Fanie Buys & Xabiso Sidloyi

Comparative analysis of design management procedures in manufacturing and architecture

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Abstract

Design changes due to lack of constructability, cost overruns, delays and dissatisfied clients are but a few of the problems experienced in construction on the account of the poor management of the design processes. This research was conducted to determine the adequacy of design management processes used by Eastern Cape (EC) architectural practices and compare these with the design management processes used in manufacturing in order to establish practices, theories, principles, technologies and deliverables that can be transferred from the manufacturing into the construction industry to improve efficiency of architectural design management. A questionnaire was designed to acquire primary, factual and attitudinal data from EC architectural practices while secondary data were acquired through a literature review. The main findings were that design management processes, continuous improvement philosophies, lean principles, and Information and Communication Technology (ICT) used by EC architectural practices are not similar to those used in manufacturing. Therefore EC architectural practices could increase their efficiency by adopting some of the design management processes, ICT, continuous improvement philosophies and lean principles originating from the manufacturing industry.

Keywords: Architectural profession, construction, design management, manufacturing, process improvement

Abstrak

Ontwerpveranderinge as gevolg van die onuitvoerbaarheid van konstruksie-ontwerpe, onbeplande kostes, vertragings en ontevrede kliënte, is net 'n paar probleme wat tydens die konstruksieproses ondervind word; dit is dikwels as gevolg van die swak bestuur van die ontwerpproses. Navorsing is onderneem om die geskiktheid van bestuursprosesse vir ontwerp, wat deur Oos- Kaapse argitekspraktyke gebruik word, te bepaal en dit te vergelyk met ontwerpbestuursprosesse wat in die vervaardigingsbedryf gebruik word, ten einde praktyke, teorieë, beginsels, tegnologiese oplossings en die uitkomste te identifiseer en dit uit die vervaardigingsbedryf na die konstruksiebedryf oor te dra om die effektiwiteit van argitektoniese ontwerpbestuur te verbeter. 'n

Prof. Fanie Buys, PhD, the Head of the Department of Building and Quantity Surveying, Nelson Mandela Metropolitan University, P O Box 77000, Port Elizabeth, 6031, South Africa. E-mail: <Fanie.Buys@nmmu.ac.za>

Mr Xabiso Sidloyi, Pr. Arch, MSc BE, Researcher: Department of Building and Quantity Surveying, Nelson Mandela Metropolitan University, P O Box 77000, Port Elizabeth, 6031, South Africa. E-mail: <xabisosidloyi162@hotmail.com>

Vraelys was gebruik om basiese-, feitelike- en meningsdata van Oos-Kaapse argitekspraktyke te bekom, terwyl sekondêre data deur 'n literatuurstudie ingewin is. Die belangrikste bevindinge was dat die ontwerpbestuursprosesse, deurlopende verbeterings-filosofieë, essensiële beginsels, en Inligting en Kommunikasie Tegnologie (IKT) wat deur Oos-Kaapse argitekspraktyke gebruik word, nie ooreenstem met dié van die vervaardigingsbedryf nie. Gevolglik kan Oos-Kaapse argitekspraktyke moontlik hul dienste verbeter deur sekere van die bestuursprosesse, IKT, deurlopende verbeteringsfilosofieë en essensiële beginsels uit die vervaardigingsbedryf aan te neem.

Sleutelwoorde: Argitekspraktyk, konstruksiebedryf, ontwerpbestuur, prosesverbetering, vervaardigingsbedryf

1. Introduction

Cull (2004: 8) reported that the South Africa construction industry would be required to double its output over the next 10 years, according to a status report compiled by the Construction Industry Development Board (CIDB). Hodgson (CIDB, 2004) noted that, over the past two years, just over half of all projects in South Africa were completed on time, within budget and relatively defect free. The increased pressure on the construction industry to improve its practices and continuous criticism of its less than optimum performance have led to research on improvement of processes and efficiency.

