INTERACTIONS BETWEEN TRANSFORMATIONS: FLOW AND VALUE AT THE DESIGN FRONT-END FOR PRIMARY HEALTHCARE FACILITIES

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ABSTRACT

Design has been conceived from an operations management perspective as a process of converting inputs into outputs, as a flow of information, and as a process of generating value to customers. The integration, alignment and balance of the management needs arising from these three views has been hypothesised as essential to successful design outcomes, and it is an area in need for further research (Ballard and Koskela 1998). Such integration is challenging at the design front end, where uncertainty and poor information availability are common place.

The aim of this paper is to examine the design front-end in four primary healthcare projects based on lean principles. A research hypothesis focused on better understanding the interactions between the conversion, flow and value generation aspects of the process has been developed and tested. Data has been collected through 22 semi structured interviews with diverse stakeholders involved with the projects. The 'as-is' design front end was mapped out and examined accordingly to good practices described in the literature. The paper identifies the influences of the procurement method used over lean design management, and the influences of design management and role definition over requirements capture and value generation. Finally, causal relationships between issues related to the transformation, flow and value views are discussed.

KEY WORDS

Design Management, Requirements capture, Value generation.

INTRODUCTION

In the course of research into lean design management the need for integration, alignment and balance of the management needs arising from the transformation, flow and value generation views of design has become apparent (Ballard and Koskela 1998). However, such integration is challenging as understanding of the flow and specially the value views on design is still poor. At the design front-end such integration is even harder, as transformation activities are also poorly understood (Reinertsen 1997). Ballard and Koskela (1998) pointed out that exploratory research is needed to develop an understanding of the interaction between the three views, as up to date there

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is little empirical data available into what actually happens in design.

The design front end has been described as critical for success, as failure to define product characteristics before design begins can be a major cause of both poor design quality and serious process delays (Cooper and Kleinschmidt 1996). Value through design is known to be produced by responding to and/or exceeding client needs and requirements (Womack and Jones 2003). Many value generation activities occur during the front end, where uncertainty and poor information availability are common place.

It is at the front end that product ideas gain shape (Zhang and Doll 2001). It is also at the front end that client needs and requirements are captured and described into a design brief. There are many idealised descriptions of requirements capture proposed by design methodologists, however a disparity exists between such idealised notions and the complex realities of requirements capture in everyday practice (Dalrington and Culley 2004).

In order to get a better understanding of the realities of design management, requirements capture and value generation, the front end of the design process in 4 primary care facilities was investigated based on lean principles. Findings describe how procurement influences design management at the front end, and how design management and role definition affect requirements capture and value generation. The findings of this investigation and insights from the literature were combined in an attempt to identify the iterations between the three views, in terms of describing how mismanagement from one view impinge or influence problems in the other views.

THREE VIEWS OF DESIGN AND THEIR INTEGRATION

A more solid conceptual foundation for design has been proposed through the integrated analysis of design as transformations of inputs into outputs, as a flow of information between different stakeholders, and as a means of generating value to the customers (Koskela et al. 1997; Ballard and Koskela 1998).

The conventional conceptualisation of design is based on the transformation view, in which the design process is divided in sub-processes, each one of them carried out by a specialist who transforms their perceptions of the client's requirements into design decisions. In the flow view, the basic idea is to eliminate waste such as unnecessary rework and to reduce the time waiting for information. In the value generation view, the aim is to achieve the best possible value from the customer perspective. Therefore, increasing the amount and quality of information about customer needs and requirements, for instance through rigorous requirements analysis, is seen as essential (Houvila et al., 1997).

Ballard and Koskela (1998) have described the need to create an understanding of the concepts, causal mechanisms and more specifically interactions between the views to move research and practice forward. Based on this thinking they put forward four research hypotheses:

H1: *Transparency of the design process from one view, achieved through explicit modelling and other means, is conductive to a successful outcome from that view.*

H2: *Use of systematic methodologies to manage the design process from one view is conductive to a successful outcome from that view.*

H3: *In design management, the management needs arising from each view should be integrated, aligned and balanced.*

H4: *For achieving a successful outcome of design from one view, orderly management of design from the other two views is necessary.*

Ballard and Koskela (1998) have adopted a viewpoint of success within and between the views to propose their hypothesis. A further, complementary hypothesis is proposed that, in our view, approaches the issue from a contrasting perspective, i.e. failure. We propose:

- Mismanagement of design from one of the views will lead to problems in one or more of the other views.

