Determining TQM practices in university R&D activities using factor analysis: Research experience of Malaysian universities

Ahmad Jusoh
ahmadjutm@yahoo.com
Fakulti Pengurusan dan Pembangunan Sumber Manusia
Universiti Teknologi Malaysia

Rushami Zien Yusoff
rzy278@uum.edu.my

Shahimi Mohtar
shahimi@uum.edu.my
Fakulti Pengurusan Teknologi
Universiti Utara Malaysia

Abstract

Overall, this paper discusses the applicability of TQM and proposes a theoretical framework of TQM to suit the need of the Research and Development (R&D) context. The dimensions for the framework were based on the previous empirical studies, the evaluation criteria of world standard criteria such as MBNQA, EFQM, and QMS ISO 9000, and quality concept from the experts. In order to understand the TQM practices in R&D environment, this paper addresses the need for the study from the university researchers' perspective. Data were collected through a large-scale mail survey from academic researchers of four Malaysian Research Universities. The constructs of TQM practices were validated and determined using factor analysis. The findings from this study suggest that the seven dimensions i.e. top management leadership, data and information management, performance management, process management, partnership, customer focus and resource management are sufficient to explain the TQM practices in R&D context.

Keywords: *TQM, R&D, technology transfer, university researchers*

Introduction

Total Quality Management (TQM) is an approach for quality movement and excellent management practices in private and public sectors (Kanji and Tambi, 1999; Korunka, Carayon, Sainfort, Scharitzer, and Hoonakker, 2003; Saraph, Benson, and Schroeder, 1989). Compared with private organizations, the implementation of TQM in public service organizations, particularly in universities, is relatively new (Elmuti, Kathawala, and Manippallil, 1996). Moreover, it is not easy to implement and operationalize the concept of TQM in the university setting since by its nature the public university sector is not primarily driven by market or consumer preferences (Koch, 2003; Korunka *et al.*, 2003; Youssef, Libby, Al-Khafaji, and Sawyer, 1998). For that reason, several studies had discussed the applicability of TQM in the university context (Bolton, 1995; Owlia and Aspinwall, 1997) and proposed a framework (Ho and Wearn, 1995; Kanji and Tambi, 1999; Osseo-Asare and Longbottom, 2002; Owlia and Aspinwall, 1998). These studies suggested that the introduction and application of TQM in the education setting is possible, but must be carefully implemented by taking into account the uniqueness and nature of the education sector.

After reviewing extensive literature related to TQM in the education sector, it was observed that (a) there is still lack of research in TQM which focuses directly on the scope of Research and Development (R&D) in universities, and (b) there are very limited research discussing TQM implementation and practices from the employees' point of view or at the individual level. (Boselie and Wiele, 2002; Korunka *et al.*, 2003; Oii, Veeri, Yin, and Vellapan, 2006; Zeitz, Johanneson, and Ritchie, 1997) most of the research related to university R&D have been performed at the organizational level (Carlsson and Fridh, 2002; Chang, Chen, Hua, and Yang, 2005; Franklin, Wright, and Lockett, 2001; Friedman and Silberman, 2003; Thursby, Jensen, and Thursby, 2001) rather than at the individual level, i.e. the university researcher (Lee, 1996; Owen-Smith and Powel, 2001). Knowing that the orientation and nature of university R&D is of a more self-centric and personal nature, it is therefore justified to investigate the issue from the researchers' perspective. This is in line with the opinion of Boselie and Wiele (2002), where they stressed that research on individual employees' perception of TQM implementation may reveal another stimulus to the discussion on the effectiveness of TQM.

This article is particularly pertinent to enriching the literature in TQM-R&D relating to the university context while focusing on university researchers to obtain a better understanding of the perceptions of TQM practices in the R&D context. Therefore, the objective of this paper is to determine the dimensions of TQM practices in the R&D context from academic researchers' perspectives. Theories, practices and issues related to TQM and R&D were reviewed and used as a basis for developing a TQM framework for R&D practices in universities. This approach will provide a more holistic view which would enhance our understanding on TQM and its context.

Literature review on TQM

There are a number of approaches to conceptualise TQM practices (Oakland, 2004; Roa *et al.*, 1996; Samson and Terziovski, 1999). The first approach is by adopting the concepts and methods suggested by quality gurus such as Deming (1982a, 1982b), Juran (1988a, 1988b), Crosby (1979), and Ishikawa (1985) while the second approach uses ISO 9000 framework and principles. The third approach uses quality award frameworks such as the Malcolm Baldrige National Quality Award (MBNQA) (Baldridge, 2006) and the European Foundation for Quality Management (EQFM) framework (EFQM, 2006). Finally, the fourth approach is based on empirical evidence or critical success factors in real practices (Black and Porter, 1996; Kanji and Tambi, 1999; Samson and Terziovski, 1999).