Rethinking Construction is a report produced by Sir John Egan's Construction Task Force in the United Kingdom. The Report commissioned by John Prescott, the Deputy Prime Minister, was published in July 1998 and is known as the 'Egan Report'. The central message of *Rethinking Construction* is that through the application of best practices, the industry and its clients can collectively act to improve their performance. The *Egan Report* (1998) suggested that there are significant inefficiencies in the construction process and that there is a potential for a systematised and integrated project process in which wastage can be reduced and both quality and efficiency improved. There are many practitioners and academics who believe that the construction industry has much to learn from manufacturing. Howell (1998) suggested that this learning could be a two-way process: manufacturing could learn from construction in areas of project based management and construction could learn from manufacturing's developing and developed solutions. The *Egan Report* recommended that the construction industry could change, by rethinking the fundamentals of its delivery processes; and offered clues as to how some of the problems might be overcome by transferring practices from the manufacturing industry to achieve continuous improvement on its performance and products. Kilpatrick (2003) is of the opinion that many industries can improve

their performance by implementing lean principles, which can be defined as:

> *a systematic approach to identifying and eliminating waste through continuous improvement.*

The architectural profession is an integral part of the construction industry's supply–chain, and some inefficiency experienced by the construction industry is directly or indirectly influenced by poor management of design processes. The increased pressure on the construction industry to improve its practices, an increased workload and demand for better quality, coupled with numerous problems facing the architectural profession, have forced architectural practices to reconsider their service delivery processes. Allinson (1993: 164) stated that:

> *getting a project from A to B is dependent upon an inextricably bound union of design and management.*

Therefore contemporary architectural practice has a need to reconcile issues of management, design and professionalism. RIBA (2005: 11) also noted that the success of the architectural profession and its practitioners relies partly on their approach to the future as they are well placed to take advantage of future opportunities and emphasised the need to act proactively.

2. Design management

De Mozota (2003: 67) defined design management as

> *an approach whereby organisations make design-relevant decisions in a market and customer-oriented way as well as optimizing design-relevant processes.*

Gorb (2003: 1) defined design management as

> *the effective deployment by line managers of the design resources available to a practice in order to help the practice achieve its objectives.*

Therefore, design management acts as an interface between management and design; and functions as a link between technology, design, design thinking, and management.

2.1 Manufacturing as a reference for construction

Certain construction practitioners, such as Ball (1988: 10) believed that in the past the construction industry was unique and that principles from manufacturing could not be adopted because of this uniqueness. Those beliefs were later dismissed by Egan (1998) who pointed out that some of the problems in construction might be

overcome by transferring established practices from the manufacturing industry. This view has been affirmed by a number of authors like Langford & Murray (2004) and Kagioglou *et al*. (2000). Egan (1998: 18) stated that

> *The parallel is not with building cars on the production line; it is with designing and planning the production of a new car model.*

Authors like Egan (1998) and Kagioglou *et al*. (2000) suggested that construction should use the manufacturing industry as a reference for overcoming some of the problems in construction. Kagioglou *et al*. (2000) suggested that there are mainly two areas in which construction could benefit from manufacturing, namely the project and operational/production processes.

2.1.1 Management of the project process

The project process in manufacturing relates to the design and construction processes; Kagioglou *et al*. (2000: 12) stated that

> *it considers the development of a solution from a need identified in the market place to the implementation of the solution and the whole life cycle of the product.*

According to De Mozota (2003: 13) the project process consists of five phases, namely investigation, research, exploration, development, realisation and evaluation, and there are various techniques and tools used by design managers in manufacturing to plan, organise and monitor progress in these design phases. The project processes utilise various New Product Development (NPD) models (the sequential approach, stage gate and development funnel processes); the NPD models have distinct differences, but have three similar activities, namely pre-development, development and post-development.

