INTEGRAL VALUE ENGINEERING IN DESIGN

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ABSTRACT

Construction industry clients demand certainty in project cost, quality and time. The inability of traditionally composed design teams to consistently deliver this suggests that their expertise is sometimes inadequate. As clients become more dynamic in the next millennium, they are likely to demand greater certainty when construction projects are implemented to support frequent revisions in their short term function. By establishing a collaborative working framework it is proposed that supply chains can be better managed to identify and design out potential problems using integrated, collaborative design processes. This proposal is being investigated by the Integrated Collaborative Design (ICD) research project, a collaboration of AMEC Construction, Loughborough University and eleven supply organisations, supported by the EPSRC and DETR through the IDAC Link programme.

Focusing on one component of the ICD project, this paper reviews existing, reactive, value engineering methods and by identifying their inadequacies establishes the need for an integrated approach. A value management context is described which integrates value engineering into continuous design processes. The paper discusses the opportunities for utilising supplier design expertise by modelling design process information flows. It also identifies potential cultural barriers to the use of design processes incorporating integral value engineering techniques and describes the linkage to other ICD components that are addressing these issues.

KEYWORDS

Collaboration; Design; Supply Chain Management; Value Engineering; Value Management

1. INTRODUCTION

The continued inability of the construction to satisfy its clients is of concern. As clients evolve, and their demands become more onerous, the construction industry must introduce new working methods to increase efficiency and client satisfaction. By better understanding and managing its supply chains, it is proposed that the construction industry can integrate organisational design expertise to establish the collaborative working methods that are anticipated to overcome current problems. These new working methods will use value engineering techniques to integrate supplier organisation design expertise in the development of design solutions that address the values of all project stakeholders.

This paper is derived from an ongoing research study of AMEC Construction and the Department of Civil and Building Engineering, Loughborough University. The study, entitled "Integrated Collaborative Design", is also collaborating with eleven representatives of construction industry sub-contractors and suppliers. It is funded by the EPSRC and the DETR through the "Integrated Design and Construction" Link programme. The study is investigating: the design information flows implemented to develop project production information; the use of value engineering techniques to facilitate inter-organisational collaborative working; and the identification and management of construction industry supply chains and how long term working relationships are established within them. Derived from the value engineering component of the study, this paper presents the use of integral value engineering to facilitate collaborative working throughout project design and construction.

2. THE FAILURES OF EXISTING CONSTRUCTION INDUSTRY DESIGN PRACTICE

The construction industry currently fails to routinely satisfy its clients. Even when experienced clients, designers and contracting organisations are involved in a project, client satisfaction is not guaranteed. Sustained growth in the field of post-occupancy evaluation (Duffy, 1990) can be considered a manifestation of continued industry and client concern regarding this inadequacy.

Improving client briefing methods is often cited as the key to client satisfaction, but attempts to improve this function often fails to consider the influence of subsequent project activity on the construction industry's ability to adequately satisfy those briefs. In particular, the relationships of the many organisations involved in individual construction projects is not well understood. While project management techniques exist to co-ordinate and schedule inter-organisational material flows during the construction phase of projects, it is proposed that by improving the industry's ability to manage this aspect of its activity, it will become better able to routinely satisfy its clients.

Problems During Design

Construction industry fragmentation is known to create difficulties for its clients who must procure individual project elements from different sources (Egan, 1998). Industry clients therefore usually appoint professional consultants to manage their interface with the construction industry, in addition to designing the project and managing its construction.

Regardless of a client's chosen procurement route, construction design activity tends to devolve into its constituent professions, with each discipline working apart from the others. Despite their isolated function, the professions are inherently inter-dependent, necessitating information exchange to facilitate the progression of project design and construction. Consequentially, these information flows directly influence design process efficiency. Further design inefficiency can occur when duplication of design effort arises due to overlap of discipline function. Duplication also arises due to the current adversarial nature of construction industry activity where, in the absence of trust, one organisation may verify the preceding design work of another before basing their function upon it. Such repetition is, to a degree, necessitated by professional indemnity insurance requirements which, in turn, are a further consequence of the presence of professional disciplines.

Despite many people considering re-design work to be an integral element of design activity, it is suggested that the waste generated by such re-design represents the process inefficiency caused by the construction industry's inability to co-ordinate, plan and distribute design responsibilities. Given the fragmented nature of their operating environment, individual construction designers often fail to contextualise their function within surrounding design activity. This confounds their representation of the client's needs and values in the design of the project element for which they are responsible. Consequently mistakes or inappropriate design decisions are made and, if not corrected, may contribute to client dissatisfaction. The correction of such mistakes, however, necessitates the re-work that causes process inefficiency.