The thoughts and ideas of quality gurus (including philosophy, concept, tools, and techniques) on quality management practices have been incorporated into ISO and Quality Award Frameworks. To be more comprehensive in conceptualising the real practices of TQM, the results from empirical studies have to be considered too. The literature reviews of conceptual papers as well as research papers in the area of university research management, R&D and technology transfer in the university-industry context have revealed certain themes or dimensions that would explain the conceptual model for TQM in the R&D context of the university.

TQM dimensions

Leadership

Everyone is responsible for quality, especially the top management (Crosby, 1979; Deming, 1982; Juran, 1988a). To achieve significant results, senior management has to visibly and actively engage in the quality effort and initiative (Baldrige, 2006; ISO 9000, 2006). In the context of R&D activities in the university, top management should develop clear vision, mission, objectives, and strategies for the organization to excel in R&D and provide necessary resources (Gitlow *et al.*, 2005; Zairi, 1994). Furthermore, senior researchers should manage research by leading co-workers and the research group as well as lead the research unit or department where he or she belongs (Hemlin, 2006).

The core issues in our leadership construct included encouragement of research activities that have both academic and commercial values (Friedman and Silberman, 2003; O'Shea, Allen, O'Gorman, and Roche, 2004; Pratt, Margaritis, and Coy, 1999), commitment of top management in providing resources to facilitate research (Baldrige, 2006; ISO 9000, 2006; Kirkland, 2005; Winn and Cameron, 1998), and promoting a culture of 'networking' with the industry that would facilitate the process of commercialization (Lee, 1996).

Strategic planning

The gurus of quality have high regard for this element, i.e. the need for short-term and long-term planning in quality movement (Deming, 1982), a plan to achieve goals and a project to solve problems (Juran, 1988a), and a plan to achieve zero defects (Crosby, 1979). A review of the quality model or framework (Baldrige, 2006; EFQM, 2006; Lembaga Akreditasi Negara, 2006) also revealed that the element of strategic planning is critical in quality management practices. Our survey questions concentrated on long-term focus of strategic planning (Clarke, 2002; Heininger, 1988; Steele, 1988), a well planned strategic planning (Baldrige, 2006), the development of policy to support research and technology transfer activities (Carlsson and Fridh, 2002; Santoro and Gopalakrisnan, 2001; Siegel, Waldman, and Link, 2003), soliciting input from faculty and senior researchers (Baldrige, 2006; Winn and Cameron, 1998) and the implementation of action plan in achieving organizational goals and objectives (Baldrige, 2006; Calvo-Mora, Leal, and Roldan, 2006; Zink and Schmidt, 1995).

Customer focus

In total quality setting, customers define quality and employees strive to produce it. This would require the producers or service providers to clearly identify the customer needs prior to product development (Crosby, 1979; Deming, 1982; Juran, 1988b). Besides, the element of customer focus is deeply stressed in many quality management frameworks (Baldrige, 2006; EFQM, 2006; ISO 9000, 2006; Lembaga Akreditasi Negara, 2006).

Generally, organizations have viewed customers as people who buy and use their products. In the context of university R&D activities, the customer could be the university, government, or firms. According to Weggeman and Groeneveld (2005), the financial provider is the real customer and it could be the government or private firms. Therefore, a research not only has to meet the requirements of the university but more importantly it must also meet the expectations of the financial provider. In addition, the expectation of the customer on the research outcome must be clearly communicated and understood (Prajogo and Sohal, 2006; Samson and Terziovski, 1999).

In short, this dimension focuses on meeting customers' requirements (i.e government, industry, financial provider) (Baldrige, 2006; Liu and Jiang, 2001; Scmitdt, Graversen, and Langberg, 2003; Stackhouse and Day, 2005), dissemination of customer-related information or requirement to researchers (ISO 9000, 2006), and also feedback and customer satisfaction analysis related to research activities (Winn and Cameron, 1998).

Data and information management

In managing quality, it is important for organizations to have a good system to manage data and information on its operation and external environment, i.e. process/product performance and their customer or market needs. Having sufficient data and information on the process performance and operations, customers, suppliers, and other stakeholders would help the organization and its employees to continuously improve their decision and action in producing and delivering goods and services that fulfil the standards and requirements (Baldrige, 2006; Deming, 1982; Ishikawa, 1985; ISO 9000, 2006; Juran, 1988b).

In the context of R&D activities in the university, it is a crucial for the university to develop an effective data and information management system which can monitor the research project, update the research completion status, and provide data on research performance (Baldrige, 2006; Winn and Cameron, 1998; Zink and Schmidt, 1995). By doing this, relevant parties such as the university top management, government, and industries can get access to the information (Hasan, 1999). The information is critical to them, especially when they finance the research project or they have some interest in investing and going further into commercialization activities. In addition, this dimension is also concerned with the information related to research activities such as expertise, facilities, research-related courses, grant application processes, research outputs, and funding must be available, updated, and reliable (Baldrige, 2006; ISO 9000, 2006; Kirkland, 2005; Stackhouse and Day, 2005; Zink and Schmidt, 1995).