2.1.2 Management of the operational/production process

The operational/production process relates to the way in which the production of products is undertaken and includes the utilisation of process improvement philosophies and Information and Communication Technology (ICT). According to Kagioglou *et al*. (2005), Oakland (1995), Koskela (1997) and Thompson & Strickland (2004), process improvement is usually achieved by: management and continuous improvement of existing processes, designing and redesigning of new processes, concurrent engineering and Lean Production. It is acknowledged by authors like Kagioglou *et al*. (2005) and

Sun & Howard (2004) that improved processes in manufacturing have been realised by significant ICT support.

3. Research method

The data for this research were collected using primary and secondary sources. A questionnaire was designed to acquire primary, factual and attitudinal data from EC architectural practices. Secondary data were acquired through a literature review of international and national publications which included conference papers, reports, journals, articles, theses and the internet. Secondary data were utilised to establish criteria and theories against which empirical research of the primary data was measured.

The aim of the research was to determine the adequacy of design management processes used by Eastern Cape (EC) architectural practices and compare these with the design management processes used in manufacturing in order to establish practices, theories, principles, technologies and deliverables that can be transferred from the manufacturing into the construction to improve efficiency of architectural design management. Design management processes is defined by De Mozota (2003: 67) as

> *any set of managerial techniques which aim to realise the potential of design as some form of socio-economic benefit.*

3.1 Target population

The survey was conducted in the EC amongst professional architectural practices registered with the South African Institute of Architects (SAIA). SAIA has two architectural institutions for the EC, namely the Border-Kei Institute of Architects (BKIA) and the Eastern Cape Institute of Architects (ECIA). The BKIA is comprised of 38 member practices with 43 from the ECIA, a total of 81 practices. Altogether 24 architectural practices were randomly selected from these 81 practices registered with BKIA and ECIA, the sample being chosen by the process known as randomisation. Walliman (2001: 201) refers to randomisation as

> *Selecting a sample from the whole population in such a way that the characteristics of each of the units of the sample approximate the characteristics of the total population.*

Therefore the composition of the sample is derived from 1:3 proportion of the population and the sizes of practices of the sample varying from small to medium (there are no large practices in the EC, according to the SAIA [2005] classification).

3.2 Questionnaire survey

A quantitative research approach through action research was adopted as it is perceived to be objective in nature and involves collection and analysis of numerical data and applying statistical methods for analysis of the data. This comprised the design and administration of a questionnaire among the sample population. A web-site was created to enable respondents to submit their response to the questionnaire on-line.

3.3 Literature review

A comprehensive literature review on the following aspects were undertaken to acquire the required insight into the topic:

- Design management processes and protocols in construction, which identified existing design management processes and protocols in construction as well as problems.
- Design management processes used in manufacturing, which identified the management of design, creativity and product development in manufacturing.
- Process improvement philosophies and lean production principles as used in manufacturing, which identified continuous improvement philosophies, concurrent engineering and lean production principles used in manufacturing.
- ICT used in manufacturing, which explored the use of ICT for simulation, integration, communication, visualisation; and the use of ICT during product development activities.

4. Survey results

Table 1 indicates that a 100% response rate was achieved and this formed the basis for the analysis and the subsequent conclusions.

Table 1: Response rate

Practice Classification:	*Questionnaire distribution*	*Number of responses*	*Percentage of responses against distribution (%)*
Small	12	12	100
Medium	12	12	100
Total	24	24	100

A 100% response rate may indicate that all respondents realise the importance of research into this field.

4.1 Adequacy of existing design management processes used by architectural practices in the EC

All architectural practices in the survey indicated that they used the SAIA Work Stages protocol for management of the design process. Table 2 reflects respondents' ratings of problems with existing design management processes and pre-project phases where 1 = minor problem and 5 = major problem. The highest ranking problem statement is 'Lack of risk assessment between design phases' with an average rating of 4.23, this also reflects the findings of the literature review and indicates that EC architectural practices generally do not identify, assess and mitigate risks during design. Usually these risks emerge later in the project and they adversely affect the project time, cost and quality parameters.

