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A framework for building quality into construction projects – Part I

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Marketplaces worldwide have become very competitive in most sectors, and companies have realised that a key area to ensure commercial success is good product quality. Several methods to help in this regard have emerged under the total quality management (TQM) umbrella. However, to date, associated research in the construction sector has received little attention by comparison to say, manufacturing. Some approaches that have been proposed for use in construction have limitations with regard to their applicability. In an attempt to bridge this gap, a new framework has been developed to help build quality into projects. It not only addresses the limitations of current approaches but also incorporates manufacturing improvement methods suited to construction projects. The resultant framework includes quality policy, product and service quality, the construction process, people and their culture and quality improvement methods. A set of guidelines for implementing the latter has also been developed.

Keywords: framework; quality improvement methods; total quality management; construction industry

Introduction

Construction is defined as 'the mobilisation and utilisation of capital and specialised personnel, materials, and equipment to assemble materials and equipment on a specific site in accordance with drawings, specifications, and contract documents prepared to serve the purposes of the client' (Merrit et al., 1996, p. 4.1). As a sector, the construction industry accounts for 10% of the UK's GDP (DTI, 2005), has an output of more than £80 billion and employs around 1.4 million people – figures that reflect its importance.

When carrying out construction projects, professionals with different backgrounds are brought together at various points to fulfil the customer's requirements. This gives rise to different problems because these professionals tend to work in isolation, while making decisions that affect one another (Evbuomwan & Anumba, 1998). In addition, there are characteristics of the construction industry (Walker, 2002) that can adversely impact quality and customer satisfaction, e.g. different weather and project each time, different team and arrangements for each project. Apart from quality problems, the industry also has performance difficulties, the main reasons for which, according to Koskela (2003), are the construction process and its peculiarities. In order to overcome these problems, it has been recommended that the industry adopt the concepts and methods that have been successfully implemented in manufacturing (Egan, 1998; Koskela, 1992). In particular, the use of TQM has been suggested. Some of the approaches reported in the construction management literature aimed at improving construction performance will be detailed and their limitations discussed. The main requirements of a framework are then established, followed by an explanation of how the framework was constructed, its main components and its advantages over previous

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approaches. Guidance on implementing the methods included in the framework are described and the expected outputs and main features highlighted.

Construction improvement initiatives

A comprehensive review of the literature related to improvement initiatives in the construction industry revealed both similar and dissimilar aspects. The models of Formoso et al. (2002) and Kagioglou et al. (2000), for example, were aimed at clearly defining the construction participants' role in the product development process. In addition, key stages in the construction process were identified where communication problems were evident. To alleviate these, Kagioglou et al. suggested that documents be used for controlling project information. On the other hand, initiatives such as the Lean Project Delivery System Model (LPDSM) (Ballard & Howell, 2003), Serpell and Alarcon's (1998) methodology and the flow concept of the Transformation, Flow and Value generation (TFV) production theory (Koskela, 2000) were oriented more towards managing flows and reducing waste in the construction process than on defining participants and their roles. Flows play a key role in construction project management and they can, according to Womack et al. (1990), have a direct impact on customer satisfaction (a very simple example being that, if materials' delays were reduced, a project could be finished earlier than scheduled).

In contrast to the previous two groups, the Value–Process–Operation (VPO) model (Emmit et al., 2004), the Client Requirements Processing Model (CRPM) (Kamara et al., 2000) and the Design Quality Indicator (DQI) (CIC, 2003) managed the improvement of communication during briefing and designing. Each adopted a different approach, for instance the VPO model promoted the use of workshops, the DQI encouraged data collection by questionnaires and the CRPM supported the use of databases. Overall, the three were aimed at establishing a common language among participants to avoid problems such as rework.

The models proposed by Yasamis et al. (2002), Arditi and Lee (2003) and Maloney (2002) were centred on evaluating construction companies with regard to their quality practices. They are useful from both the client viewpoint, because they provide information about what to expect from a contractor, and a company perspective because they can be utilised as self-assessment models to identify improvement opportunities.

Al-Momami (2000) and Abdel-Razek (1998) proposed that construction companies should use quality planning, employee's satisfaction and quality systems to improve their performance. The 20 steps for designing quality houses developed by the Department of Housing and Urban Development (DHUD, 2005) offered practical guidance on how to achieve quality in the affordable housing sector. Since this approach dealt with the whole construction process, it considered both design and construction aspects.

While the initiatives considered different features of quality, most of them either addressed only one or two quality issues, e.g. communication, participants' role (Kagioglou et al., 2000), were limited to one sector in the industry, e.g. affordable housing (DHUD, 2005) or only covered one or two stages in the construction process, e.g. briefing, tendering (Arditi & Lee, 2003; Kamara et al., 2000). Therefore, there is a need to generate a more comprehensive approach that combines the relevant aspects of quality with the construction process and simultaneously contains methods for improvement.

The rationale for developing a framework is that it provides the structure for launching quality initiatives in a planned manner and offers step-by-step guidance on how to proceed if a set of goals is to be achieved. The advantage of having such a tool is, therefore, that it can be used to develop plans for improvement at each stage of the construction process and to programme the allocation of resources and personnel. A framework should cover the whole process and be useful for both building and civil engineering projects.