Case study data is used to test this hypothesis. The analysis also provides insights into H1 and H4.

INVESTIGATION METHODOLOGY

Twenty two interviews were carried out with project directors, general managers, architects, architectural advisors, project managers, design managers, healthcare planners and clients involved in a public private partnership in which four primary healthcare projects were developed. Interviews were tape recorded, and an interview summary pro-forma (Miles and Huberman 1999) produced after each interview. In addition, analysis of documents describing the overall initiative as well as requirements was also carried out.

The design front end process was mapped and problems identified. A cognitive map was used to describe the interaction of issues related to the management needs arising from each of the three views on design. A cognitive map is a description of an individual or several individuals' concepts about a particular domain, being composed by

ideas and links between these ideas (Miles and Huberman 1994). The links between ideas are causal, being understood as: (a) A is the explanation of B; (b) B is the consequence of A; or (c) A is the means and B is the goal. Cognitive maps have been drawn from the interviews pro-forma. The software decision explorer was used to support the creation of the maps. The software allows the identification of the 'centrality' of an idea, which is used to identify strategic issues on a map (Rodhain 1999). The next section describes the main investigation findings.

CASE STUDY DESCRIPTION

MODERN METHOD OF PROCUREMENT FOR PRIMARY HEALTHCARE IN THE UK: LIFT

The healthcare service in the UK has recently undergone substantial changes, reflected in the healthcare modernisation programme (DOH 1998). There is a current aim that health and social care should be delivered jointly, so that the patients can assess the services they need in one place, on the same day. This has created an opportunity to take a new, fresh approach to the design of buildings that house healthcare, as well as an opportunity to consider the impact that the physical environment has on patients and on healthcare staff.

In order to avoid a fragmented approach to the delivery of primary healthcare facilities and to concentrate it to the areas of greatest need, the British Government established a new procurement route, i.e. Local Improvement Finance Trust—LIFT. LIFTs are Public Private Partnerships set up to allow NHS Primary Care Trusts (PCTs) and their local partner organisations to develop primary care facilities. Public Finance Initiative (PFI) was not a suitable procurement for primary healthcare due to the fact that the value of any individual project is not attractive to the private sector. Through LIFT a number of schemes are clustered and delivered by a single private sector partner, selected through bidding. The private sector partner should bring construction skills for the developments, being responsible for:

- Designing the facilities, based on requirements established by the PCTs as the public sector client
- Building the facilities and financing the capital costs
- Providing facilities management and other support services over a 25 year period

Similarly to what occurs in PFI, the intention is that the private sector will find innovative and cost-effective ways to meet the NHS requirements by sharing the capital and revenue costs of primary healthcare provision (Mohan 2000). The local LIFT own and lease the premises to healthcare practitioners. In this way, both issues of changing funding of primary care buildings and quality of provision have been recognised as essential.

The LIFT programme has been launched in the UK in 2001 with six first wave local LIFT partnerships in the areas of Barnsley, Camden and Islington, East London, Newcastle and North Tyneside, Sandwell and Manchester, Salford and Trafford (MaST). This research focuses on the 4 first tranche schemes developed at the MaST partnership.

THE OVERALL VISION AND VALUES FOR LIFT SCHEMES

LIFT has a twofold objective i.e. providing local health and social care buildings and catalyse the regeneration of deprived urban areas. Health and social care involves a wide range of services, such as local clinics and GPs surgeries, opticians, dentistry, ophthalmology, pharmacies, along with social services and local authority functions, including libraries. Some of the new facilities will also include services previously restricted to hospitals, such as diagnostic, minor surgery and rehabilitation clinics.

Value generation in a LIFT scheme is linked to a host of different issues. The design of LIFT schemes is challenging as the buildings are innovative and complex. Complexities and value lie within the patient treatment, the need to provide therapeutic environments which are supportive of the healing process, and the need for a patient-centred service model (Gesler et al. 2004). There are complexities at the functional level of the buildings and the operating conditions, as different services need to be delivered jointly, and the service mix and ways of operation are varied and, in most cases, unknown at the front end. There are also complexities at the architectural level as schemes need to be aesthetically interesting to attract people to use the facilities, promoting the health of the population. Therefore, LIFT aims to create a client driven organisation (Whiteley, 1991), in which the value of buildings is based on the needs of clients, building users and those of the community as a whole.