People management

Among the issues that were stressed by quality gurus are employee involvement, reward and recognition, training and development, and team work (Crosby, 1979; Deming, 1982; Ishikawa, 1985; Juran, 1988a). Meanwhile, referring to the TQM framework, it also showed that the element of people management is extremely important (Baldrige, 2006; EFQM, 2006). In the university context, this element is crucial either in teaching and learning, or research activities. The performance appraisal system, incentives, and rewards must fully support and motivate the staff to excel in research and technology transfer activities (Birley, 2003; Chang *et al.*, 2005; Franklin *et al.*, 2001; Goldfarb and Henrekson, 2003; Houghton, 2005; Logar, Ponzurick, Spears, and France, 2001; Siegel, Waldman, Atwater, and Link, 2003). The reward can be in financial or non-financial forms. Non-financial rewards such as recognition, autonomy, and freedom of doing research would motivate the researcher to be actively involved in research and technology transfer activities (Clarke, 2002; Liu and Jiang, 2001).

To excel in research, the university must have a recruitment policy that requires the staff to have some degree of research capability, interest, commitment, and relevant experience (Hemlin, 2006). This policy would promote a dynamic research environment (Scmitdt *et al.*, 2003). Meanwhile, training and development exercises are necessary to produce a significant number of good staff in research activities (EFQM, 2006; Hemlin and Gustafsson, 1996; Winn

and Cameron, 1998). Besides formal training, other training approaches such as a mentor system would be effective to reduce the gap in knowledge and skill of doing research (Johnston and Mccormack, 1997).

Process and system management

Historically, the process and system management approaches are used in the total quality setting to ensure the quality of process and product (Deming, 1982; Ishikawa, 1985; Juran, 1988a; Taguchi, 1986). Accordingly, the approach was naturally built-in into the TQM framework and quality management system, i.e. MBNQA, EFQM, and ISO 9000 (Baldrige, 2006; EFQM, 2006; ISO 9000, 2006). The approach is not only pertinent in manufacturing but also in service organizations (Behara and Gundersen, 2001). The application of that approach in university R&D activities is also significant. According to Scmitdt *et al.* (2003) a research organization transforms an input (grants and competences) through a process to an outcome (dissertations, publications, patents, and rewards). This means that research is a process approach.

To realise its commercialization potential, the research has to go through the right processes starting from project selection, project development, and project commercialization (Logar *et al.*, 2001; Siegel, Waldman, Atwater, and Link, 2004). To make the process effective, the researchers must be well informed of the procedures involved (Baldrige, 2006; Calvo-Mora *et al.*, 2006) and other related units or departments must be well coordinated too (Kirkland, 2005). For that reason, all the processes involved have to be managed, planned, monitored, and assessed.

Partnership and resources

Partnering is a commitment between two or more organizations for the purpose of achieving specific goals and objectives by maximising the effectiveness of each participant's resources (Besterfield, Besterfield-Michna, Berterfield, and Besterfield-Scare, 2003). In university R&D practices, the issues related to partnership, such as collaboration and funding, have been discussed seriously in previous studies. Houghton (2005) and Scmitdt *et al.* (2003) mentioned that the requirements of and encouragement from the stakeholder is the prime mover for researchers to collaborate and engage in partnerships. The form of partnerships may exist in many ways such as collaboration with colleagues as well as with other people outside academia, e.g. businesses and public organizations (Hemlin, 2006). A collaboration is formed on the complementary and sharing basis to relieve the constraints of financial resources, infrastructure, and expertise as well (Scmitdt *et al.*, 2003).

Resources and good infrastructure are important to ensure the effectiveness of research activities. According to Chang *et al.* (2005) the establishment of infrastructure or office to manage intellectual property issues (invention disclosure, patents, licensing, and royalty) and commercialization activities (incubators and spin-off companies) would create awareness among academics, and can lead to involvement in the exploitation of research products. Logar *et al.* (2001) also mentioned that the main barrier in research commercialization is the failure of the university to provide the necessary infrastructure. Other than that, as stated by Carlsson and Fridh (2002), the amount of funding in research and commercialization activities would influence the level of technology transfer.

Research model

Based on a review of literature, it is a basic proposition of this study that seven dimensions i.e. leadership, strategic planning, customer focus, data and information management, people management, process and system management, and partnership and resources are comprehensive enough to explain the concept of TQM practices.

Methodology

In this section, we discuss sample and data collection procedure, survey instrument, data preparation, data screening and analysis procedures.

Sample

The population and sample of the study were the academic researchers in the field of science and technology (S&T) within four Malaysian public universities which have a status of 'research university' i.e Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM) and Universiti Malaya (UM). Academic researchers in the field of S&T were chosen because they receive more funds for R&D activities a compared to other field of researches (MASTIC, 2004). Sample for the population were drawn from a list of academic staff of science and technology-based faculty i.e. faculty of science, engineering, computer, medicine, allied health and agriculture.