Table 2: Problems with existing design management processes and pre-project phases

Problems: *(Rating: 1 = Minor problem, 3 = Neutral, 5 = Major problem)*	*Practice Classification*		*Average all*	*Ranking*
	Small	*Medium*		
	Rating			
Lack of involvement of appropriate expertise in the conceptual phases	2.17	2.17	2.17	7
Poor co-ordination of information in design and project planning phases.	2.09	2.17	2.13	8
Poor design management process definition and control.	2.59	2.33	2.46	5
Poor management of briefing stage by architects.	1.75	2.09	1.92	9
Incorrect information and mistakes regarding the nature of client's problem statement.	2.83	2.59	2.71	3=
Poor co-ordination of design information between design consultants.	2.50	2.50	2.50	4=
Poor assessment of process performance between design phases.	3.09	2.75	2.92	2
Lack of risk assessment between design phases.	4.17	4.42	4.23	1
Poor communication between design consultants and construction team.	2.42	2.58	2.50	4=
Design changes and buildability problems during construction.	2.59	2.83	2.71	3=
The final building not satisfying client requirements.	2.42	2.00	2.22	6

The respondents rated 'Poor assessment of process performance between design phases' as the second highest problem, while 'Poor management of briefing stage by architects' was rated last.

4.2 Similarities between design management processes as used in manufacturing and by EC architectural practices

4.2.1 Investigation phase

Table 3 lists the methods used in manufacturing during project appraisal and responses indicating which ones are used by EC architectural practices. The method used by all respondents is the interview (formal and informal) while the literature review is the second most used method followed by user surveys and questionnaires. No respondents indicated that they used the focus group method. It can thus be concluded that at least one of the methods used in manufacturing are used by EC architects.

Table 3: Methods used during project appraisal stages of design process

Methods	*Practice Classification*		*Total*	*Average all*	*Ranking*
	Small	*Medium*		*%*	
Literature review	4	7	11	46	2
User surveys and questionnaires	3	6	9	38	3
Focus groups	0	0	0	0	
Informal or formal interviews	12	12	24	100	1
None	0	0	0	0	
Other	0	0	0	0	

4.2.2 Research phase

Other results from the research revealed that respondents do not use any method for establishing clients' value criteria, 59% indicated that they use scope management tools and 92% that they use schedule and time management tools.

Table 4: Documents/deliverables produced during appraisal and definition stages

Documents/deliverables	*Practice Classification*		*Total*	*Average all*	*Ranking*
	Small	*Medium*		*%*	
Stakeholder list	9	10	19	79	3
Statement of need	4	3	7	29	7=
Business case	6	6	12	50	5
Business plan	4	5	9	38	6
Project execution plan	3	4	7	29	7=
Terms of reference	6	10	16	67	4
Performance management report	0	0	0	0	8=
Communication strategy	0	0	0	0	8=
Procurement plan	0	0	0	0	8=
Project brief	11	9	20	83	2
Design brief	12	12	24	100	1
Value management	0	0	0	0	8=
Risk management plan	0	0	0	0	8=
Other	0	0	0	0	

Table 4 lists the documents/deliverables used in manufacturing during the appraisal and definition stages, and responses indicating which ones are used by EC architectural practices. The respondents indicated that they produced design briefs (100%), project briefs (83%), stakeholder lists (79%) and terms of reference (67%). Some 50% indicated that they produced a business cases, while the least produced were business plans (38%), statements of need (29%) and project execution plans (29%). None of the respondents indicated that they produced performance management reports, communication strategies, procurement plans, value management and risk management plans.

The findings suggest that architectural practices focus more on the documents/deliverables needed for production of the designs as indicated by the most produced deliverables and that they ignore deliverables needed for communication, process definition, process management and measurement. Therefore architectural practices do not produce documents and deliverables needed for effective management of the design process and this often results in the final products not being delivered on time, at the right cost and quality.

