

# Application of Delphi Technique in Predicting Total Quality Management Constructs in Ghanaian Construction Industry

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## Abstract

Delphi technique has been generally accepted in the past decade by a broad range of institutions, and policy research organizations including construction industry for predicting outcomes. However, its application in determining Total Quality Management constructs in the construction industry is rare. The objective of this paper is to apply Delphi technique process to predict Total Quality Management constructs in Ghanaian construction industry. The paper objective is based on the premise that the technique has never been used to determine Total Quality Management constructs in Ghanaian construction industry, despite the numerous empirical studies that have been conducted in this area of study. The study adopted literature review and Delphi survey technique as the main research method to retrieve data for the study. All the eight constructs (Leadership and Top Management, Supplier Quality Management, Quality System Evaluation, Client Focus and Involvement, Company Vision and Plan Statement, Product Selection and Design Management, Construction Process Management and Improvement, Construction Employees Involvement and Motivation) identified were considered by the experts to have reached consensus. Seven (7) of the constructs were considered by the experts to have a very high influence (VHI: 9-10), with the exception of one (1) construct (Product Selection and Design Management) which had a high influence (HI: 7-8.99). Hence, it can be concluded that the established constructs have high impact on Total Quality Management implementation in Ghanaian construction industry. It is believed that attention given to these constructs will enhance performance of companies implementing Total quality management in the construction industry.

## Keywords

Construction Industry, Delphi Technique, Ghana, Predicting, Total Quality Management

## 1. Introduction

The Delphi technique was originally developed in the 1950s as a tool for forecasting and problem solving of complex topics at the RAND Corporation by Helmer and Dalkey (Buckley 1995). The inspiration behind the naming of this technique is based on Greek mythology. The oracle at Delphi located at an ancient Greek Temple was consulted to forecast the future. This religious ritual was done to enhance accurate and timely decision making before carrying out major societal and state activities such as waging war against other States. The method adopted by the research team at RAND was that, experts of a particular subject matter could be solicited for their opinion about the likelihood of future events or scenarios within that same field of the subject matter. The Delphi technique is part of a group of decision-making (policymaking) techniques that includes the nominal group technique (NGT) and interacting group method (IGM). The Delphi technique differs in various ways from NGT and IGM, largely because it is individual based, anonymous and independent. The element of group interaction is eliminated from the technique (Loo 2002).

According to Loo (2002), the Delphi process is mostly used when investigating and drawing up policy-making or policy evaluation strategies that will set the future direction for public or private sector respectively. Furthermore, the technique is a qualitative methodology seeking to produce a consensus of a group of experts on an issue of concern (Miller 2001) through a survey consisting of rounds. The method is based on structural surveys and makes use of the intuitive available information of the participants, who are mainly experts within the discussed subject matter. The method provides qualitative as well as quantitative results and has beneath it explorative, predictive and even normative elements (Cuhls 2003). There is an agreement that Delphi is an expert survey in two or more 'rounds' in which the results and findings of the second and later rounds of the survey of the previous round are given as feedback. That is, the participants who are experts answer from the second round under the influence of the other experts' opinions. Thus, the Delphi method is a relatively strongly controlled group communication process, in which matters, on which naturally unsure and incomplete knowledge is available, are judged upon by experts (Häder and Häder 1995). The technique requires knowledgeable and expert contributors individually responding to questions (Ellis et al. 2021; Mambwe 2021) and submitting the results to a central coordinator or a researcher conducting the study (Aigbavboa and Thwalla 2012). The coordinator processes the responses, looking for central and extreme tendencies, and their validations (Grisham 2006). The results are fed back to the input provided by the coordinator (researcher). The experts are then asked to resubmit their opinions, aided by the input provided by the coordinator (researcher). This process continues until the coordinator sees that a consensus has been formed. The technique removes the bias that is possible when diverse groups of experts meet together. In the Delphi method, the experts do not know who the other experts are in the process. Hence, the Standard-Delphi-Method is a survey which is directed by a coordinator (researcher) as already stated, comprising several rounds with a group of experts, who are anonymous among each other and for whose subjective-intuitive prognoses a consensus is aimed at (Cuhls 2003).

After each survey round, a standard feedback about the statistical group judgement calculated from median and interquartile range of single projections is given and if possible, the arguments and counter-arguments of the extreme answers are fed back. In the Delphi process, nobody 'loses face' because the study is done anonymously using a questionnaire. Rowe and Wright (1999) and Häder and Häder (1995) inform that it is commonly assumed that the method makes better use of group interaction whereby the questionnaire is the medium of interaction. The method is especially useful for long-range forecasting, as expert opinions are the only source of information available (Aigbavboa and Thwalla 2012).