Main requirements

While reviewing the literature, it became apparent that there was confusion between the three terms 'model', 'framework' and 'methodology'. Wong (2005) analysed these three concepts and concluded that a model provided an answer to 'what is', while a methodology offered an answer to 'how to'. In contrast, a framework answered both. He also explained that a model and a framework were conceptual in nature while a methodology was methodical. The first two are descriptive, while the latter is prescriptive. It can be said, therefore, that a *model for quality in construction* would show the elements that should be considered to achieve quality, a *framework* would not only present such elements but would also present ways on how to put them into practice to achieve it and a *methodology* would give detailed steps of how to achieve it. A framework then is suitable for providing an overall picture and structure for carrying out and implementing quality initiatives (Yusof & Aspinwall, 2000).

In order for it to be effective and widely adopted, according to Tzortzopoulos et al. (2004), it should satisfy a set of desirable and compulsory requirements. Based on these ideas and using Kano's terminology (Corbella & Maturana, 2003), the requirements of a framework have been divided into two categories, 'expected' and 'attractive'. The first refers to those requisites that must be satisfied in order to ensure that it answers both 'what is' and 'how to' achieve quality in construction. The latter, however, refers to features that may enhance the framework but are not essential. With regard to the first category, the authors adopted and adapted the ideas of Dale and McQuarter (1998), Yusof and Aspinwall (2000) and Dale (2003) – developed in the TQM arena – to generate the following requirements. A framework must:

(1) Be able to answer 'What is quality in construction?' (i.e. present the elements that constitute quality);
(2) Display a general picture of the activities that could be applied to build in quality, and
(3) Determine the role of various quality improvement methods within the whole construction process (i.e. show how to achieve quality).

In addition to these, a set of 'attractive' requirements was drawn from the weaknesses of the approaches reported earlier and the key points proposed by Evbuomwan and Anumba (1998), Koskela (2000), Tzortzopoulos et al. (2004) and Yusof and Aspinwall (2000). A framework should be:

(1) Simple, i.e. user friendly to everyone involved in a project, e.g. customers, designers, engineers, contractors;
(2) Easy to understand by all the participants in a construction project;
(3) Systematic, i.e. gives guidance on how to perform various activities (e.g. gathering and organising customer needs) during the stages of the construction process and provides the necessary methods to support these activities;
(4) Well structured, i.e. clearly presents both the elements that will help to build quality into projects and the links between them;
(5) Comprehensive, i.e. applies to a great variety of projects and supports the activities performed during the whole construction process;
(6) Practical, i.e. the relevant participants in a construction project can use it in real situations without the need of experts, and
(7) Applicable, i.e. it is accepted and perceived as credible and valuable by its users in a wide variety of building and civil engineering projects.

These requirements not only give support to building a new framework but they can also be used as criteria for its evaluation. In fact, they provided guidance for the development of the proposed framework, the ultimate objective of which was to produce a tool that could be applied in construction projects to improve performance, quality and ultimately customer satisfaction.

Stages in the framework construction

In order to address the question 'What is quality in construction?', the literature related to the concept of quality was reviewed. In general, it has been categorised into three main groups: corporate, product and service (Owlia & Aspinwall, 1996).

Corporate quality

Corporate quality refers to the image that customers have of an organisation. Yasamis et al. (2002) stated that quality-conscious companies normally have a strong quality culture, which is helpful for achieving customer satisfaction. The foundations of corporate quality are, therefore, defined at organisational rather than project level. They proposed that companies should adopt the manufacturing critical success factors (CSFs) of TQM as indicators of corporate quality but did not investigate their appropriateness for the construction industry. The first step towards constructing the framework was, therefore, to determine whether or not they were suitable for the construction sector.

A postal survey of 300 UK construction companies was carried out for this purpose, full details of which can be found in Delgado et al. (2005). The main conclusion from the study was that manufacturing companies had more experience in the application of such factors than their construction counterparts, but in general, both industries recognised the same factors as critical for successful TQM implementation. Table 1 shows the proposed CSFs and their constituent elements for the construction industry.

The authors of this paper feel that the awareness and use of such CSFs is evident in the quality policy of a company, which according to Seaver (2001), plays a key role in corporate quality. From the customer perspective this may be a valuable simplification because the quality policy may be the only evidence that customers will have, prior to setting up a working relationship with a company, about its commitment to providing both corporate and product/service quality. Seaver (2001) argued that organisations should aim to surpass customer expectations (delight customers) and that the quality policy should recognise this fact.

In order to establish whether or not a quality policy can be used to reflect the awareness and use of the CSFs presented in Table 1, five (from companies that had participated in a previous UK survey – Delgado & Aspinwall, 2005) were reviewed. Excerpts are quoted in Table 2 and, as can be seen, most included at least one paragraph related to one or more of the CSFs, and all those proposed are incorporated.

This was expected since all five companies have been certified to ISO 9001: 2000, which requires organisations to establish quality policies consistent with TQM principles (ISO 9001: 2000). Consequently, in the framework under development, the quality policy can be considered as a good indicator of the awareness and use of CSFs within construction organisations, which in turn reflects quality at corporate level (Yasamis et al., 2002).