4.2.3 Exploration phase

Table 5 indicates that none of the respondents use the 6-3-5 or C-Sketch methods for conceptualisation of design solutions. Altogether 54% of respondents indicated that they use the Gallery method and the most used method is the 'Individual Criticism' method. The Individual Criticism method is similar to the Gallery method, the only difference with the Individual Criticism method being that feed-back is given by an individual instead of a group. The reason for the popularity of the Individual Criticism method is that it is easier to implement and less time consuming as compared with other methods.

Table 5: Methods used for conceptualisation of design solutions

Methods	*Practice Classification*		*Total*	*Average all %*	*Ranking*
	Small	*Medium*			
6-3-5 method	0	0	0	0	3=
C-Sketch method	0	0	0	0	3=
The Gallery method	3	10	13	54	2
Individual Criticism method	12	10	22	92	1
(Some practices indicated that they used more than one method)					

Other results from the research revealed that respondents do not use any method for evaluating concept designs, that they used 2D CAD renderings (100%), 3 Dimensional CAD (54%) and scale models (46%) for actualisation of design solutions, and that they used the Percentage-Complete Matrix (42%) and QS estimates (75%) for monitoring and controlling project budget.

4.2.4 Development and realisation phases

Table 6: Documents/deliverables produced between design concept and technical documentation stages

Documents/deliverables	*Practice Classification*		*Total*	*Average all %*	*Ranking*
	Small	*Medium*			
Concept design plan	1	3	4	17	3=
Outline concept design	3	5	8	33	2
Full concept design	12	12	24	100	1=
Value engineering	0	0	0	0	4=

Technical drawings	12	12	24	100	1=
Prototype and testing	0	0	0	0	4=
Cost plan	0	0	0	0	4=
Other	0	0	0	0	
(Some practices indicated that they used more than one method)					

Table 6 lists the documents/deliverables used in manufacturing during the design concept and technical documentation stages and which ones are used by EC architectural practices. All respondents indicated that they produced concept design plans (100%), full concept designs (100%) and technical drawings (100%). The above documents are the standard set of documentation that architects need to produce for design development, contract procurement and construction. A third of respondents indicated that they produced outline concept designs and 17% indicated that they produce concept design plans. These two sets of documentation are produced during the feasibility study and most projects undertaken in architectural practices do not require feasibility studies. No respondents indicated that they produce Value Engineering (VE) because it requires an articulation and prioritisation of client's and designer's values. None of the respondents indicated that they produced Prototypes or cost plans as costing on architectural projects is normally performed by the Quantity Surveyor.

4.2.5 Post-project evaluation

Table 7: Activities/documents produced after completion of projects

Activities/ documents	*Practice Classification*		*Total*	*Average all %*	*Ranking*
	Small	*Medium*			
Maintenance plan	1	3	4	17	3
Post-project review	4	5	9	38	2
None	7	4	11	45	1
Other	0	0	0	0	
Total	12	12	24	100	

Table 7 indicates that 38% of respondents indicated that they produce a post-project review and only 17% produce a maintenance plan. This indicates that only 55% of practices produce activities/ documents after project completion is 55%. The remaining 45% of respondents indicated that they did not produce any activities/documents with the majority being smaller practices. This is

unsatisfactorily as preparing maintenance plans and manuals are vital tools for property owners. Buys (2004: 182) states that a maintenance plan should be prepared so that any expected future maintenance is provided for.

4.3 Similarities between continuous improvement philosophies and lean production principles as used in manufacturing and those used by EC architectural practices

Table 8: Process improvement philosophies and lean principles implemented in architectural practices

Philosophies and principles	*Practice Classification*		*Total*	*Average all %*	*Ranking*
	Small	*Medium*			
Continuous improvement	6	6	12	50	1=
Business Process Re-engineering	0	0	0	0	2=
Concurrent Engineering	0	0	0	0	2=
Lean Production	0	0	0	0	2=
None	6	6	12	50	1=
Other	0	0	0	0	
Total	12	12	24	100	

Table 8 lists philosophies and principles used in manufacturing for process improvement and responses indicating which ones are used by EC architectural practices. Altogether 50% of respondents indicated that they implement the continuous improvement philosophy, and the remaining 50% indicated that they did not implement any improvement philosophy or lean principles, i.e. Business Process Re-engineering, Concurrent Engineering and Lean Production principles. These findings indicate that there is a great scope for improvement in EC architectural practices if they adopt the process improvements and philosophies from manufacturing. The EC architectural practices would not only make dramatic initial increases in efficiency and quality, but they would obtain the greatest value through sustained improvements.