Another important concept in LIFT is that of 'value for money'. The government's procedure for demonstrating value for money is based on an appraisal that compares the economic costs and benefits of alternative investment solutions, i.e. the annual cost of a LIFT scheme is summarised and compared with those of a publicly financed scheme, called the public sector comparator

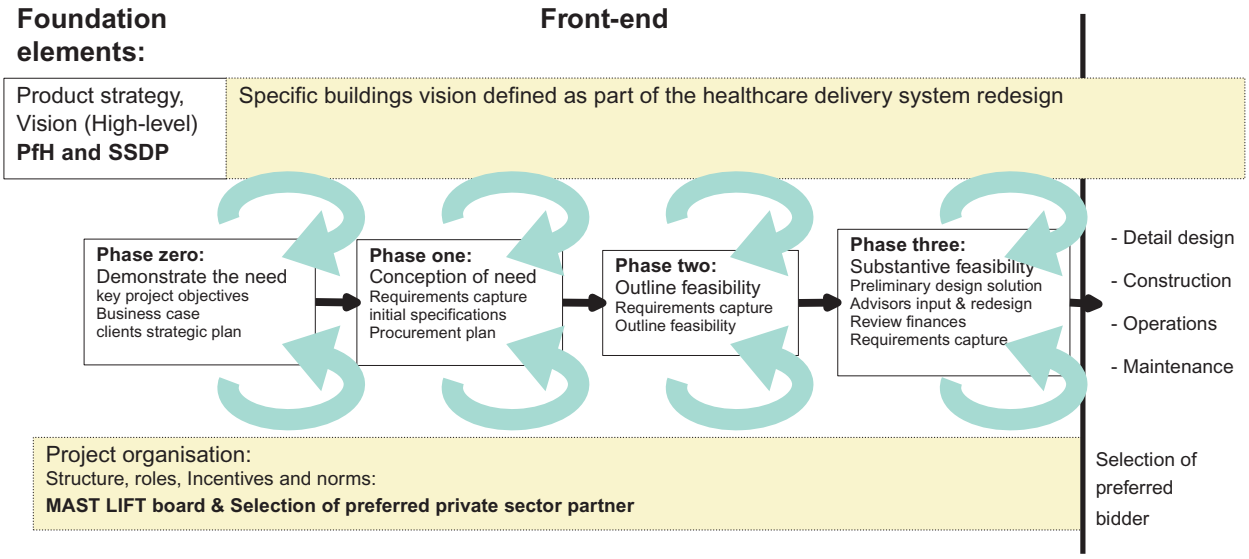

Figure 1: Design front-end on 1st tranche MaST schemes

(Pollock et al. 2002). In this sense, value is taken as costs, and it includes both initial costs and those incurring throughout the life cycle of the facility. Therefore, both economic and the use value (i.e. benefits for users) of buildings throughout time are considered in LIFT.

THE DESIGN FRONT END FOR MAST LIFT SCHEMES

An overview process map has been developed based on a combination of the interviewees' descriptions as well as on the analysis of documents (Figure 1). The 'as-is' process is contrasted with front end activities described in the literature.

The new product development literature generally describes 3 front end phases, i.e. idea generation, product concept and product definition and planning (Cooper, 1994 Zhang and Doll 2001; Van Aken and Nagel 2004). The front end is defined as the 'cross-functional strategic, conceptual and planning activities that typically precede the detailed design and development of a new product' (Khurana and Rosenthal 2002). It was assumed that in a construction environment the front end encompasses all 4 pre-project phases, as proposed in the process protocol (Kagioglou et al. 1998).

The successful development of front end activities depends on foundation elements, i.e. definition of a clear the product strategy and setting up the project organisation (Kurana and Roselthal 2002). The product strategy and vision for LIFT schemes were defined both at the national and local levels. The overall LIFT strategy was established nationally. At the MaST level, Primary Care Trusts (the clients) developed a document called Strategic Service Development Plan (SSDP), setting out the vision for the schemes in terms of service requirements (SSDP 2002). However, the specific objectives for each scheme were in reality refined and detailed iteratively during the design front end.