Product quality

In terms of projects, the final output of the construction process consists of products and services, so customer satisfaction at this level will result from both elements. With reference to product quality, Garvin (1984) suggested eight dimensions (see Table 3), which according to Yasamis et al. (2002) are applicable to the products of the construction industry.

Table 1. CSFs for TQM implementation in the construction industry.

Factors	Constituent elements
Management leadership	1. Management provide policies promoting customer satisfaction 2. Management build an improvement culture 3. Management practice participation in decision making 4. Communication links established between employees and management 5. Clear mission developed regarding business objectives 6. Management act as key driver in continuous improvement
Continuous improvement system	1. There is a quality improvement coordinating body (e.g. quality steering committee) 2. Improvement teams exist in all functions 3. Quality tools and techniques are widely used 4. Recognition given for contributions on improvement ideas 5. Continuous improvement conducted to improve processes
Measurement and feedback	1. A system to feedback customer concerns is established 2. Internal measures (such as quality costs, quantity of rejects) collected to monitor quality improvement 3. Critical processes are identified for improvement 4. Measurements from critical processes are taken for improvement purposes
Improvement tools and techniques	1. Statistical techniques used in design processes 2. Statistical techniques used in contract processes 3. Training on tools and techniques provided 4. Marketing and sales use quality tools for improvement activities 5. Appropriate techniques are implemented when necessary
Supplier quality management	1. Suppliers are involved in customer's improvement activities 2. Supplier audit and evaluation are important activities to be conducted 3. Suppliers provide relevant quality data 4. Working with suppliers towards long term partnerships 5. Training of suppliers is conducted 6. Suppliers selected on the basis of quality aspects
Systems and processes	1. Systems and procedures for quality assurance are implemented 2. Information and data collection system established to monitor improvement activities 3. Relevant training system in place 4. Key business processes identified, improved and monitored 5. Key business processes focused on meeting the needs of customers
Resources	1. Sufficient financial resources provided to support improvement activities 2. Human resource availability considered in improvement activities 3. Investment decisions based on sound resources consideration 4. Technical resources (e.g. software, equipment) are provided
Education and training	1. Employees are trained in job-specific skills 2. Employees are trained in quality-specific tools and techniques 3. Employees are trained on total quality concepts 4. Training time is provided for employees 5. Management always update their knowledge 6. Continuous learning is provided through education and training
Work environment and culture	1. A pleasant environment exists in working areas 2. Positive values such as trust, honesty, hardworking, are fostered by management 3. Teamwork and involvement are normal practices 4. Attitudes and behaviours are reinforced through a caring culture 5. The current pay scheme motivates employees to contribute towards building a quality culture

Source: Delgado et al. (2005).

Table 2. Excerpts from quality policies.

Policy	CSFs	Excerpts from quality policies
I	Management leadership	'Managers at all levels are responsible for ensuring that all subordinates are trained in and comply with the requirements of the company quality manual and quality programme manuals which have the full and unqualified support of the Board of Directors.'
	Systems and processes	'The company implements systematic, planned and cost effective procedures for determining and controlling all activities that affect the quality of the service and the end product provided to clients.'
II	Continuous improvement system	'Continuously review and improve business processes, ensuring that customer requirements and statutory and regulatory requirements are met, maintained and exceeded if possible.'
	Supplier quality management	'Establish and develop sustainable relationships, based on mutual trust, with all parts of the supply team.'
	Resources	'Provide adequate, competent resources to ensure the highest standards of quality.'
III	Measurement and feedback	'Adopting an approach of evaluating the effectiveness and adequacy of operations and processes through established monitoring, measuring and reporting methods, and to ensure that as improvements are identified, they are introduced in all relevant parts of the business.'
	Education and training	'Providing relevant training to ensure all employees are competent to carry out their work.'
IV	Improvement tools and techniques	'The company will identify customers' needs in accordance with best national and international practice.'
V	Work environment and culture	'The company is totally committed to providing a comprehensive and efficient service to its customers through a trained, experienced and motivated workforce.'

Service quality

While product quality is mainly associated with the users and occupants of the finished facility (clients could also be users), in construction clients are the direct recipients of service quality. Parasuraman (1985) suggested 10 dimensions (see Table 3) for service quality, which according to Maloney (2002), could be adopted in the construction industry. These could be used as a checklist when providing services to customers. It is important to highlight that regardless of the main activity of the construction company (e.g. design, construction) the dimensions for quality are equally applicable. For instance, design organisations are responsible not only for providing a service but also for ensuring that drawings and specifications for the product are correct and readily address the needs of customers. In the case of contractors, whilst they are mainly responsible for building a quality product, they simultaneously offer a service.

By dividing construction quality into the three main components presented, i.e. corporate, product and service, the question 'What is quality in construction?' is addressed. The next step in the framework's development process involved the second requirement, i.e. to display a general picture of the activities that could be applied. In fact, the third requirement, i.e. to determine the role of various quality improvement methods within the construction process, was simultaneously addressed, since both are related.

Construction stages

In order to understand better how the requirements have been considered in the framework, it is necessary to look at the construction process stages. According to Austen and Neale (1984),

Table 3. Product and quality service dimensions.

