and application barriers affecting design management practices and tools

5.3 Hierarchy of Pre-Application and Application Barriers

Figure 4 is a matrix where barriers in columns can lead to barriers in the rows and illustrates the pre-application / application barrier hierarchy from interview comments. There are two clear groups of barriers that can be identified. The first group can be defined as primary barriers that can cause the other group - the secondary barriers.

The most influential primary barrier is the lack of leadership from senior management. It is potentially the pre-cursor to the other eleven barriers. For example, in the case of an inflexible client programme and the client ignoring the design freeze process, a D&B contractor has the opportunity to illustrate to the client the benefits of providing a more flexible programme and buying into the design freeze process. However, interview and case study experience suggest that this opportunity could be taken more often.

A lack of agreed design management processes, as the second most influential barrier has the potential to directly cause four other barriers and indirectly a further four barriers. The lack of leadership from senior management and a lack of agreed design management processes are both internally originating barriers, as are a further five out of the six primary barriers. In conclusion, it is clear that the company has significant influence over pre-application and application barriers and therefore has the capacity to reduce the effect of the barriers and improve the success of design management practices within projects.

Key

X	illustrates dependency
i	internal occuring barrier
e	external occuring barrier

		primary barriers						secondary barriers				
	internal or external	lack of leadership from senior management	no agreed project design management process	inflexible client programme	commercial decisions/lack of decisions affecting design	insufficient design management resources	inflexible construction programme	construction team ignoring design freeze/change control	client ignoring design freeze / change control	parties not collaborating	insufficient design resources	designers lacking required skills
internal or external		i	i	e	i	i	i	i	e	e	e	e
lack of leadership from senior management	i											
no agreed project design management process	i	X										
inflexible client programme	e	X										
commercial decisions / lack of decisions affecting design	i	X	X	X								
insufficient design management resources	i	X										
inflexible construction programme	i	X		X	X							
construction team ignoring design freeze / change control	i	X	X									
client ignoring design freeze / change control	e	X	X									
parties not collaborating	e	X	X			X	X					
insufficient design resources	e	X			X							
designers lacking required skills	e	X										

Figure 4: Matrix illustrating hierarchy of pre-application and application barriers

6. DESIGN MANAGEMENT HANDBOOK MODIFICATIONS

Figure 5 outlines the contents of the Design Management Handbook trialed throughout the company and modifications, additions and withdrawals based on interview comments and case study experiences. The tools P10 Job Description, D03 Decision Matrix and D04 Task Force Meeting will be removed from future versions of the Handbook as the majority of interview respondents did not use them, claiming they do not help to manage the design process.

Several modifications and additions were suggested. It was suggested to combine the designer's brief section of P01 Brief Document with C02 Work Package Document to streamline the briefing document issued to designers. This was undertaken for the case study project and to date has been welcomed by the project team.

The handbook size (256 pages) initially overwhelmed some interviewees believing they were expected to read it from cover to cover rather than as a reference tool to provide support where they need it. Therefore, the introductory section will be modified by explaining how best to use the Handbook. Other suggestions were to reinforce the need to rigorously review stakeholder requirements early in the project before contract close, as it is a key project risk area for the company, and provide more guidance on the level of design management resources required for a project.

A Project Design Management Plan was developed out of case study and interview findings which highlighted the need for a design management framework in which to define the practices and tools to be deployed on a project. It illustrates which, how and the format of the practices and tools to be deployed based on specific project processes and contractual requirements. It has been well received on the case study project by the team, designers and the client by providing clarity of how the design process will be executed and a framework for the design management practices and tools.

Also to be included are a suite of Design Process Performance Indicators. These are part of associated research at the company and will be added once complete.

Remaining additions were not design management activities as such, but rather activities carried out by other disciplines during the design process. Respondents recognised that commercial and procurement processes needed modification to align with the new design management processes. Also a model designers' contract was needed to limit delays in agreeing a contract that is acceptable to both parties.