Multi-disciplinary Design Management Contractors (DMCs) have emerged to provide clients with a single source from which complete construction projects can be procured. Consequentially, these organisations exhibit internal structures that, if not managed appropriately, would mirror the fragmentation of the wider construction industry due to their incorporation of a number of design disciplines. To avoid the inefficiency that would arise if their constituent disciplines operated in isolation from each other, DMCs tend to manage their design offices to ensure communication, co-ordination and collaboration between disciplines. In addition to internally practising collaboration in their design function, DMC organisations also tend to use project managers to co-ordinate their design and construction activities.

Hence, the working practices of DMC organisations go some way towards establishing the collaboration and integration required to overcome the inefficiency of current industry fragmentation. Their ability to propagate these more efficient working practices throughout the construction industry is, however, restricted by their organisational boundaries which limit the extent of their influence. It is therefore necessary to develop mechanisms that will allow all sectors of the construction industry to, independently from DMCs, integrate their design activities in a more collaborative manner and harness the design expertise that may be possessed by members of their supporting supply chains.

Problems During Construction

The activity of organisations undertaking the construction phase of projects also tends to fragment into specialist functions. Many of these organisations, such as specialist equipment suppliers for example, also contribute design expertise to the project. In addition to co-ordinating their physical activity on site, it is therefore also necessary to co-ordinate the information flow constituting an ongoing design function that occurs concurrently to construction and is dependent upon the exchange of information between design and construction activities.

In addition to the traditional view that client satisfaction depends upon project performance relating to workmanship, design quality, cost, and so forth, two further causes of client dissatisfaction commonly arise during construction. Firstly, because traditional procurement is becoming less able to satisfy clients' evolving needs, projects are being fast-tracked by overlapping design and construction to reduce their duration. The management of projects must be particularly effective during the period of overlap which, in some cases, can constitute the majority of the project. The integration of design and construction planning is therefore required.

Secondly, the construction industry's current reliance upon competition to deliver what is initially perceived to be the lowest cost solution may also lead to client dissatisfaction. The working practice implications of competition are such, however, that the cost of their management will often exceed any initial minimisation of tender sums. For example, the reliance of some organisations involved in project construction on the submission of claims to attempt to increase profitability creates an environment that is not conducive to the integrated, collaborative working required to improve industry efficiency.

The existing adversarial working culture leads is clearly a source of dissatisfaction amongst all stakeholders, which can be carried forward to the next project where they work together. Hence, in the long term, working relationships are becoming less conducive to client satisfaction. To move away from this reliance upon competition by establishing supply chains that will exist in the long term (i.e. for longer than the duration of a single project), opportunities to established collaborative working relations between the members of these supply chains will be created.

The Influence of Evolving Client Function

Impediments to the effective management of design and construction, and the consequent ability of the construction industry to satisfy its clients, have been recognised by Government. Recent reports (Latham, 1994; Egan, op. cit.) have identified the need for the construction industry to better understand its clients, and the way in which it delivers projects to them. The need for construction to learn from other industries, where similar problems have already been identified and solved, has been established. This paper proposes revisions to current practice that respond to these suggestions by faciliating construction industry management of its design and construction activities in a more efficient, collaborative manner.

3. THE NEED TO AMEND CONSTRUCTION INDUSTRY PRACTICE

Strategies for Process Improvement

It is apparent that greater collaboration between parties is required if construction projects are to be delivery more effectively. To achieve this, the structure, membership and operation of construction industry supply chains must be understood to facilitate the identification design expertise distribution within them.

Collaborative, mutually beneficial working methods have been proposed to reduce design process inefficiency by incorporating the design expertise of construction industry supply chain members into the continuous project design function of traditional main or design management contractors. It is anticipated that this will cause the design of each project element to be undertaken by the most capable organisation, causing design efficiency to be improved as initial design appropriateness would be more likely and the need for re-work reduced. If design expertise is duplicated within the supply chain, organisations possessing the greatest competency will be identified and integrated into the project design process. It is proposed that the distribution of design expertise within industry supply chains can be identified by modelling information flows (both between and within organisations) occurring during the project design phase. Building upon previous work (Austin et. al., 1999), the tools required to perform this task are currently being developed by the Integrated Collaborative Design project. The modelling process will also identify design 'bottlenecks' in addition to facilitating inference of physical design co-ordination difficulties. These can then be specifically addressed to minimise inefficiency and ensure client satisfaction.