Product quality dimensions	Service quality dimensions
Performance – basic functions of the facility	Access – the ease with which the customer can contact the construction company
Features – characteristics that supplement the basic functions of the facility	Communication – the ability to disseminate information about the construction project to the customer
Reliability – the level of confidence with which occupants can use the facility without failure	Competence – the company's ability to carry out the service offered to the customer
Conformance – the extent to which the facility is consistent with pre-defined standards	Courtesy – the degree of respect, politeness, kindness and consideration of the company's personnel to the customer
Durability – the amount of time that occupants can use the facility before replacement is required	Credibility – the ability of the company to do what it says it will do
Serviceability – the speed and ease with which maintenance can be carried out	Reliability – the degree to which construction activities are correct
Aesthetics – the degree of satisfaction that occupants experience with the facility's look and feel	Responsiveness – the ability to react to problems that have arisen during the project
Perceived quality – the degree of satisfaction that occupants experience with the facility's image	Security – the ability to keep customer information confidential
	Tangibles – the appearance of both the personnel and the facilities of the company to the customer
	Understanding the customer – the ability of the company to understand customer needs and offer personalised attention to the customer

Source: Garvin (1984); Parasuraman et al. (1985).

these are briefing, designing, bidding, construction and commissioning. While they offer a simple portrayal of the process and do not consider current procurement approaches such as design-build or construction management at risk (AIA, 2004), they are based on recognised international practices and so will be linked to appropriate quality improvement methods to support continuous improvement activities (see Table 4). The methods were grouped into seven clusters based on Juran's (1992) quality planning stages. The specific ones included in each group can be found in Delgado and Aspinwall (2005).

The briefing stage of the construction process includes both the collection of customer needs and the elaboration of a blueprint. Therefore, the quality improvement methods that have potential for use are *gathering*, *organising customer needs* and *technology*. After the briefing phase, comes design, in which the *formal methods* and *technology* can be used. The next stage is bidding and the methods that could potentially be employed here are *planning and programming tools* and *technology*. At the construction phase, *quality control* and *technology* are useful. During commissioning, *performance measures* can be applied. The last step in the construction process is maintenance, which was not studied in detail during this research project.

Having linked the activities in the construction process and the potential quality improvement methods to support them, the question 'How to achieve quality in construction?' has been addressed. Applying the relevant quality improvement methods at each of the stages within the construction process can help to ensure that quality is delivered to the customer. It is worth emphasising at this point that a service is being provided to the customer during the whole construction process and the quality improvement methods apply equally to this. For instance, the needs of customers

Table 4. Quality improvement methods for supporting the construction process.

Stage	Brief description	Quality improvement methods (groups)
Briefing (schematic design)	Customer needs are collected and a blueprint elaborated	Gathering customer needs, organising customer needs and technology
Designing (detailed design and construction documentation)	The facility that will satisfy the customer needs is designed. The specification documents that will help to assemble the final product are developed	Formal methods and technology
Bidding	A contractor is chosen to carry out the site construction work	Planning and programming tools and technology
Construction	The facility is built in accordance with drawings and specifications. Construction materials are selected	Quality control and technology
Commissioning	Users take over the facility	Performance measures and technology

in terms of service may be collected by means of *personal interviews* or *customer surveys*. Similarly, service requirements can be analysed and then translated into technical ones using a formal method such as Quality Function Deployment (QFD).

Framework representation

The next step in the framework development process was to create a schematic that considered all the essential and the attractive requirements discussed. This entailed two decisions, the first being related to corporate quality. As argued earlier, the CSFs for TQM implementation can be used as indicators of an organisation's quality level, but since their awareness and use can be reflected in the company's quality policy, it was decided to incorporate this into the framework rather than the CSFs (note that the quality policy may be directly formulated from the list of CSFs shown in Table 1, by generating statements such as those extracted from actual policies). The second decision was related to the construction participants and their culture. The development of the quality policy, the execution of construction activities and the application of quality improvement methods depend on people, so it was felt essential to include them in the framework. Top Management was put as a separate entity since it is a well-known fact that without their commitment any such initiative will fail. Authors such as Kanji and Asher (1996) have used a pyramid to represent a TQM framework, so the first draft to incorporate all the above features was triangular in shape (see Figure 1).

Elements of the framework

As can be seen, it comprises three main levels: (i) the quality policy, established by top management; (ii) the construction process; and (iii) a set of quality improvement methods aimed at supporting the activities during the construction process. Note that people, and more particularly culture, form the foundation of the framework, since the success or otherwise of its implementation directly depends on them. Top Management was located at the top of the schematic because they lead the quality efforts within an organisation.