The project organisation involved a novel structure with more than 25 public and private sector organisations. A strategic partnership board (SPB) linking 6 PCTs at the 3 local areas was set up. In addition, there are a number of stakeholders involved within each scheme as users. Stakeholder groups vary from scheme to scheme in number and composition, and the group membership varies through time. Due to the complexity of the organisation both in nature and size, and to the inexperience of the teams, there was poor clarity of the organisational structure and of roles and responsibilities.

Phase zero aims at demonstrating the need for the project (Kagioglou et al. 1998). In MaST, most activities of this phase were part of the SSDP, i.e. establishing the business case and key objectives of the schemes. At this stage there were uncertainties relating to which schemes would be developed (13 were initially proposed), and the private sector partner was unknown. Therefore, part of the clients' strategic plan, i.e. prioritisation of schemes, was defined during phases 1 and 2. Also, stakeholders were not identified, neither was a project execution plan put in place.

Phase 1 focuses on the conception of the need, aiming to identify potential solutions to the need and plan for feasibility (Kagioglou et al. 1998). The preliminary project brief should be developed at this stage. In MaST, phase 1 focused on the definition of bidding for the selection of the private sector partner. As a description of building requirements was necessary for bidding, a consultancy company was involved to produce a 'tenant requirement' document. Three to four meetings

per scheme were undertaken with PCTs to establish requirements, and a 'template' produced for all 13 schemes. However, as consultation was ineffective the quality of the final document has been criticised, as it was perceived that not enough attention was given to the specifics of each scheme.

The goal of phase 2 is to identify a number of design solutions that respond to the project brief and select some to be considered after examining feasibility (Barrett and Stanley 1999). Design proposals were developed by the bidders with a basis on the information described on the (poor) tenant requirements document. Architects had very little access to the clients, and no access to buildings' users. There was poor information available on site and environmental issues, and for some of the schemes there was uncertainty with regards to the viability of the selected sites.

Finally, phase 3 should focus on the definition of the most appropriate design solution for concept design development and outline planning approval. Within MaST, the phase was related to developing design sufficiently to allow the final bidding stage. The phase should also involve a revision of building requirements based on a better understanding of clients needs. However, while design solutions were proposed by architects, requirements were captured by PCTs through user group meetings and open public consultations. As a result, requirements were inappropriately incorporated into the design proposals, partially due to their poor definition and partially due to pressures from the bidding process.

An architectural advisor was also involved to assess design quality, and changes in designs were introduced as a result of his feedback. However, client representatives were unaware of the architectural advisor's involvement, and there was a perception that the advisors comments did not consider the decisions made at user group meetings, in which requirements were established. Therefore, wasteful redesign occurred. The poor management of the design front-end had a number of consequences, discussed as follows.

INFLUENCES OF PROCUREMENT OVER DESIGN MANAGEMENT

A number of design management problems happened during the development of the 1st tranche of MaST schemes, some of which were caused by the procurement strategy adopted, more specifically the bidding process though which the private sector partner was selected. The timescales for the front end, determined by the bidding timescales, were inappropriate. Bidding timescales were determined nationally, without considering the fact that PCTs needed time both to get familiarised with the construction process and also to conduct healthcare service redesign activities.

Furthermore, there was a lack of clarity of who is responsible for managing design and requirements. The PCTs inexperience with regards to the design and construction was well known. Therefore, it was expected that the private partner would support the client in understanding construction and managing the design front-end. However, the private sector partner was selected after the design front end happened. Consequently, PCTs were responsible for developing design activities, i.e. capturing and managing requirements and dealing with land information/selection, and did not have the necessary expertise or support to do so. As a result, there was a lack of clarity on requirements at the front end and also throughout design development, which led to a number of design changes.

After the selection of the private sector partner, design management responsibility was owned by the contractors, who are part of a joint venture i.e. Excellcare. However, it was identified that the contractors did not have the necessary skills to manage design, and that architects were not empowered to do so. Therefore, interviewees perceived that design management should have been responsibility of a higher level. On the other hand, contractors stated that an appropriate design brief and land information should have been made available at the beginning of the process, but that actually did not happened due to the difficulties PCTs were having with requirements. There is a general perception that no one was involved from the beginning of the process neither to protect the interests of the buildings' users nor to observe if clients and users were getting what they needed.