Czinkota and Ronkainen (2002) indicated that Delphi technique produces valuable results which are accepted and supported by the majority of the expert community. The above instance proves that the Delphi method in research is an accepted practice. However, it is not entirely appropriate for all research activities. Delphi technique is time consuming and does not allow for instant communication or intellectual stimulation. However, arguments have been made to support the claim that Delphi technique is superior to conventional uses of groups in problem solving or forecasting. Over time, the method has gained a favourable popularity across many scientific disciplines as a method of inquiry. Czinkota and Ronkainen (2002) support the assertion that the Delphi method has gained considerable approval across disciplines. They inform that it has been used as a study instrument in the fields of library and information science (Buckley 1995), in the medical disciplines (Linstone and Turoff 1975), in multi-country studies of communications in Europe (www.feiea.org.uk 2003), and by actuaries to predict economic conditions (SOA 1999). However, its application in determining Total Quality Management constructs in the construction industry is rare. Consequently, the objective of this paper is to assess how the Delphi technique could be used to predict and understand the constructs of Total Quality Management in the Ghanaian construction industry. The paper describes the Delphi technique before illustrating the process of execution. This was followed by a brief statement on the epistemological approach of the Delphi techniques for the study.

## **2. Literature Review**

### **2.1 Designing, Constructing and Executing the Delphi Study**

Given the rationale behind the Delphi technique, the design, construction and execution of the Delphi study for the current research followed a sequential process as suggested by Loo (2002). According to Loo, four vital planning and execution activities were to be followed, which are: Problem definition; Panel selection; Determining the panel size; and Conduction of the Delphi iterations. Supporting Loo's (2002) approach, Delbecqet al. (1975) suggest a basic Delphi methodology that includes distinct stages such as, Delphi question development (objective), expert

panel selection, sample size, first questionnaire, first questionnaire analysis and follow-up questionnaires. This methodology forms the basis of the research study and is explained in the subsequent sections.

### Stage 1 – Delphi question development

The formulation of the Delphi question is vital to the whole process. It is paramount that the panel of experts understands the broad context within which the questionnaire is designed. In order to achieve the objectives of the study, key questions were asked. The foundation for constructing the questions for this study was based on the guidelines given in Table 1, with corresponding wording and phrasing given for this study.

Table 1: Delphi question formulation

Key Delphi questions?	Phrasing for this study
Why are you interested in this study?	This study was initiated because of the belief that there is no holistic constructs to guide the implementation of TQM in Ghana. This assumption is solid because there is a discrepancy about the criteria and indicators that determine successful TQM implementation in the developed countries.
What do you need to know that you do not know now?	Despite the existence of some constructs for Total Quality management implementation, these are not comprehensive and do not capture the entire requisite features. The criteria and indicators that will determine successful TQM implementation will come out clearly at the end of this study.
How will the results from the Delphi Study influence Total Quality management Implementation?	The results of the Delphi Study will enable the development of a conceptual framework for the TQM implementation framework to be developed. The criteria which would collectively predict and assure successful TQM implementation framework will be established.

### Stage 2 – Delphi Expert Panel Selection

A critical part of conducting a Delphi interview technique is selecting the right experts (also known as panelists, participants or respondents) and their role is crucial to the success of the research (Hasson et al. 2000). Experts must be sufficiently interested and involved in the subject being examined to ensure high commitment response rate. According to Hasson et al (2000), controversial debate rages over when a professional becomes an ‘expert’. The claim that one group represents valid expert opinion, has been criticized as scientifically untenable and overstated (Hasson et al. 2000). For the purpose of this research McKenna’s (1994) definition of ‘expert’ as being a panel of informed individuals otherwise called experts hereafter was used. McKenna’s (1994) definition was further supported by Goodman (1987:730) stating that the Delphi technique “tends not to advocate a random sample of panelists, instead, the use of experts or at least of informed advocates is recommended”. Likewise, Helmer (1977:1819) argues that since a “Delphi inquiry is not an opinion poll, relying on drawing a random sample from the population of experts is not the best approach, rather, once a set of experts has been selected (regardless of how – but following a predetermined qualifying criteria), it provides a communicative device for them that use the conduct of the exercise as a filter in order to preserve anonymity of responses” which is core to the Delphi technique. Therefore, Linstone (2002) states that the most significant danger in selecting the panel of expert lies in the path of ‘least resistance’ through the selection of a group of cosy friends and/or like-minded individuals, which thus negates the strength of the process. Panelists form the cornerstone of the Delphi technique and clear inclusion criteria should be applied and outlined as a means of evaluating the results and establishing the study’s potential relevance to other settings and populations (Igbal and Pison-Young 2009). According to Dalkey and Helmer (1963), there are detailed criteria for the selection of panel experts; recommending that in a typical Delphi study, experts should meet the following two recommendations which were also postulated by Rodgers and Lopez (2002). The first recommended criterion is that the experts should exhibit a high degree of knowledge or experience in the subject matter. Another criterion is that they should be the representative of profession so that their suggestions may be adaptable or transferable to the population. Similarly, Adler and Ziglio (1996) stated that the Delphi participants in any study should meet four “expertise” requirements, which are: knowledge and experience with the issues under investigation; capacity and willingness to participate; sufficient time to participate in the Delphi; and effective communication skills. In choosing panelists for this study, each expert was required to meet at least five of the following minimum criteria:

Residency: Have lived or is living within one of Ghana's Metropolis, Municipality or District; at least more than one year;

Knowledge: Has knowledge of Total Quality management; Academic Qualification, has been presented an earned degree (National Diploma/B-Degree/M-degree/PhD) related to any field;

Experience: Has a history of currently performing consultation services for Ghana's organ of State, individuals, businesses, agencies, companies, and/or organizations, relating to Total Quality Management projects or other related projects.

Employment: Currently serves (or has previously served) in a professional or voluntary capacity (e.g., at place of employment - institution, business, agency, department, company) as supervisor or manager of establishment that is involved with project management and its related issues in Ghana;

Influence and Recognition: Has served/currently is serving as a peer-reviewer for one or more manuscripts received from a journal editor prior to its publication in the primary literature, with focus of the manuscript(s) on Total Quality management;

Authorship: Is an author/co-author of peer-reviewed publications in the field of infrastructure development with emphasis on developing countries;

Research: Has submitted one or more proposals to or has received research funds (grant/contract) from national, local government, regional, and/or private sources that support Total Quality management of construction projects in Ghana;

Teaching: Has organized, prepared, and successfully presented one or more Total Quality Management training workshops focusing on the group for which expertise is sought; Membership: Member of a professional body. Should be the representative of a professional body so that their opinions may be adaptable or transferable to the population;

Willingness: Panel members must be willing to fully participate in the entire Delphi studies.

The adoption of five criteria was considered stricter than the recommended number of at least two criteria by Rodgers and Lopez (2002) and Dalkey and Helmer (1963). The five minimum criteria were framed after the four recommendations made by Adler and Ziglio (1996), with the inclusion of experts' residency status, which was considered to be compulsory for all selected experts. Also, a minimum number of five criteria were set because the method may be undermined if panelists are recruited who lack specialist knowledge, qualifications and proven track records in the field (Keeney et al. 2001) amongst others. Although of course expertise comes in many guises and may include those who are 'experts by experience' (Hardy et al. 2004). In general, a varied panel is considered best in producing a credible Delphi study and individuals who might provide a minority or differing perspective should be actively recruited to the panel (Linstone and Turoff 2002), which was adopted for the study. With regard to the recruitment process itself, panelists were recruited via e-mail, with a brief overview of the study objective. Thereafter, those that consented to the preliminary invitation were sent a detailed description of the Delphi study. Hence all experts selected for the current study met the five criteria set for the study. After the verification exercise, selected experts were then sent the first round questionnaire survey which was presented in the form of both closed and open-ended questions.

### **Stage 3 – Determining the Panel Size**

Since the nature of the Delphi technique calls for a qualitative rather than a quantitative approach, the use of experts for input indicates that the number of participants should be expected to be much lower than normal quantitative surveys. Determining the minimum number of experts to participate in a typical Delphi survey has been a subject of debate overtime. Various scholars have recommended different sample sizes. For instance, Helmer and Dalkey (1963) used a panel of seven experts in their original Delphi experiment in 1953 (Helmer 1983). Linstone (1978:296) finds that "a suitable minimum panel size is seven". Linstone justified this by saying that the research runs the risk of accuracy deteriorating rapidly as number increases. Hence Linstone's observation was supported by Cavalli-Sforza and Ortolano (1984:325) who postulated that a "typical Delphi panel has about eight and twelve members", while Phillips (2000:193) also informs that the optimum number of participation should be between seven and twelve members both citing the same reason as Linstone. De Leo (1995) emphasizes that the number of panelists should be less than fifty; while Miller (1993) refers to the economics of scale in large groups of Delphi surveys. Miller assumes that beyond the first thirty responses, additional responses do not generate much new information. Similarly, Dunn (1994) suggests a ten to thirty participants, apprising that as the complexity of the policy issue increases, the sample size needs to be larger to include the entire range of participants both for and