With regard to quality at corporate level, Top Management should establish the vision of the company, the quality policy and the annual objectives. As already discussed, the quality of the end product and the service that the company provides should be considered during the

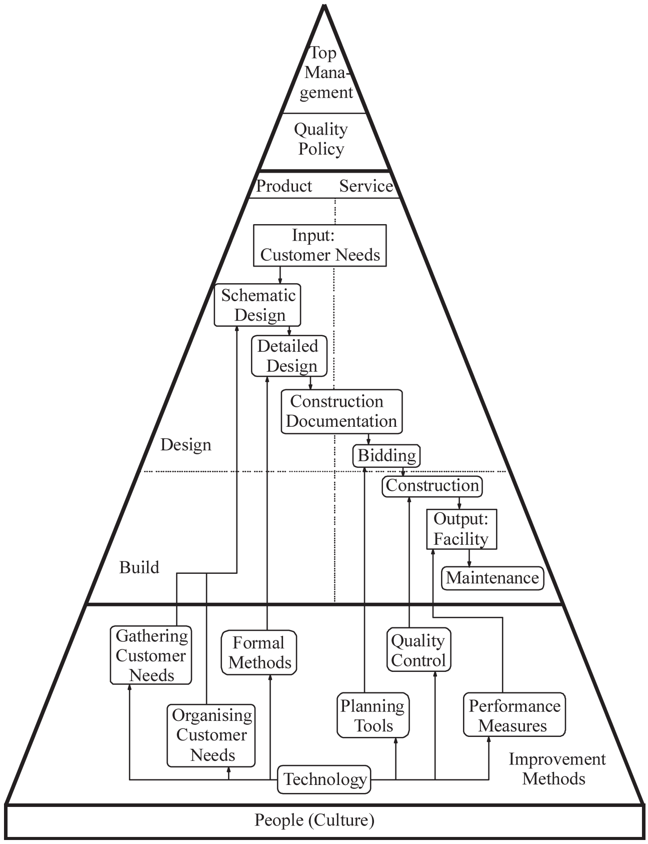

Figure 1. First draft of the framework.

construction process. The dimensions associated with both of these aspects (see Table 3) can be used as checklists to ensure that customers receive both.

The middle part of the triangle shows the construction process and its stages, each of which may be supported by the use of different quality improvement methods and technology. In fact, the lines shown in the figure represent the links that are possible. Having described the framework in general, each section will now be described in more detail. In addition, a guide for implementing the framework's methods will be presented.

Quality policy

An organisation's quality policy is part of its strategic planning process, which includes setting the direction for the company to improve its situation for long-term prosperity and finding the means to achieve that direction (Dale, 2003). The main idea is to communicate throughout the company that something should be done in terms of quality if the company is to survive and compete in the future. The Japanese approach known as 'Hoshin Kanri', or policy deployment, can be adopted when defining a company's quality policy (Tennant & Roberts, 2000, described its major elements). The main advantages of this approach over conventional planning systems are that it combines strategic objectives with tactical daily management, covers all functions in a company and increases quality goals' consensus.

In order to establish the quality policy within the organisation, Top Management should have a customer-focused vision, be relevant for people at all levels within the company, and appropriate for five years. Dale (2003) suggested gathering information on the company, its clients, competitors and market, and then holding meetings between Top Management strategists and employees to determine the vision. He also mentioned that it was important to be realistic and communicate the result to everyone in the organisation.

Before embarking on the strategic planning process, Tennant and Roberts (2000) suggest that the following questions should be answered: 'What business do we want to be in? What are our long term objectives? Do we have the correct core competencies?'. The information collected can be classified using a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. This helps to identify those factors with the highest overall priorities, which are chosen to generate the vision of the company, i.e. a statement that indicates where the organisation would like to be in the future (Juran, 1992) and then to develop an annual plan. Making use of the Pareto principle[1] (Juran, 1992), it may be possible to recognise the factors that constitute 80% of the total priority and to select them to form the basis of the company's quality policy. Alternatively, the list of CSFs shown in Table 1 may be employed as a starting point to identify improvement areas within the company. Regardless of the approach employed, the outcomes of the policy deployment process should be visibly displayed in common areas within the company so that everybody (including customers) can see them (Dale, 2003).

Activities for building quality into projects

The middle part of the triangle, as already stated, shows the stages that are normally carried out during the construction process. They have been broken down into activities (see Table 5) using ideas from CIC (2003); DHUD (2005); Evbuomwan and Anumba (1998); Juran (1992); Kamara et al. (2000); Preiser and Vischer (2005); Torbica and Stroh (1999).

It is suggested that three teams – design (e.g. architects, civil engineers), construction (e.g. contractors, suppliers) and implementation, i.e. people responsible for implementing quality improvement methods (e.g. quality manager, external consultant) – carry them out. The marked cells within the table identify the team responsible for the particular activity and the unmarked ones include recommendations that may be useful during their execution. As can be seen, there are activities in which the three teams could take part simultaneously. This idea has its origin in Concurrent Engineering (CE) principles (Evbuomwan & Anumba, 1998), which promote the integration, collaboration and coordination of the construction process players as early as possible to consider various life-cycle issues associated with the project, e.g. maintenance costs, demolition issues.

Once the client has decided on a particular project, a construction company is approached to carry out the work. The successful company identifies the characteristics of the project and defines it with regard to: name, customer(s) details, location, time-span, budget, land area, procurement approach to be employed and other features that may be relevant, e.g. refurbishment work. Design and implementation teams (along with a construction team) are formed to work on the project.

These firstly identify the future customers (users) of the facility; the list obviously depends entirely on the type of construction required. Some customers are more important than others, so they should be prioritised. The most important customers' needs should then be given preference during subsequent stages of the process. In order to prioritise customers, the values suggested by Cohen (1995) can be adopted: 1 – low priority, 3 – medium priority, 9 – high priority. Again, the Pareto principle could be used to identify the customers that, for example, will use the facility most of the time.