EFFECTS OF POOR DESIGN MANAGEMENT OVER VALUE GENERATION

The poor definition of the design management's role and of who was responsible for it had consequences throughout the process. Firstly, requirements management was inconsistent and there was no audit trail for changes in requirements. It was perceived that there was no appropriate ownership and control over requirements, as these were managed partially by the PCTs, and partially by the contractors' design managers. Requirements gathered and decisions made in PCT user group meetings were not appropriately registered, and not all requirements were identified at the front end. Also, requirements were not ranked nor the ability to deliver properly analysed.

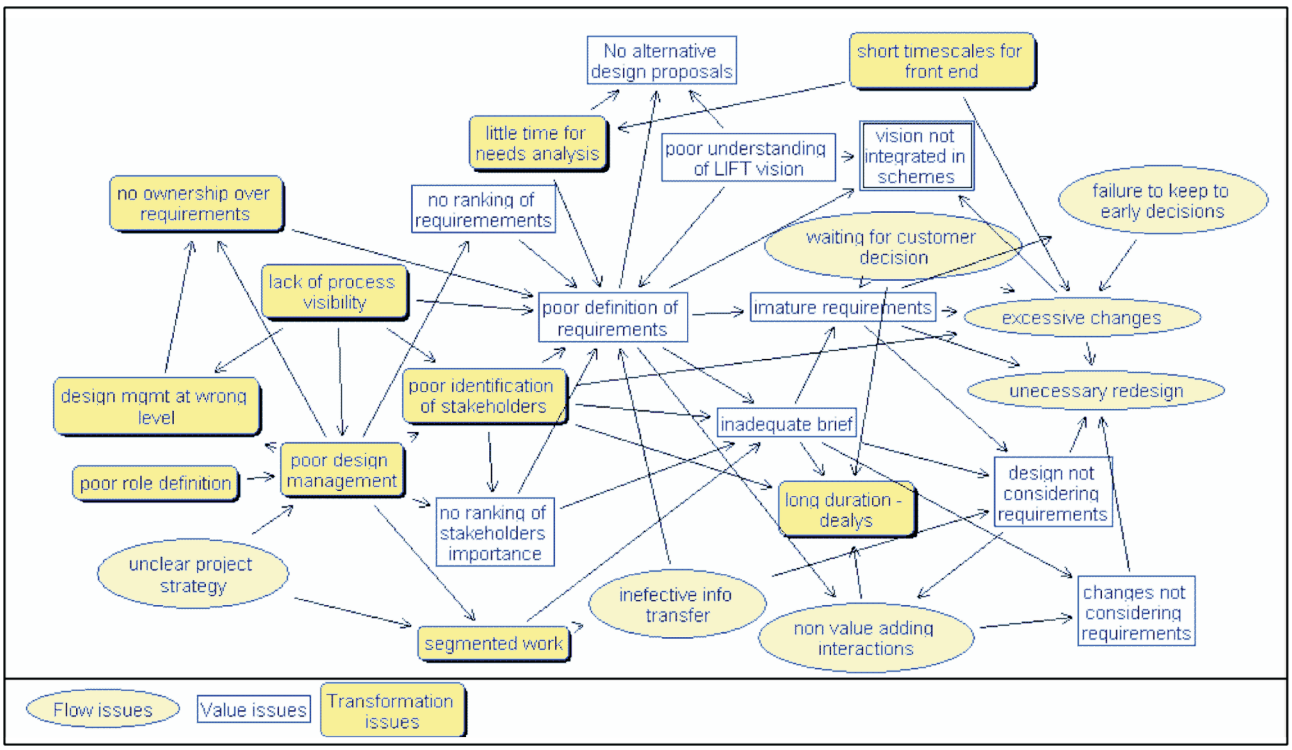

Figure 2: Cognitive map describing links between transformations, flow and value issues at MaST

Secondly, designers did not appropriately consider requirements in design development. This may be due to the lack of clarity and constant changes in requirements. Also, as there was no appropriate design brief for the schemes, there were also no criteria available to analyse design. Thirdly, changes in requirements have been dealt directly by the architects and requests from users were generally included in design without considering affordability or the effects that the changes had in terms of time delays or costs. Fourthly, PCTs faced difficulties with signing off requirements and designs. Requirements should have been signed off at the front end but this never happened due to constant changes of needs and also of the stakeholders involved.