against the policy issue area. According to Andranovich (1995), if the group of experts is fairly homogeneous (sharing similar opinions) then ten to fifteen panelists will be enough and if there are diverse interests present among the experts, then the size of the group will need to be increased to ensure balance (Zami and Lee 2009). Skulmoski, Hartman and Krahn (2007) highlighted a number of factors which should be considered in order to determine sample size for a Delphi technique: Heterogeneous or homogeneous sample (Delbeq et al. 1975); Decision quality/Delphi manageability trade off (Linstone 2002); Internal or external verification. Therefore, a sample size of 10 panelists was adopted based on the following premise in conjunction with the qualifying criteria's as established in stage two of the Delphi study which are: Experts should have a fair and practical split between academics and practitioners; Panelist in both categories should have an extensive experience relating to Total Quality Management and its related issues. Beside the above criteria, the current study also adopted Rowe et al. (1991) recommendations that the resultant selected participants should represent a wide variety of backgrounds to guarantee a wide base of knowledge and experience. The adopted experts' number of 10 seems appropriate, given the amount of data and subsequent analyses each panelist generates.

#### **Stage 4 – Conducting the Delphi Iterations**

Sequences of questionnaire rounds are used to obtain iterative responses to issues in a Delphi study (Masser and Foley 1987). For instance, Woudenberg (1991) proposes two or ten rounds as appropriate numbers of rounds, supporting the assertion that accuracy is expected to increase over rounds, because of the repetition of judgement and group pressures for conformity. Likewise, Critcher and Gladstone (1998) suggest between two and five rounds. The Delphi study for the research consisted of three rounds. In average, each round took about a month to be completed. A questionnaire was designed for each round based on responses to the previous one. Round one's questionnaire was designed based on a summary of the comprehensive review of literature highlighting sets of criteria and indicators that are potentially relevant to the implementation of Total Quality Management in Ghanaian construction industry. These were structurally and constructively put together to frame the first round of the Delphi survey. Closed and open-ended questions were used in this round; thereafter, this was analysed and formed the basis of round two and three of the study. Frequencies were obtained to measure the degree of consensus reached amongst participants regarding the criteria, indicators that influence successful implementation of Total Quality Management in Ghanaian construction industry and for other related questions. Also, content analysis methodology was adopted to analyse responses to the open questions to "minimize redundancy" (Rubin et al. 1998:6). The purpose of the second round of the study was to allow experts to review and comment on the criteria and indicators that influence successful implementation of Total Quality Management in Ghanaian construction industry, which were proposed by expert participants in round one. Closed and opened questions were used in this round to investigate participants' comments, expressing agreement, disagreement or clarification concerning proposed criteria and indicators that influence Total Quality Management implementation in Ghanaian construction industry.

The specific nature of the closed-ended questions stimulated participants' reactions. Frequencies were likewise obtained to measure the degree of consensus reached amongst participants. Furthermore, content analysis approach was adopted to analyse responses to the open questions. The final round was specifically designed to: Inform the experts of the findings of the analysis of responses to the questionnaire of round two; request their final affirmation / comments on attributes and issues that did not receive any consensus in round two. The questionnaire of round three was designed based on the findings of content analysis and measures of frequencies responses to the questionnaire of round two. Closed and opened questions were also used and frequencies were obtained to indicate consensus reached among experts regarding criteria and indicators that influence successful implementation of Total Quality Management in Ghanaian construction industry as presented in the study. Where consensus was not reached, the reasons for the disagreements were noted and reported in the findings section of the study.

Over the three round Delphi survey, consensus was reached regarding most of the criteria and indicators that influence successful implementation of Total Quality Management in Ghanaian construction industry. Based on the findings of the analyses of responses to the Delphi rounds, a list of criteria and indicators that influence successful implementation of Total Quality Management in Ghanaian construction industry was prepared which informed the conceptual framework for the broader study.