The next activities comprise gathering and organising customer needs. These may be addressed simultaneously to save time. *Customer surveys* is one of the quality improvement

Table 5. Activities for building quality into construction projects.

Stages	Activities	Design team	Construction team	Implementation team
INPUT	Customer needs	The client approaches a construction company with a general idea about the facility		
Schematic design	Define project and form design team	Personnel within the construction company identify the main characteristics of the project and form a design team	The participation of the construction team is recommended at this stage of the process to ensure that it will be represented in the design team	
	Identify and prioritise customer groups	The design team may help to carry out these activities		Customer groups are identified and prioritised
	Gather and organise customer groups' needs	The design team may help to carry out these activities		More detailed needs than those stated at the beginning of the project are collected and organised
	Translate customer needs into technical characteristics	The technical characteristics that will satisfy the needs of the customer groups are determined	The construction team may help to carry out this activity	The implementation team may help to carry out this activity
Detailed design	Translate technical characteristics into construction specifications	The technical characteristics are transformed into specifications (e.g. drawings, plans and schedules)	The construction team may help to carry out this activity	The implementation team may help to carry out this activity
Bidding	Translate construction specifications into materials, labour and equipment	The design team may help to carry out this activity	The specifications are used to quantify the materials, labour and equipment required to build the facility	The implementation team may help to carry out this activity
Construction	Translate materials, labour and equipment into controls		Materials, labour and equipment are controlled to ensure that a quality product is built	The implementation team may help to carry out this activity
OUTPUT	Facility			Measurement and feedback are used to determine the level of success of the project

methods that help to support the collection of customer needs, so a questionnaire to gather requirements may be developed. If the eight product quality dimensions (see Table 3) are used to classify the needs, the 'organisation of customer needs' activity can be eliminated. The ten service quality dimensions (see Table 3) can also be included. Within the survey, the authors suggest the use of the law of ideality promoted by the Theory of Inventive Problem Solving (TRIZ) (Terninko et al., 1998), to encourage customers to think of the best possible facility that will not just satisfy their needs but exceed them.

As can be seen in Table 5, the next activity is to translate customer needs into technical characteristics. The design team should recognise the requirements that are more important to customers and determine the characteristics that will satisfy them. With this information, the House of Quality (HoQ) – part of the QFD process – can be used to start the detailed design phase, in which technical characteristics are translated into construction specifications (e.g. drawings, plans, schedules). The authors believe that regardless of the procurement approach employed (e.g. design–bid–build, design–build), the possibility of developing a quality product is high, if the important customer needs have been included in the final design.

During the bidding stage, members of the construction team translate specifications into materials, labour and equipment requirements. These should be controlled throughout the construction phase to ensure that they comply with the original specifications (*inspection* and *sampling* could help here). The final activity is to measure performance at the end of the construction process. For instance, to assess customer satisfaction, a similar survey to that used for gathering customer needs could be used, although now they are asked to rate the building's features with regard to level of satisfaction rather than importance. This will help to determine whether the original set of customer needs were addressed and to what extent the customer is happy with the final product.

Guide for implementing the framework's methods

Once a particular method has been decided upon, the authors recommend using the guidelines shown in Figure 2 – the elements of which are based on ideas and concepts gathered from Cohen (1995); Dale (2003); Pheng (1993) – to implement it. The sequence with which the steps are carried out may be modified to suit the particular application.

Although rather obvious, the framework's methods should not be applied without careful planning. Their utilisation will require resources such as time, people, money and equipment. Therefore, before embarking on the methods' implementation process, companies will need

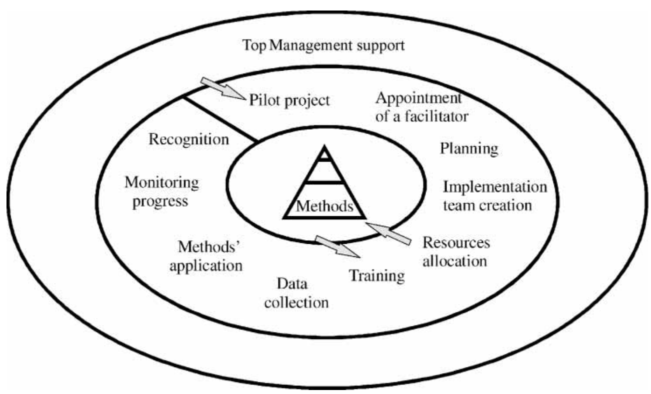

Figure 2. Guide for implementing the framework's methods.

to establish their necessity. The reason for locating the quality policy towards the top of the triangle in Figure 1 was to show that the application of the framework's methods should be directed at achieving the goals set in the company's quality plan, e.g. to satisfy customers.

As can be seen in Figure 2, the outer circle comprises Top Management support; this is because they must be committed to implement the method in question. Before attempting an organisation-wide implementation of the method, a pilot project should be selected, ideally one that is about to start, but is similar to another performed in the past where a customer complaint was received. Top Management should then choose a facilitator or leader who will plan, organise and coordinate the implementation activities. Such a person (either an employee or a consultant) would be responsible for drawing up a plan of the way forward in which activities are identified along with details of who, when, where, why and what will be carried out. Depending on the nature of the project, an implementation team may be created, which would be led by the facilitator. If the project is sufficiently small, there is no need to create a team because the facilitator can work alone.