Finally, there was a lack of strategic integration between high-level LIFT health vision and the schemes being delivered. There were a number of time consuming interactions during design, responding to changes in requirements which were not mature O'Brien and Smith, 1995), generating major unnecessary design rework. the quality of the designs developed at the front-end was perceived to be poor, leading to extensive redesign after the selection of the preferred bidder, which makes explicit the large incidence of non value adding activities. Changes were introduced in design to respond to a 'wish list' which changed constantly, instead of responding to a coherent set of clients and users requirements. This situation happened also throughout detail design development. Finally, redesign led to process delays, i.e. more than one year delay to reach financial close for the 4 schemes.

DISCUSSION: RESEARCH HYPOTHESIS

In order to test the proposed research hypothesis, design management issues identified in the case study were linked to the problems proposed in the literature within each one of the views. These are described in Table 1.

A cognitive map was then developed to identify the causal links between issues related to each of the views on design. The map is presented in Figure 2; shadowed rectangles represent transformation related problems, ovals represent flow related issues, and rectangles represent value issues. The central concepts on the map (i.e. concepts with a greater number of links) were identified as being the poor definition of requirements, the inadequate brief, the poor identification of stakeholders and excessive changes.

The poor definition of requirements is a value related issue (V) which has had consequences over other value issues i.e. it led to an inadequate project brief, which resulted in design proposals not appropriately considering requirements. The poor definition of requirements has also generated problems from a flow perspective (F), i.e. unnecessary redesign occurred due to the poor consideration of requirements. Also, long project duration and delays (T) occurred as a consequence of non value adding interactions (F), which happened due to the poor definition of requirements (V).

Table 1: Management problems related to each of the three views on design

	Problems in the literature	Case study problems
Transformation	Decomposition is not sufficient to understand / improve design[6]	Short timescales for front end
		Poor definition of roles
		Poor identification of stakeholders
		Poor definition of design management
		Design management at the wrong organisational level
		No ownership over requirements
	Non value adding activities are not explicitly represented[6,7]	Not enough time for needs analysis and to generate solutions
	Long duration and not enough time to generate solutions	Lack of process visibility—activities were unknown to stakeholders
		Long duration and delays
	Partial design, from the point of view of one discipline only[6]	Segmented work: requirements and design developed by different groups
Flows of information	Changes in requirements	Excessive changes of requirements
		Business strategy unclear with evolving healthcare needs
	Effort to transfer information	Transfer of information ineffective
	Time consuming or insufficient interactions to improve design[7]	Time consuming non value adding interactions
	Uncertainty due to lack of definite information[6,8]	Uncertainty due to lack of definite information (req. and site)
	Uncertainty due to lack of decision	Unclear project strategy
		Complex decision making process at client organisation
		Failure to record and stick to early decisions
	Rework caused by design errors[7]	Rework caused by design errors detected in latter phases
	Transfer of information	Poor understanding of LIFT vision at lower levels
	Waiting of information[8]	Waiting for customer decisions
	Unnecessary work	Unnecessary redesign due to poor requirements maturity
		Changes in design not considering requirements, leading to unnecessary redesign
		Assumptions on affordability not checked prior to (re) design
Value generation	Design is not conceptually related to its costumers	Customer integrated but with poor understanding of who stakeholders were and who should make decisions
	Not all needs are identified in the beginning of the process	Poor understanding of LIFT vision at lower levels
		Poor identification/definition/ understanding of requirements
	Missing or evolving requirements	Inadequate brief
		No ranking of stakeholders or requirements
	Loss of requirements	No alternative concepts defined before design development
		Designs not appropriately considering requirements

6 Koskela, 2000
7 Huovila et al. 1997
8 Reinerstein 1997

Similarly, the inadequate project brief (V) led to immature requirements being incorporated in the designs (V). Consequently, clients had difficulties in sticking to early decisions (F), which led to excessive changes both in requirements and in the design (F). As a result, the LIFT overall vision was not appropriately incorporated in the final designs (V).

Furthermore, the poor identification of stakeholders, a transformation (T) related issue, had value consequences in terms of obstructing the ranking of stakeholders and ranking of requirements importance (V). Finally, poor design management (T) had consequences in terms of transformation, flow and value issues. Poor management of the design process led to segmented work (T), i.e. architects designing and clients gathering requirements in isolation, which influenced an ineffective flow of information, i.e. designers were not aware of all changes in requirements (F), and consequently designs did not consider requirements (V).