Despite the role of design management contractors in simplifying clients' contact with the construction industry and in establishing the potential of greater collaboration to improve construction industry efficiency, their influence over industry function is restricted by the extent of their organisational boundaries. The presence of a number of design disciplines with these organisations, however, has caused the Integrated Collaborative Design study to use their controlled internal environments to represent the wider industry structure for piloting purposes as this will allow the principles of supply chain design integration to be established and validated. If initially found effective within a DMC, it is anticipated the wider construction industry could subsequently adopt the validated revised working practices, although it is accepted that the organisational boundaries currently present in this environment are more rigorously enforced and would exhibit greater resistance to change than the discipline boundaries those present within design management contractors.

Implementation of Strategies for Process Improvement

The above design methodology necessitates development of a culture within the construction industry conducive to collaborative working. Currently, however, many existing aspects of construction industry activity (contract forms, professional disciplines, etc.) impede the establishment of such a working environment and must be overcome before the design expertise of subordinate organisations can be integrated into the design activity. The practices of other industries (Bhote, 1989; Gatanby and Foo, 1990) demonstrate that long term inter-organisational partnerships can create working environments within which products can be delivered in a collaborative manner, harnessing the expertise of all involved organisations. Given their effectiveness in other industries, the construction industry should establish similar long term partnerships (i.e. collaborative inter-organisational relationships that exist for longer than the duration of a single project) to realise the potential benefits of collaborative working.

Inter-Organisation Collaboration Using Value Engineering Techniques
The need to harness the design expertise of supply chain members and integrate it into the overall project design process has been identified above. Value engineering can be used to facilitate inter-organisational collaboration. Given that value engineering is a well established and widely practised discipline, it is anticipated that construction industry familiarity will facilitate its use for this purpose. Within the life of an individual project, it is anticipated that this collaboration will occur initially during project definition, if required, and intermittently throughout project scheme design and construction.

By integrating supply chain members into the project definition process it will be possible to ensure that, from the outset, projects are structured in a manner appropriate to specialist project elements that the client has stated are required and for which the project design team would not possess design experience. Existing value engineering techniques are ideally suited to the integration of supply chain members into project design processes, although their application to problems of steadily diminishing scope as the project progresses will necessitate the development of new techniques.

4. THE ROLE OF VALUE ENGINEERING IN INTEGRATED COLLABORATIVE DESIGN

The Need for Integral Value Engineering
Integral value engineering may facilitate collaboration between organisations throughout project design and construction, particularly as the industry is familiar with traditional value engineering methods. The steadily increasing concurrency of construction project design and construction can also justify this new application of value engineering principles which have traditionally been associated with design activity alone.

Integral value engineering, where activity is implemented within the ongoing project process by reference to a database of project value criteria, has been found effective by US architecture and engineering firms (Kirk, 1989; Dell'Isola, 1997). Because existing implementations of integral value engineering, however, were developed for deployment within the equivalent of an individual design management contractor, they fail to facilitate the collaboration required to integrate design expertise present in supporting industry supply chains.

A Strategy for Implementing Integral Value Engineering

Review of Existing Value Engineering Practice
Development of the strategy commenced with review of existing value management and value engineering methodology proposal to identify their commonalties and establish a premise for good integral value engineering practice. The workshop schedules of each methodology were compared by plotting them on the RIBA Plan of Work, extended to represent those activities required to instigate a project and which occur before a decision to build has been made (Kelly and Male, 1993). It was found

that, because several of the reviewed methodologies were not developed to relate to the RIBA Plan of Work, their location on that process plan had to initially be inferred from the objectives of each workshop. To avoid any ambiguity arising from this interpretation of methodology schedules, it was ensured that all the workshops implemented at each stage of the RIBA Plan of Work performed the same function. This necessitated a limited extent of alteration to the schedules *inferred* by the first interpretation of those methodologies not contextualised against the RIBA Plan of Work by their authors. The review concluded by identifying commonalties in the revised workshop schedules. As illustrated by Figure 1, a correlation between workshop purpose and timing was apparent and an inherent grouping of workshops identified.