We employed stratified random sampling and divided the population into four strata i.e USM, UKM, UPM and UM. A total of 350 samples were picked randomly. A total of 181 responses were obtained representing a response rate of 51.7 percent. To increase the response rate, follow-up questionnaire were sent and we managed to increase the response rate to 66% (231 respondents).

Survey instrument

The survey instrument was a 4-page (A4 size) paper questionnaire. A total of 75 questions divided into two parts, were included in the questionnaire. The first part of the questionnaire consists of 68 questions on TQM practices and the second part has 7 questions on demographic profile.

For TQM practices, the measurements are based on the seven dimensions of TQM developed by the authors. The questionnaire was then piloted on 13 academic researchers and 6 experts in the field of TQM and R&D management. Responses to these items or questions were made on six-point Likert format ranged from 1(Strongly disagree) to 6 (strongly agree). Based on the feedback from the pilot test, some of the questions have been revised to make it more refined and clearly worded.

Analysis Procedures

In order to determine TQM practices in university R&D activities we used the factor analysis procedure and reliability analysis to identify relatively small dimensions underlying a relatively large set of variables (Meyers *et al.*, 2006). Therefore the variables assigned to each of the seven dimensions of TQM (our initial framework) have been subjected to factor analysis to ensure that they are reliable indicators of those constructs (Nunnally and Bernstein, 1994). To achieve practical significance, a cut-off loading of 0.4 has been used to screen out variables which are deemed weak indicators of the constructs or dimensions (Hair *et al.*, 2006;

Stevens, 2002). In addition, after the items have been factored to some dimensions, the authors conduct the reliability analysis to ensure that the dimensions are statistically reliable. Nunnaly and Bernstein (1994) suggested that in exploratory research such as this, alpha value of 0.7 is sufficient.

The discussion in the literature on sample size requirement for factor analysis has come to conclusion that there is no consensus on the minimum sample size for factor analysis, with the recommendation ranging from 100 to 300 (Froman, 2001; Hair *et al.*, 2006; Meyers *et al.*, 2006). In our study, a sample size of 231 is considered sufficient to run factor analysis (Arrindell and Van de Ende, 1985; Comrey and Lee, 1992).

Results

A principle component factor analysis with varimax rotation was conducted to validate the underlying structure of TQM practices. To interpret results from factor analysis, several key statistics were examined such as Kaise-Meyer-Olkin (KMO) measure, Barletts's Sphericity test, eigenvalues, percent of variance explained, loading factor and number of factor extracted.

After the eighth iterations, we finally found the simple structure that would explain the TQM constructs well. In the final iteration, the KMO measure of sampling adequacy value was 0.933 indicating that the present data were suitable for the application of factor analysis. According to Meyers *et al.* (2006), a value of 0.70 or above is considered adequate. Bartlett's test of sphericity was also found to be significant ($\chi^2 = 7441.68$, $p < 0.001$) and this providing evidence that the variables are independent and appropriate for factor analysis.

The factor structure was extracted using eigenvalue and loading factor of 0.4. According to Hair *et al.* (2003) factors with eigenvalue of less than one are considered insignificant and not retained. Besides, factors with have low loading value (<0.4) or cross-loading will become a candidate for deletion (Hair *et al.*, 2006). By using this criteria, finally (after eighth iteration) the principle component analysis recommended only 43 items should be used out of the original 68 items. All these 43 items are loaded into seven factors and the percent of variance explained by these seven factors is 66.72%. In social science research, the rule of thumb for this criterion is that a factor solution should account for a minimum of 60 percent of the total variance (Hair *et al.*, 2003). Thus we can conclude that all the seven dimensions are sufficient enough to explain the concept of TQM in R&D environment.

Table 1: Total Variance Explained

Component /Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	**17.910**	**41.651**	**41.651**
2	**2.371**	**5.514**	**47.165**
3	**1.994**	**4.638**	**51.803**
4	**1.954**	**4.543**	**56.346**
5	**1.716**	**3.990**	**60.336**
6	**1.458**	**3.390**	**63.726**
7	**1.286**	**2.991**	**66.717**
8	.950	2.209	68.926
↓	↓	↓	↓
43	.067	.155	100.000

Extraction Method: Principal Component Analysis

The details of the factor analysis including the reliability of the factors are shown in Table 2. The variables or items are identified by their code names that are explained in Appendix A.