In conclusion, the changes made were relatively small in number and most were minor modifications. The main changes were the removal of three tools and the provision of a PDMP to implement the Handbook practices and tools on projects. Significantly other project processes are now aligning with the new DM processes.

handbook section	topics cover and tools provided	modifications	additions	removals	reason
Introduction	origins of handbook, intended readership, handbook structure, contact information		Explain correct way to use handbook as a reference tool		Handbook size can be overwhelming and barrier to use
1 Design management	The need for and what is design management? Nature of the design process Why current design management goes wrong How can we better manage the design process?				
2 The design process	Nature of the process Involve parties at the right time Allow adequate design time Engender common design processes				
3 Stakeholders objectives, briefs and tasks	The need to, barriers to and incorporating stakeholder needs in the design				
	P01 Brief document P02 Concept design kick-off meeting P03 Scheme design kick-off meeting P04 Detailed design kick-off meeting	Combine design discipline part of brief document with work package document			Streamline designer briefing documentation
			Outline how to review stakeholder requirements, removing ambiguity in design brief docs		key risk area needing careful management
4 Managers and structures	The need for, barriers to, qualities of and training good design managers			P10 Job description	Does not help manage the design process
	P10 Job description				
5 Selecting team members	Importance of the team, necessary relationships and attitudes, skills and competencies		Model contract for designers		Need to align commercial with DM issues
	P07 Consultant benchmarking P08 Consultant interviews		Procurement schedule for subcontract design		Need to align procurement with DM issues
6 Planning the design process	The need for, barriers to and planning the design process		Project design management plan		Show how will use DM ideas and tools on specific project
	P06 Master design programme P09 Discipline design programme				
7 Ensuring design delivery	The need for, barriers to and effective design delivery	Combine design discipline part of brief document with work package document			Streamline designer briefing documentation
	C01 Information transfer schedule C02 Work package document C03 Co-ordination meeting M01 Progress report M02 Progress meeting		Design process performance indicators		Next phase of design management development
8 Managing information flow	The need for, barriers to and effective information flow management				
	C04 Design workshop C05 Staged information delivery C06 Fix information C07 Interface schedule				
9 Developing the design	The need for and barriers to effective design development Design Development during each project phase Focusing design development			D03 Decision matrix	Does not help manage the design process
	D01 Value analysis D02 Brainstorming D03 Decision matrix D04 Task force meeting D05 Design review document D06 Design proposal document			D04 Task force meeting	Does not help manage the design process
			Outline how to undertake cost control of design development		Need to align commercial with DM issues
			Cost plan		Need to align commercial with DM issues
10 Design changes	The effect of, barriers to, and managing design change proposals Identifying and				
	P05 Design change workshop				

Figure 5: Design Management Handbook Contents, Modifications, Additions and Withdrawals

7. DESIGN MANAGEMENT MATURITY ASSESSMENT

Figure 6 illustrates the three stages of the maturity assessment. The gap between the first and second assessments indicates the change in respondents' perception of the company's design management maturity caused by the awareness training. All maturity scores for design management areas reduced by an average of half a maturity level to 2.2 (18% reduction), to "Thinking of doing something about it" on the maturity scale (Figure 1). This highlighted inadequate practices, with the perception of the company's design management maturity was better than the reality. Significant reductions were associated with developing the design, and managing design changes (both 0.8 drop) – two areas that are absolutely critical to successfully deliver a project. These and other maturity scores set the benchmark from which the company measured impacts of the training initiative.