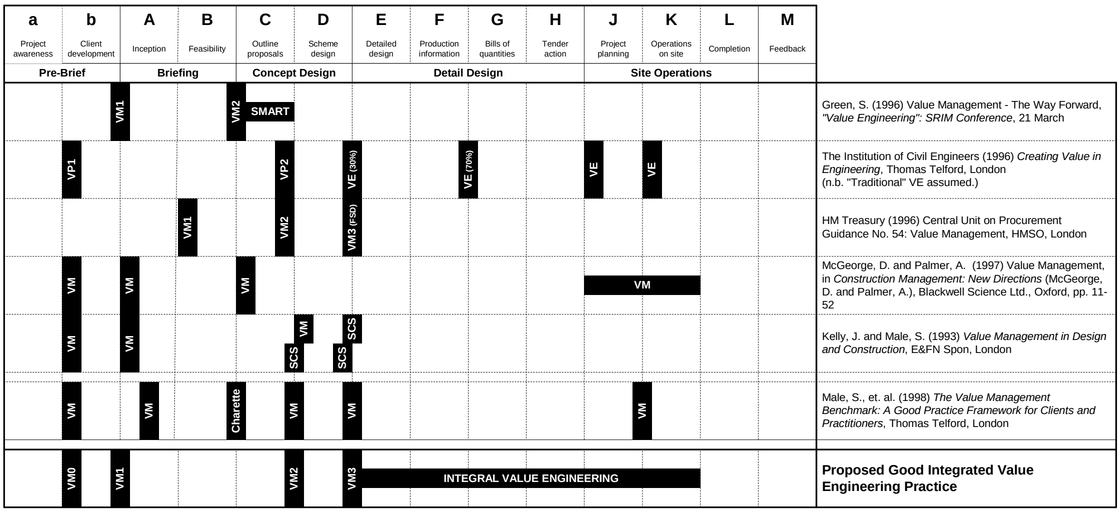

FIGURE 1: Derivation of Integral Value Engineering Good Practice

Figure 1 also defines the context of integral value engineering within the synthesis of good practice. The contrast between the continuous nature of integral value engineering and the periodic nature of preceding value management activities should be noted. The traditional application of value management and value engineering to pre-detailed design activity is apparent from Figure 1 and is justified given that the scope of the problems considered by those techniques would typically be of sufficiently broad scope that they must be considered early in design to ensure they can be incorporated into the project at minimum cost. As projects progress, their constituent problems will steadily reduce in scope and increase in level of detail. When applied to this phase of project implementation, value engineering studies must therefore be carried out with increasing frequency. Eventually, they will be perceived as an integrated element of the continuous project activity. The components of this proposed good practice methodology is presented in Table 1.

Workshop	Purpose of Workshop

VM0	Analyse client needs and establish that a construction project is the most appropriate response to those needs. If a client first approaches the industry with a preconceived need to build, then this workshop should be retrospectively undertaken to validate that need against synthesis of the client's value system.
VM1	Define construction project brief and identify the project task. Derive a number of possible means of satisfying the project brief and select the potentially most appropriate solutions for further development as outline proposals.
VM2	Re-visit the client's value system to identify any change since VM0. Judge each outline proposal against the current value system and select the solution most able to satisfy the client's needs for further development as the project scheme design.
VM3	Final review of project scheme design before detailed design commences. The design is compared against standard functional benchmarks to ensure its efficiency and correspondence with the historical norm for that project type. Any deviation from this norm must be justified by the client's value system.
Integral Value Engineering	The proposed continuous, integrated, consideration of value throughout project detailed design and construction. Collaborative working facilitates the introduction of supply chain member design expertise to ensure that design solutions deliver best value.

TABLE 1: Summary of Good Integral Value Engineering Practice Workshops

The Key Principles of Integrated Value Engineering

The review of existing value engineering methodology proposals illustrate an inferred definition of the terms "value management" and "value engineering". It was apparent from the UK methodologies studied that value management activity in the project inception and definition stages and value engineering occurs in the later stages of the project. Integral value engineering is therefore considered an extension of value engineering, rather than value management. This definition is also supported by the more limited, technical problems that arise in the latter stages of the project delivery process.

Aside from the need to understand industry supply chains and the location of design expertise within them, the successful deployment of integral value engineering will be dependent upon translation of the client's value system, synthesised during VM0, into a database that can be readily referred to and understood by designers in the later stages of project design. The role of this database in providing the link between early value management activity and later integral value engineering is illustrated by Figure 2.