These seven new factors are compared with the original seven theoretical TQM constructs as being discussed in section 4.0. The first factor is a combination of items from Leadership (LS) and Strategic Planning (SP) constructs. Thus, we renamed the first factor as **Top Management Leadership** (TML) with an eigenvalue of 17.91 which accounted for 41.65% of the variance and has 13 items. The second factor was classified as **Data and Information Management** (DIM) with an eigenvalue of 2.37 and accounted for 5.51% of the variance and has 5 items. As expected, all items are grouped according to its original construct. The third factor consists of items from People Management (PM) construct. Since the items extracted were focused more on performance and appraisal system, we renamed the third factor as **Performance Management** (PfM) with an eigenvalue of 1.99 which accounted for 4.64% of the variance and has 5 items. The fourth factor was be labeled as **Process and System Management** (PSM) with an eigenvalue of 1.95 which accounted for 4.54% of the variance and has 6 items. As designed, all items are grouped according to its original construct. The fifth factor consists of items from Partnership and Resource (PR) construct. While the items were concentrated on partnership issues, we renamed the fifth factor as **Partnership** (Pns) with an eigenvalue of 1.72. The factor accounted for 3.99% of the variance and has 5 items. The sixth factor can be classified as **Customer Focus** (CF) with an eigenvalue of 1.49 which accounted for 3.39% of the variance and has 5 items. As expected, all items are grouped according to its original construct. Finally, the seventh factor was named as **Resource Management** (RM) with an eigenvalue of 1.29. The items for this factor were extracted from the Partnership and Resource construct. Given that the items were focused on resource issues, we renamed it to resource management. This factor accounted for 2.99% of the variance and has 4 items.

Table 2: Factor Analysis - TQM constructs and reliabilities

Items	Factor							Cronbach Alpha (α)
	1	2	3	4	5	6	7	
LS2	.701							
LS1	.683							
SP2	.644							
SP11	.628							
LS5	.614							0.929
SP3	.611							
LS4	.571							
SP8	.568							
SP10	.565							
LS3	.563							
SP1	.552							
SP9	.531							
SP5	.525				.412			
DIM2		.785						
DIM3		.740						
DIM5		.738						0.909
DIM4		.729						
DIM1		.691						

Table 2: Factor Analysis - TQM constructs and reliabilities (cont'd)

Items	Factor							Cronbach Alpha (α)
	1	2	3	4	5	6	7	
PM10			.849					0.902
PM11			.807					
PM12			.758					
PM9			.627					
PM13			.607					
PSM7				.793				0.858
PSM6				.654				
PSM5				.612				
PSM2				.599				
PSM8		.400		.575				
PSM9				.567				
Pns3					.812			0.90
Pns2					.803			
Pns1					.772			
Pns8					.546		.431	
Pns7					.446			
CF4						.757		0.827
CF1						.747		
CF2						.741		
CF5						.605		
CF3						.554		
RM11							.788	0.819
RM10							.749	
RM9							.539	
RM5							.529	

Validity and reliability

The issues of validity and reliability are very important in order to determine whether the seven constructs or dimensions of TQM: (a) really measure the concepts the researchers want to measure (Hair *et al.*, 2006); (b) are stable, accurate and able to provide consistent results in repeated use (Hair *et al.*, 2006). Two types of validity were considered in this study. They are content validity and construct validity. In dealing with the content validity, we have used three approaches:

(a) Selection of the measurement items was based on comprehensive review of literature (Behara and Gundersen, 2001; Samson and Terziovski, 1999). In this study, we have done extensive reviews of international journals (in the field of quality, R&D and technology transfer) and international quality award framework and standard (such as MBNQA, EFQM and ISO).

(b) Soliciting input and feedback from the experts (Cooper and Schindler, 2000; Nunnally and Bernstein, 1994) to improve the instrument. Accordingly we have conducted interview series with three experts in the field of TQM and three professors who have vast experiences and knowledge in R&D management and technology transfer issues in the context of public university.

(c) Pilot testing (Forza, 2002; Hair *et al.*, 2003). In view of that, we have sent 30 questionnaires via mail to potential respondents i.e. academic researchers in USM.

13 of them were returned and the feedbacks obtained were used to refine the instrument.

Therefore, after implementing the above three approaches, we believe that the instrument developed in this study is considered to have content validity.

A measurement tool has construct validity if it measures the theoretical construct or if it fits the theories around which the test is designed (Sekaran, 2003). The construct validity of each dimension was assessed by using the Principle Component Factor Analysis (Hair *et al.*, 2006). An internal consistency analysis was performed to evaluate the reliability of the instrument. The most popular test of reliability is Cronbach's coefficient alpha (Sekaran, 2003). The higher the alpha value, the better the measuring instrument. As shown in Table 3, the alpha value for each construct is higher than 0.7. Therefore, we can conclude that each factor is a sufficiently reliable measurement of TQM concept.

Findings

The comparison between the factor analysis output and the original construct as shown in Table 3.