It is important to ensure that the project is properly and fully resourced – details of which should be specified in the plan. The facilitator and the team members should be trained in the use of the method. Once they are familiar with how it works, data collection can begin and the method can be applied. It is important that milestones are set to monitor progress and to verify that everything is working as planned. The last milestone will be the customer satisfaction measurement. At the end of the project, the implementation team members and the facilitator should receive recognition for their work. It is also at the end of the project when the lessons learned can be logged and a record kept for use in future projects. Unless the method has not worked well, it should be expanded to other projects until it becomes standard practice within the organisation.

Main features

It is believed that the proposed framework has addressed most of the limitations found in the approaches reported in an earlier section. It considers quality from three different angles: corporate, product and service, it covers the whole construction process, and offers both quality improvement methods to support the activities of such a process and a guide to implement them. In addition, it has novel aspects, because the framework recommends the use of the Law of Ideality suggested by TRIZ (a scarcely explored theory in the construction sector), encourages the collection and organisation of customer information, a generally neglected area within the construction industry, and puts the voice of the customer, rather than the voice of the designer, at the heart of the construction process.

By applying the framework in a wide variety of projects within a particular company, a better understanding and knowledge of customer needs can be expected. In addition, customers can be assured that their main requirements will be considered during the construction process. Companies can also expect improved communication between customers and those in charge of establishing their needs (e.g. implementation team members). Ultimately, it is hoped that both the level of quality and the level of customer satisfaction will increase.

Conclusions

Research on quality in the construction industry has become a major concern as evidenced from the amount of literature dedicated to it. Since everybody is a customer of the industry, improvements in the sector can help to increase the quality of life. Hence, construction companies require practical advice and support for adopting and implementing initiatives for continuous quality improvement.

Practitioners, researchers and governments have developed models, frameworks and methodologies aimed at improving performance. While some initiatives tried to improve communication and flow management (Ballard & Howell, 2003; Formoso et al., 2002; Kagioglou et al., 2000; Serpell & Alarcon, 1998), others endeavoured to enhance say briefing, designing or tendering activities (Al-Momani, 2000; Arditi & Lee, 2003; Kamara et al., 2000; Maloney, 2002; Yasamis et al., 2002). They either addressed only one or two quality issues, e.g. communication, role definition (Formoso et al., 2002), were limited to one stage of the construction process, e.g. tendering (Arditi & Lee, 2003) or dealt with only one sector in the industry, e.g. affordable housing (DHUD, 2005). Therefore, it was felt that a more comprehensive approach was necessary to overcome these limitations.

A set of framework requirements was proposed – these were categorised as 'expected' and 'attractive' (there being three associated with the former and seven with the latter) and the concept of quality was viewed from the corporate, product and service angles. The framework was developed into a triangular representation and a guide for the implementation of its methods formulated. Its elements were the company's quality policy (for corporate quality), product and service quality, the construction process and the quality methods that would support improvement activities during the execution of construction projects. The latter were linked to the most suitable construction stages in the schematic diagram.

Comparing the framework with the approaches found in the literature, its main features and its innovative aspects are:

- the framework considers quality from three perspectives;
- it supports all the stages of the construction process;
- it encourages communication with customers; and
- it may be used by companies regardless of their focus within the sector, e.g. building, civil engineering projects.

The next stage was to evaluate the framework, an aspect that will be covered in a second paper.

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Note

1. 'In any population which contributes to a common effect, a relative few of the contributors account for the bulk of the effect' (Juran, 1992, p. 57).

References

Abdel-Razek, R. (1998). Quality improvement in Egypt: Methodology and implementation. *Journal of Construction Engineering and Management*, *124*(5), 354–360.

AIA. (2004). *Primer on project delivery*. The American Institute of Architects and The Associated General Contractors of America, US.

Al-Momani, A.H. (2000). Examining service quality within construction processes. *Technovation*, *20*(11), 643–651.

Arditi, D., & Lee, D. (2003). Assessing the corporate service quality performance of design-build contractors using quality function deployment. *Construction Management and Economics*, *21*(2), 175–185.

Austen, A.D., & Neale, R.H. (1984). *Managing construction projects: A guide to processes and procedures*. Geneva, Switzerland: International Labour Office.

Ballard, H.G., & Howell, G.A. (2003). Lean project management. *Building Research & Information*, *31*(2), 119–133.

CIC. (2003). Design quality indicator. Construction Industry Council, UK. Available online http://www.dqi.org.uk (accessed February 21, 2006).

Cohen, L. (1995). *Quality function deployment: How to make QFD work for you*. Reading, MA: Addison-Wesley.

Corbella, D.S., & Maturana, S. (2003). Citizens role in health services: Satisfaction behaviour: Kanos Model, part 1. *Quality Management in Health Care*, *12*(1), 64–71.

Dale, B.G. (2003). *Managing quality* (3rd ed.). Oxford: Blackwell.

Dale, B.G., & McQuarter, R. (1998). *Managing business improvement & quality: Implementing key tools & techniques*. Oxford: Blackwell.

Delgado, D.J., & Aspinwall, E. (2005). Improvement tools in the UK construction industry. *Construction Management and Economics*, *23*(9), 965–977.