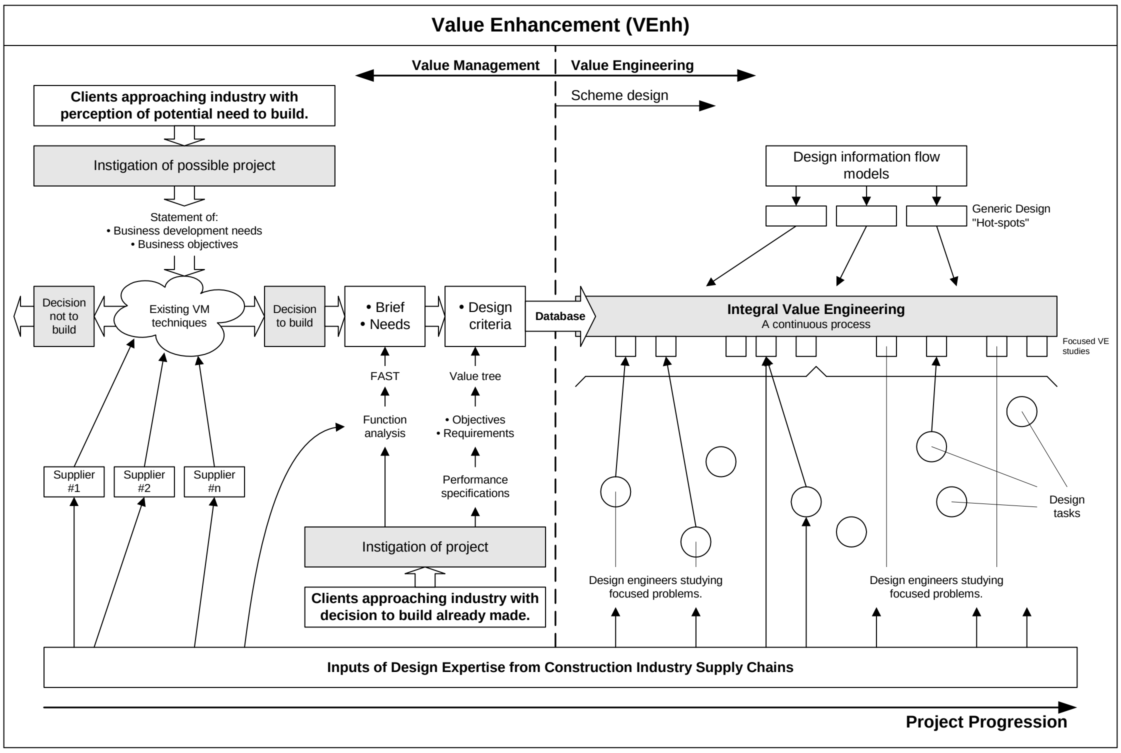

FIGURE 2: The Structure of Integral Value Engineering

A diverse range of terms currently exist to describe how projects deliver value to their procurers. To overcome the problems that this diversity can create, use of the existing term "value management" has been proposed to represent all practices associated with the delivery of value from projects (Male et. al., 1998). This definition is problematic, because it is anticipated that this new interpretation of an existing term will compound diversity problem. A new term may therefore be justified to describe the complete process of value delivery in construction projects. "Value Enhancement" (VEnh) is accordingly proposed which, not only includes the management or engineering of value delivery but also aims to promote and enhance the values themselves.

Before integral value engineering can be attempted, further work is required to address a number of issues. First of all, the format and tools required to implement frequent, focused integral value engineering studies is not yet known. In addition, mechanisms must be developed to translate the integral value engineering database and present the embodied client value system to designers in a manner appropriate to the current stage of project progression. It is anticipated that quality function deployment, in particular its "cascading houses of quality" principle, may provide a suitable mechanism (Lyman, 1992). When periodically translating the client's value system for communication to design and construction engineers in a format appropriate to current stage of project progression, it may become necessary to extend that value system to provide additional value criteria required by imminent project tasks. This will necessitate development of a greater understanding of what value-related information it is appropriate to ask a client to provide as construction project delivery progresses.

5. CONCLUSIONS

This paper has presented an analysis of construction industry function that has established the need for collaborative, integrated inter-organisational function during both project design and construction. Integral value engineering has been proposed as the means to achieve this and, derived from analysis of existing proposed UK value management and value engineering methodologies, a good integral value engineering methodology has been proposed. It is therefore concluded that this paper has provided the construction industry with an insight into how value engineering can facilitate the collaborative working required to resolving current industry inadequacies. The future work required from the ongoing research study to realise the implementation of proposals has been outlined and is progressing.

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