In summary, the analysis of the cognitive map makes the causal relationships between issues related to each one of the views clear. The map describes the mismanagement of transformation issues leading to problems from both value and flow perspectives (T→V→F). It also describes mismanagement from a value perspective leading to flow and transformation problems (V→F→T). The mismanagement of flow issues was also identified as impinging problems from a transformation and value perspectives (F→T→V). There are also causal links within each view, i.e. mismanagement of transformation generating transformation problems, mismanagement of flow leading to flow problems, and mismanagement of value leading to value generation problems. Figure 3 attempts to graphically describe the dynamic interactions between the views.

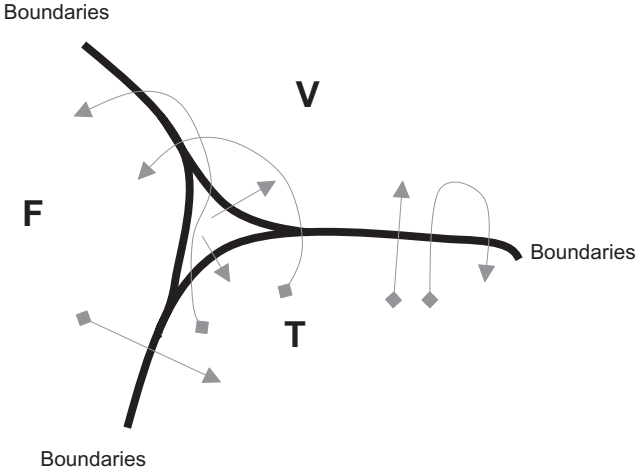

Figure 3: Dynamic design interactions framework

Therefore, the case study results provide support for the proposed hypothesis, i.e. *the unsuccessful management of design from one of the views resulted in problems in one or more of the other views*. However, more empirical evidence is necessary to confirm that similar links between the views occur in different environments, for instance by analysing the design front end developed under different procurement frameworks (such as PFI) and for different types of projects (e.g. schools).

Based on the results here presented, a question could be posed. If one consider that the causal links between failure in appropriately managing design from one view really leads to problems within that view AND also the other views, one may question H1 (*Transparency of the design process from one view, achieved through explicit modelling and other means, is conductive to a successful outcome from that view*). It may be the case that even though one appropriately manages design from one view, problems within that view would occur due to the mismanagement of the other views. This actually supports the need for integration of the management needs from each of the views.

Similarly, the use of systematic methodologies to manage the design process would only be effective if such methodologies holistically approach all the three views. It may well be the case that such methodologies need to recognise the different nature of the different design activities and stages, proposing appropriate managerial regimes for activities with a different nature. For instance, the more uncertain, creative activities (e.g. idea generation, concept definition) should be loosely managed so that the creativity and serendipity necessary for innovation can occur, while the less uncertain activities (e.g. selection of alternative solutions) should be developed under more formal managerial regimes by adopting, for instance, the ideas of flexible gates (Van Aken and Nagel, 2004).

Finally, the results here proposed provide indicative support for H4 (*For achieving a successful outcome of design from one view, orderly management of design from the other two views is necessary*). Assuming that the mismanagement from one view leads to problems in the other views, all views need to be appropriately managed. However, it may be the case that success is not achieved even though all views are appropriately managed. There is an assumption that cause and effect relationships can always be identified. However, in reality it is the pattern forming that should be considered and cause and effect relationships cannot be identified apart from hindsight.

CONCLUSIONS

This paper reported research results from a case study examining the front end of the design process in the development of four primary healthcare facilities based on lean principles. Results describe the front end process and problems that occurred due to the mismanagement of design from a transformation, flow and value generation perspective. A research hypothesis has been tested, in which it has been demonstrated that the mismanagement of design from one perspective conducted to problems from the other perspectives.

More empirical research is needed to validate, better understand and extend the conceptual framework here discussed. The model presented in Figure 3 needs further development, and some questions are put forward for further investigation, i.e. (a) what are the boundaries between the three views, and are they flexible or not; (b) are there design activities not explicitly linked to any of the views, and therefore under an 'unclassified' area? (c) what are the contextual characteristics related to such activities? (d) how one could place activities within the right categories/views? (e) do cyclical design activities change domains (e.g. F→V) throughout time?

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