Delgado, D., Liu, J., & Aspinwall, E. (2005). A comparison of surveys of TQM critical success factors in manufacturing and construction UK industries. In *Proceedings of the fourth international conference on quality and reliability*, Beijing Institute of Technology, 135–145.

DHUD. (2005). *Project book: A design-focused workbook*. Department of Housing and Urban Development, Richmond, VA. Available online http://www.designadvisor.org (accessed August 6, 2008).

DTI. (2005). *Construction statistics annual*. London: Department of Trade and Industry.

Egan, J. (1998). *Rethinking construction*. London: Department of Environment, Transport and the Regions.

Emmit, S., Sander, D., & Chistoffersen, A. (2004). Implementing value through lean design management. In *12th annual conference on lean construction*, Denmark. Available online http://www.iglc2004.dk/13727 (accessed November 16, 2005).

Evbuomwan, N.F.O., & Anumba, C.J. (1998). An integrated framework for concurrent life-cycle design and construction. *Advances in Engineering Software*, *29*(7–9), 587–597.

Formoso, C., Tzortzopoulos, P., & Liedtke, R. (2002). A model for managing the product development process in house building. *Engineering, Construction and Architectural Management*, *9*(5/6), 419–432.

Garvin, D. (1984). Product quality: An important strategic weapon. *Business Horizons*, *27*(3), 40–43.

ISO 9001. (2000). *Quality management system: Requirements*. London: British Standard Institution.

Juran, J.M. (1992). *Quality by design: The new steps for planning quality into goods and services*. New York: The Free Press.

Kagioglou, M., Cooper, G., Aouad, G., & Sexton, M. (2000). Rethinking construction: The generic design and construction process protocol. *Engineering, Construction and Architectural Management*, *7*(2), 141–153.

Kamara, J.M., Anumba, C.J., & Evbuomwan, N.F.O. (2000). Establishing and processing client requirements – a key aspect of concurrent engineering in construction engineering. *Construction and Architectural Management*, *7*(1), 15–28.

Kanji, G.K., & Asher, M. (1996). *100 methods for total quality management*. London: Sage.

Koskela, L. (1992). Application of the new production philosophy to construction, Stanford University, CA. Available online http://www.ce.berkeley.edu/~tommelein/Koskela-TR72.pdf (accessed October 20, 2005).

Koskela, L. (2000). An exploration towards a production theory and its application to construction, Finland: VTT Building Technology. Available online: http://www.inf.vtt.fi/pdf/publications/2000/P408.pdf (accessed October 20, 2005).

Koskela, L. (2003). Is structural change the primary solution to the problems of construction? *Building Research & Information*, *31*(2), 85–96.

Maloney, W.F. (2002). Construction product/service and customer satisfaction. *Journal of Construction Engineering and Management*, *128*(6), 522–529.

Merrit, F.S., Loftin, M.K., & Ricketts, J.T. (1996). *Standard handbook for civil engineers* (4th ed.). New York: McGraw Hill.

Owlia, M.S., & Aspinwall, E.M. (1996). A framework for the dimensions of quality in higher education. *Quality Assurance in Education*, *4*(2), 12–20.

Parasuraman, A., Zeithaml, V.A., & Berry, L.L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing*, *49*(4), 41–50.

Pheng, L.S. (1993). The rationalisation of quality in the construction industry: Some empirical findings. *Construction Management and Economics*, *11*(4), 247–259.

Preiser, W.F.E., & Vischer, J.C. (2005). *Assessing building performance*. Oxford: Elsevier.
Seaver, M. (2001). *Implementing ISO 9000:2000*. Aldershot: Gower.
Serpell, A., & Alarcon, L. (1998). Construction process improvement methodology for construction projects. *International Journal of Project Management*, *14*(4), 215–221.
Tennant, C., & Roberts, P.A.B. (2000). Hoshin Kanri: A technique for strategic quality management. *Quality Assurance*, *8*(2), 77–90.
Terninko, J., Zusman, A., & Zlotin, B. (1998). *Systematic innovation: An introduction to TRIZ*. Boca Raton, FL: CRC Press.
Torbica, Z.M., & Stroh, R.C. (1999). Impact of total quality management on home-buyer satisfaction. *Journal of Construction Engineering and Management*, *125*(3), 198–203.
Tzortzopoulos, P., Sexton, M., Cooper, R., & Kagilglou, M. (2004). Evaluation of product development process models focusing on their implementation. In *Proceedings of the 12th IGLC conference on lean construction*, Denmark. Available online http://www.iglc2004.dk/13727 (accessed October 20, 2005).
Walker, A. (2002). *Project management in construction* (4th ed.). Oxford: Blackwell.
Womack, J., Jones, D., & Roos, D. (1990). *The machine that changed the world*. New York: Rawson.
Wong, K.Y. (2005). A framework for knowledge management implementation in SMEs. Unpublished PhD Thesis. The University of Birmingham, UK.
Yasamis, F., Arditi, D., & Mohammadi, J. (2002). Assessing contractor quality performance. *Construction Management and Economics*, *20*(3), 211–223.
Yusof, S.M., & Aspinwall, E. (2000). A conceptual framework for TQM implementation for SMEs. *TQM Magazine*, *12*(1), 31–36.