Table 3: Original and new constructs of TQM

Original Constructs (Before Factor Analysis)	**New Constructs (After Factor Analysis)**	**Items changes**
• Data and Information Management **(DIM)** : 6 items	-Construct remained as in original-	Reduced to 5 items
• Process and System Management **(PSM)**: 9 items	-Construct remained as in original-	Reduced to 6 items
• Customer Focus**(CF)**: 7 items	-Construct remained as in original-	Reduced to 5 items
• People Management (PM): 14 items • Partnership and Resources	Renamed the construct: **Performance Management (PM)** Renamed the construct: **Partnership (Pns)**	Reduced to 5 items Have 5 items
• (PR): 12 items	Renamed the construct: **Resource Management (RM)**	Have 4 items
• Leadership (LS): 9 items	Renamed the construct:	Have 13 items
• Strategic Planning (SP): 11 items.	**Top Management Leadership (TML)**	

It is important to note that from these results, we can verify that each of the three constructs i.e. DIM, PSM and CF still remained as original constructs. Hence, they form 'solid' constructs from both theoretical and empirical perspectives. For the other constructs, although it seems that there are some differences in theoretical and empirical constructs, the differences are more on the 'face' and not the substance. For instance, performance management construct is one of the main issues in people management because it concerns reward, recognition, appraisal and performance. It can be considered as a subset of a broader view of people management. Since the other items in people management construct (such as training and career advancement) are not strong enough to measure people management in a broader scope, we have to accept that only 5 items regarding 'performance' are strongly correlated to each other and reliable enough to explain the smaller scope of people management. Therefore the construct have to be renamed due to its focus.

Meanwhile, for Partnership and Resources construct, it was split into two different constructs accordingly. Obviously, the break-up do not distort the overall structure but it refines and improves the structure to be more interpretable. Therefore the individual construct of partnership and the construct of resource management will have a higher degree of explanation on TQM concept.

Finally, the combination of leadership and strategic planning constructs to only one factor named Top Management Leadership is theoretically acceptable. Top management as a leader in the organization has to show effective leadership style in order to inspire people in the organization to achieve desired goals and results (Weggeman and Groeneveld, 2005). At the same time a leader has to set the direction for the organization and its people (Goetsch and Davis, 2003). So the roles of inspiring and setting directions are equally important as a leadership function. Empirically, the analysis has proven that these two constructs have to be merged.

Thus, based on the factor analysis and reliability tests, the final constructs that can measure the concept of TQM in R&D environment are Top Management Leadership, Data and Information Management, Performance Management, Process and System Management, Partnership, Customer Focus and Resource Management.

Conclusions, limitations and further research

In conclusion, there is no doubt that R&D activities are important to the university, government, industry, and society in general. Using TQM as a framework to understand this phenomenon is appropriate because of its holistic approach. Since R&D has become one of the major thrusts for boosting the Malaysian economy and the university is regarded as one of the main players, it is crucial to investigate how it is practised in the university setting.

As mentioned previously, the purpose of this study was to determine the constructs or dimensions of TQM practices in the R&D context from academic researchers' perspectives. Accordingly, this study is felt to have significantly contributed to the quality management theory building efforts particularly in the higher education context. This was attained in the following ways:

a) The constructs of TQM practices in university, particularly in the context of R&D were identified through exploratory factor analysis based on survey responses from 231 academic researchers from research universities. The factor analysis, validation and reliability procedure were comprehensive enough to explain the constructs of TQM.
b) This study will enrich the literature in TQM both theoretically and empirically by minimising the knowledge gap in TQM-R&D related to the university context, while focusing on university researchers to obtain a better understanding of TQM practices in the R&D context.
c) The percent of variance explained for top management leadership was large enough (42%) to confirm that in any quality management program or initiative, the top management is the prime mover for significant improvements.
d) It is important to note that although the constructs of leadership and strategic planning are put separately in the MBNQA or EFQM frameworks, this study has proven that they can be merged.

This study provides the basis for further research in quality management particularly in the education sector and in the area of R&D or technology transfer. Since this study only reveals

the academic researchers' perspectives on TQM practices, it limits the scope of generalization. In view of that, similar research can be conducted from other perspectives and can focus on other related elements such as university R&D managers and faculties. Moreover, comprehensive set of TQM constructs that was disclosed in this study can also be tested in future studies. These new initiatives will definitely further contribute to theory building in quality management.

APPENDIX A: Survey Questions

***Instruction*:** Please circle the number (1 to 6) which accurately reflect your level of agreement, where: 1= Strongly Disagree; 6 = Strongly Agree.

Leadership (LS)

LS1	Vision, mission and objectives regarding commercialization of research output are clear to me.	1 2 3 4 5 6
LS2	Vision, mission and objectives on R&D are clearly communicated to me.	1 2 3 4 5 6
LS3	It is a norm in my university that senior researchers would coach junior researchers in doing research.	1 2 3 4 5 6
LS4	Top management's commitment is high in achieving the vision of the university in R&D activities.	1 2 3 4 5 6
LS5	Top management encourages me to build research networks with scientist communities, industries and other government research institutes.	1 2 3 4 5 6

Strategic Planning (SP)