Other results from the research revealed that two-thirds of respondents indicated that architectural practices can become more efficient by rethinking their service delivery processes, while the remaining respondents indicated that they invested between 0.1-0.5% of their annual business volume in research and development, process

improvement is not adequately addressed in board meetings, they are not adequately benchmarking other design practices and industries, they are encouraging employees to make suggestions to improve office processes and 58% of respondents indicated that they are not rewarding employees for improvement of office processes, they are not adequately identifying and eliminating non-value adding activities, and that they are not adequately transferring processes from other industries.

4.4 Similarities between ICT used in manufacturing to that used by EC architectural practices

Table 9: ICT and collaborative tools used by practices

ICT and collaborative tools	*Practice Classification*		*Total*	*Average all %*	*Ranking*
	Small	*Medium*			
Internet	12	12	24	100	1=
Extranet	0	0	0	0	
Intranet	0	0	0	0	
E-mail	12	12	24	100	1=
Other:	0	0	0	0	
(Some practices indicated that they used more than one method)					

Table 9 indicates that the most utilised ICT and collaborative tools are the internet and e-mail, used by all respondents from both classifications, while no respondents indicated that they used the extranet or intranet.

Other results from the research revealed that: EC architectural practices are not adequately identifying and implementing ICT according to the needs of each project, not all EC managers are aware of current trends and technologies in project control, collaboration, CAD and management; they are only using standard ICT tools (e-mail and internet), and that they are not using extranets for project control.

5. Conclusion

The results indicated that architectural practices in the EC use the SAIA Work Stages protocol for management of the design process. Respondents indicated that the SAIA Work Stages protocol was adequate for their design processes as it contributed to a limited extent to 10 of 11 problems identified by the literature review. However,

the SAIA Work Stage Protocol contributed to a lack of risk between design phases. The researcher found that there is inconsistency in the way the SAIA protocol is implemented; this is due to the fact that the SAIA does not stipulate a definite set of deliverables in its phases. The inconsistency is made worse by the utilisation of temporary multi-organisational teams for each project, this making it difficult for professionals to organise themselves into a team working environment due to variations in their roles and responsibilities. The inconsistency has resulted in difficulties in performance measurement, control and attempts at continual improvement in design processes.

The results also showed that design management processes used by EC architectural practices at various stages are not similar to those used in manufacturing. Research by Egan (1998) and Kagioglou *et al*. (2000) has established that productivity in construction lags behind that of manufacturing and therefore EC architectural practices can increase their efficiency by adopting some of the design management processes, theories and deliverables used in the manufacturing industry.

The results revealed that EC architectural practices are not using similar process improvement philosophies and lean principles as used in manufacturing and that the majority of EC architectural practices do not implement any process improvement philosophy. EC architectural practices can therefore improve their services by considering continuous improvement and lean practices originating from manufacturing.

The results also indicated that EC architectural practices are not always utilising ICT for simulation, integration, visualisation and communication of design projects. Therefore more effective utilisation of ICT during design management processes will result in improved communication and collaboration that will ensure design constructability and clear communication through ICT tools.

It is recommended that further research be conducted to develop an improved SAIA design management process protocol, using manufacturing principles as reference point, which will also consider the whole life cycle of construction projects whilst integrating participation under a common framework. Furthermore, more in-depth research on how lean principles, as applied in manufacturing, can be applied to construction design management to improve performance.

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