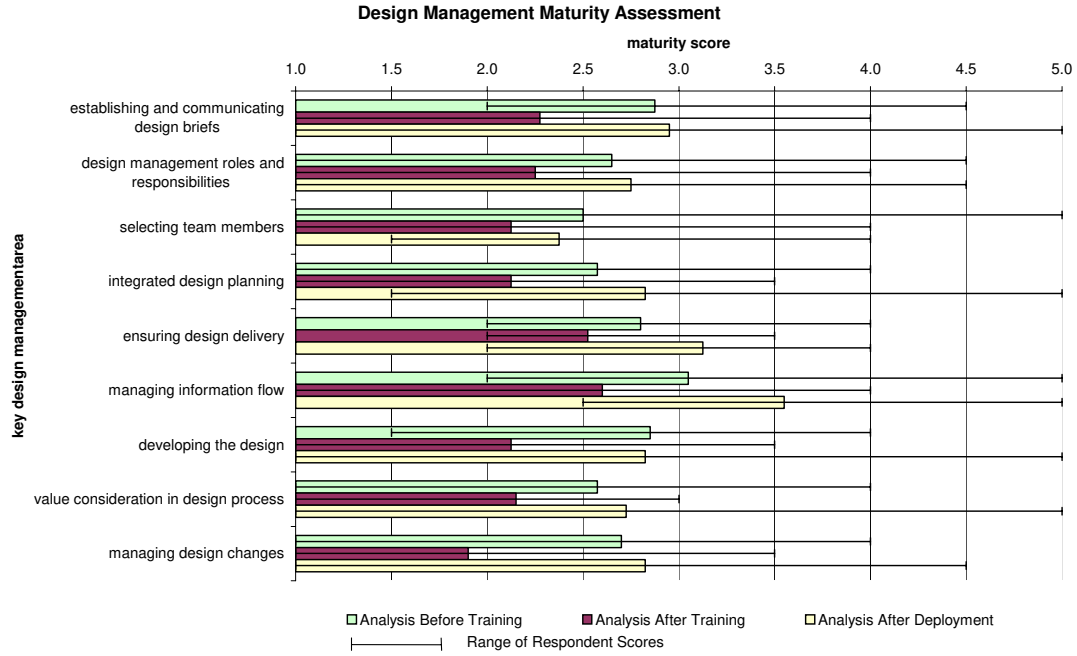

Figure 6: Design Management Maturity Assessment Results

The maturity assessment carried out after the training initiative had been deployed showed that respondents believe the company has improved all design management performance areas since the training started. The maturity score has increased by 29% from the second assessment to 2.9. This is almost a full level increase in maturity to "Beginning to do something about it". Notably there has been a 36% average increase to an average maturity score of 3.0 across Establishing and Communicating Design Briefs, Integrated Design Planning, Managing Information Flow, Developing the Design and Managing Design Changes – all fundamental activities to the successful design management. Other processes have also improved, albeit to a lesser degree. The least improved area was Selecting Team Members. This may be due to the fact that only a few respondents were involved in this exercise as it is the responsibility of senior management, yet few felt that this was being done rigorously.

Many interviewees considered the Design Management Maturity Model useful in helping understand current practices that are no longer working, where improvements are needed and how much they can improve – key factors in promoting change (Filson and Lewis, 2000). One interviewee offered "it shows clearly where we really need to focus our attention to improve performance". This suggests it is a useful tool in defining and helping to improve design management maturity.

In conclusion, according to the maturity assessment, the training initiative has raised awareness of the true design management performance across the company, and most importantly has delivered design management maturity improvements across the company. However, there is also significant scope for future development as the company reports a maturity score of 2.9 with the short term aim to ensure that all design management practices are being done as normal business (level 4).

8. CONCLUSIONS

This paper has reported on the impact of a design management training initiative within a major UK civil and building design and construction company. This has led to several conclusions:

- The Handbook is being used and is useful for diffusing design management practices and tools and the training initiative has improved design management in practice.

- The Design Management Maturity Model can help define and improve design management maturity.

- 30 out of the 39 practices and tools are critical to design management.

- The critical impacts delivered most are a timely delivered design, a design meeting client requirements, a co-ordinated design and fewer late design changes, yet few practices and tools helped provide cost certainty of design.

- Selection barriers can be very disruptive, yet do not occur often.

- Lack of leadership from senior management and no agreed design management processes are the critical pre-application barriers.

- Lack of leadership from senior management, construction team and client ignoring design freeze / change control, parties not collaborating, no agreed design management processes and inflexible construction are the critical application barriers.

- Lack of leadership from senior management and the lack of agreed design management processes are the critical barriers throughout the design process.

- A Design and Build Contractor has the capacity to improve the success of design management practices within projects by reducing the effect of the barriers.

- Involving client and design team in the change process and using a Project Design Management Plan can help to implement design management practices and tools by overcoming key implementation barriers.

9. ACKNOWLEDGEMENTS

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