SP1	In addition to knowledge creation, the strategic planning in R&D is focussing on commercialization aspect as well.	1 2 3 4 5 6
SP2	The R&D strategic planning has chosen certain areas of research as the core/strategic research in university.	1 2 3 4 5 6
SP3	To me the strategic planning in R&D was carried out at planned intervals.	1 2 3 4 5 6
SP5	University provides a clear policy on intellectual property rights to researchers.	1 2 3 4 5 6
SP8	The faculty/research centre is involved in university strategic planning pertaining to R&D matters.	1 2 3 4 5 6
SP9	Inputs from senior researchers are considered by university in developing a strategic plan.	1 2 3 4 5 6
SP10	I/other researchers in the faculty can carry out the action plan according to the research strategies of the university.	1 2 3 4 5 6
SP11	I am clear about research strategies in this university.	1 2 3 4 5 6

Data & Information Management (DIM)

DIM1	The Information Technology System that I use is effective in searching and spreading the data/information related to research works.	1 2 3 4 5 6
DIM2	Information related to research (i.e. facilities, expertise & funding) that I need are well managed by the university.	1 2 3 4 5 6
DIM3	In my opinion, the university has data and information management system that can effectively measure the research performance in the faculty.	1 2 3 4 5 6
DIM4	The university provides information on researchers' performance indicators to stakeholders.	1 2 3 4 5 6
DIM5	Data and information about faculty's research performance are used by the university to make decisions on resources allocation.	1 2 3 4 5 6

People Management (PfM)

PM9	The performance appraisal system gives emphasis to the planning of	1 2 3 4 5 6

	excellent research works.	
PM10	The performance appraisal system encourages me/other researchers to do research in collaboration with other researchers from the same faculty.	1 2 3 4 5 6
PM11	The performance appraisal system encourages me/other researchers to do research in collaboration with other researchers across different faculties (multidiscipline).	1 2 3 4 5 6
PM12	The performance appraisal system encourages me/other researchers to do research in collaboration with industries.	1 2 3 4 5 6
PM13	The university is serious in taking care of and retaining good researchers.	1 2 3 4 5 6

Process and System Management (PSM)

PSM2	The Research Management Centre has communicated clearly the procedures of doing research in this university to me.	1 2 3 4 5 6
PSM5	The Research Management Centre has communicated clearly the procedures of commercializing the research output to me.	1 2 3 4 5 6
PSM6	I really know the procedures of how to transfer the knowledge discovered in research works (such as presentation at seminar and publication).	1 2 3 4 5 6
PSM7	I really know the main processes of research management that I need to follow (such as proposal, research, development, and commercialization).	1 2 3 4 5 6
PSM8	In my opinion, the main processes of research management are well managed by the Research Management Centre	1 2 3 4 5 6
PSM9	The relationship between departments* involved in the administration of research management has encouraged me to keep engaging in R&D and commercialization activities. **(such as bursar, RMC, faculty, technology transfer office and legal affairs unit)*	1 2 3 4 5 6

Partnership (Pns) and Resources Management (RM)

Pns1	The university supports me to do collaboration research with other researchers from different disciplines.	1 2 3 4 5 6
Pns2	The university supports me to do collaboration research with other universities / research institutes.	1 2 3 4 5 6
Pns3	The university supports me to do collaboration research with industries	1 2 3 4 5 6
Pns8	The collaboration made was on the complementary basis in terms of expertise and resources.	1 2 3 4 5 6
Pns7	My research's sponsors really encourage me to do collaboration research.	1 2 3 4 5 6
RM5	The university has facilities and physical infrastructures to support me/other researchers involved in commercialization activities.	1 2 3 4 5 6
RM9	The university have facilities and physical infrastructure to support me/other researchers involved in R&D activities.	1 2 3 4 5 6
RM10	The financial resources are sufficient for me to carry out R&D activities.	1 2 3 4 5 6
RM11	The financial resources are sufficient for me to carry out commercialization activities.	1 2 3 4 5 6

Customer Focus (CF)

CF1	My researches are meeting the government requirements.	1 2 3 4 5 6
CF2	My researches are meeting the industrial requirements.	1 2 3 4 5 6
CF3	In my opinion, researches in my faculties are in line with the need of their sponsor.	1 2 3 4 5 6
CF4	I have taken necessary actions after receiving feedback on my research performance from my sponsors.	1 2 3 4 5 6
CF5	The requirements/needs of the sponsors were communicated clearly to me/other researchers.	1 2 3 4 5 6

References:

Arrindell, W. A., and Van de Ende, J. (1985). An empirical test of the utility of the observation-to-variables ratio in factor and components analysis. *Applied Psychological Measurement,* 9: 165-178.

Baldrige. (2006). *Baldrige national quality program-criteria for performance excellence*. Retrieved 20 Sept, 2006, from http://www.quality.nist.gov

Behara, R. S., and Gundersen, D. E. (2001). Analysis of quality management practices in services. *International Journal of Quality and Reliability Management,* 18(6): 584-603.

Besterfield, D. H., Besterfield-Michna, C., Berterfield, G. H., and Besterfield-Scare, M. (2003). *Total Quality Management* (3 ed.). New Jersey: Prentice Hall.

Birley, S. (2003). University, academics and spinout companies: lesson from imperial. *International Journal of Entrepreneurship Education,* 1(1): 1-21.