### 3. Research Methodology

The research was conducted with reference to existing theoretical literature, i.e. published and unpublished literature. This was followed up with Delphi survey method to collect data from experts (construction professionals) through email. A Delphi Study is a group decision mechanism requiring qualified experts who have deep understanding of the issues at hand (Okoli and Pawlowski 2004; Ellis et al. 2021; Mambwe 2021). The list of experts was generated from peer reviewed conference proceedings and journal articles. It was also based on their articles written on Total Quality Management in the Ghanaian construction industry. Seventeen invitation letters were sent to the experts through email to indicate their willingness to participate in the study. Thirteen experts showed their interest to participate in the study. During the first stage of the Delphi questionnaire administration, three experts were further dropped. The remaining ten experts concluded the survey. This number of panelists was considered adequate based on literature recommendations from scholars which have employed the technique previously. Hollowell and Gambatese (2010) suggested that since most studies incorporate between eight (8) and sixteen (16) panelists, a minimum of eight (8) is reasonable. Hollowell and Gambatese (2010) argued that the size of a panel should be dictated by the study characteristics, number of available experts, the desired geographical representation and capacity of the facilitator. Experts in Ghana were asked to rate the impact and influence of the factors in predicting the success of Total Quality Management implementation in the construction industry. An impact scale used is shown in Table 2 below. Data obtained from the Delphi survey was analyzed with Microsoft EXCEL, spread-sheet software. The output from the analysis was a set of descriptive statistics such as means, median, standard deviations and derivatives of these statistics. The results were further presented in a table. The steps in conducting Delphi survey has been discussed in the previous section.

Table 2. Impact scale

No impact / influence		Low impact / influence		Medium Impact / influence		High impact / influence		Very high impact / influence	
1	2	3	4	5	6	7	8	9	10

### 4. Discussion of Results

A set of factors that were relevant to Total Quality Management were emphasized through a comprehensive review of literature. Although, most of the reviewed literature was based on studies from the developed countries, they were collectively used to examine the factors that determine the success of Total Quality Management in the Ghanaian construction industry. The influence of the factors on Total Quality Management was obtained as a product of the impact on the construction industry in Ghana. The main factors were based on the level of influence, as categorized on the questionnaire. This was established by assessing the extent to which the listed factors will determine the Total Quality Management implementation in the construction industry. The rating was based on an ordinal scale of one to ten with one being low influence or no impact and ten being high influence or very high impact. The levels of influence and impact were obtained as a product of the consensus achieved.

By applying the Median Absolute Deviation to determine whether a factor reached consensus or not, all the eight (8) critical factors (Leadership and Top Management, Supplier Quality Management, Quality System Evaluation, Client Focus and Involvement, Company Vision and Plan Statement, Product Selection and Design Management, Construction Process Management and Improvement, Construction Employees Involvement and Motivation) were considered by the experts to have reached consensus. Consensus was also reached for four (4) attributes (Leadership and Top Management, Company Quality System Evaluation, Product Selection and Design Management, Construction Process Management and Improvement) under the critical factors that determine Total Quality Management in the construction industry, with an IQD score of 1.00 or cut-off ( $IQD \leq 1$ ) (Table 3). Seven (7) factors from the eight (8) identified critical factors that determine Total Quality Management in the construction industry were considered by the experts to have a very high influence (VHI: 9-10), with the exception of one (1) factor (Product Selection and Design Management) which had a high influence (HI: 7-8.99). These indicate that all the factors have high influence on Total Quality Management implementation in the construction industry.

Table 3. Total Quality Management (TQM) in the Construction Industry Main Factors

Total Quality Management in the Construction Industry Main Factors	$\bar{x}$	M	SD	MAD	IQD
Leadership and Top Management (LTM)	9.10	10.00	1.85	0.90	1.00
Company Supplier Quality Management (CSQM)	8.40	9.00	1.43	0.80	1.25
Client Focus and Involvement (CFI)	8.30	8.00	1.06	0.70	1.50
Company Quality System Evaluation (CQSE)	9.10	9.00	0.57	0.30	0.25
Company Vision and Plan Statement (CVPS)	8.40	9.00	1.43	0.80	1.25
Product Selection and Design Management (PSDM)	7.80	8.00	0.79	0.40	0.25
Construction Process Management and Improvement (CPMI)	8.60	9.00	0.84	0.40	0.50
Construction Employees Involvement and Motivation (CEIM)	9.00	10.00	2.21	1.00	1.25

M=Median;  $\bar{x}$ =Mean; SD=Standard Deviation; MAD=Median Absolute Deviation; IQD=Interquartile Deviation

## 5. Conclusion and Recommendation

This study intended to apply Delphi technique in predicting Total Quality Management constructs in the Ghanaian construction industry. Eight constructs which influence TQM implementation in the Ghanaian construction industry were identified. These are: Leadership and Top Management, Supplier Quality Management, Quality System Evaluation, Client Focus and Involvement, Company Vision and Plan Statement, Product Selection and Design Management, Construction Process Management and Improvement, Construction Employees Involvement and Motivation. It is believed that attention given to these factors will minimize difficulties related to the implementation of Total quality management and will enhance performance of companies implementing Total quality management. Further research is also suggested to be carried out by using empirical fieldwork (questionnaire survey) to determine the importance, similarities and differences of the identified constructs.

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