Black, S. A., and Porter, L. J. (1996). Identification of the critical factors of TQM. *Decision Sciences,* 27(1): 1-21.

Bolton, A. (1995). A rose by any other name: TQM in higher education. *Quality Assurance in Education,* 3(2): 13-18.

Boselie, P., and Wiele, T. V. D. (2002). Employee perceptions of HRM and TQM, and the effects on satisfaction and intention to leave. *Managing Service Quality,* 12(3): 165-172.

Calvo-Mora, A., Leal, A., and Roldan, J. L. (2006). Using enablers of the EFQM model to manage institutions of higher education. *Quality Assurance in Education,* 14(2): 99-122.

Carlsson, B., and Fridh, A. C. (2002). Technology transfer in United States universities. A survey and statistical analysis. *Journal of Evolutionary Economics,* 12: 199-232.

Chang, Y. C., Chen, M. H., Hua, M., and Yang, P. Y. (2005). Industrialization academic knowledge in Taiwan. *Research Technology Management,* 48(4): 45-50.

Clarke, T. E. (2002). Unique features of an R&D work environment and research scientists and engineers. *Knowledge, Technology and Policy,* 15(3): 58-69.

Comrey, A. L., and Lee, H. B. (1992). *A first course in factor analysis* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cooper, D. R., and Schindler, P. S. (2000). *Business research method* (7th ed.). New York: McGraw-Hill/Irwin.

Crosby, P. B. (1979). *Quality is free: The art of making quality certain*. New York: McGraw-Hill.

Deming, W. E. (1982). *Quality, productivity and competitive position*. Cambridge, Mass.: Massachusetts Institute of Technology.

EFQM. (2006). *The fundamental concepts of excellence*. Retrieved 24 Sept, 2006, from http://www.quality-foundation.co.uk

Elmuti, D., Kathawala, Y., and Manippallil, M. (1996). Are total quality management programmes in higher education worth the effort? *International Journal of Quality and Reliability Management,* 13(6): 29-44.

Forza, C. (2002). Survey research in operations management: a process-based perspective. *International Journal of Operations and Production Management,* 22(2): 152-194.

Franklin, S. J., Wright, M., and Lockett, A. (2001). Academic and surrogate entrepreneurs in university spin-out companies. *Journal of Technology Transfer,* 26: 127-141.

Friedman, J., and Silberman, J. (2003). University technology transfer : Do incentives, management and location matter? *Journal of Technology Transfer,* 28: 17-30.

Froman, R. D. (2001). Elements to consider in planning the use of factor analysis. *Southern Online Journal of Nursing Research,* 2(5): 1-22.

George, D., and Mallery, P. (2003). *SPSS for windows step by step: A simple guide and reference 11.0 update* (4th ed.). Boston: Allyn and Bacon.

Gitlow, H. S., Oppenheim, A. J., Oppenheim, R., and Levine, D. M. (2005). *Quality Management* (3rd ed.). New York: McGraw-Hill.

Goetsch, D. L., and Davis, S. B. (2003). *quality management: introduction to total quality management for production, processing and services* (4th ed.). New Jersey: Prentice Hall.

Goldfarb, B., and Henrekson, M. (2003). Bottom-up versus top down policies towards the commercialization of universities intellectual property. *Research Policy,* 32: 639-658.

Hair, J. F., Jr, Babin, B., Money, A. H., and Samouel, P. (2003). *Essential of business research methods*. New Jersey: John Wiley and Son, Inc.

Hair, J. F., Jr, Black, W. C., Babin, B. J., Anderson, R. E., and Tatham, R. L. (2006). *Multivariate data analysis* (6th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Hasan, H. (1999). *Effective information for managers: using multi-dimensional data structures to support research management*. Retrieved Sept 8, 2006, from http://www2.vuw.ac.nc/acis99/Papers/PaperHasan-034.pdf

Heininger, S. A. (1988). R&D and competitiveness: what leader must do. *Research Technology Management,* 31(6): 6-7.

Hemlin, S. (2006). Managing creativity in academic research. *Science Studies,* 1: 83-92.

Hemlin, S., and Gustafsson, M. (1996). Research production in the arts and humanities: a questionnaire study of factors influencing research performance. *Scientometrics,* 37(3): 417-432.

Ho, S. K., and Wearn, K. (1995). A TQM model for higher education and training. *Training for Quality,* 3(2): 25-33.

Houghton, J. W. (2005). Changing research practices and research infrastructure development. *Higher Education Management and Policy,* 17(1): 1-19.

Ishikawa, K. (1985). *What is total quality control?* Englewood Cliffs, New Jersey: Prentice Hall.

ISO 9000. (2006). *Quality management principle*. Retrieved 20 Sept, 2006, from http:www.iso.org/iso/en/iso9000-14000/understand/qmp.html

Johnston, S., and Mccormack, C. (1997). Developing research potential through a structured mentoring program: issues arising. *Higher Education,* 33: 251-264.

Juran, J. M. (1988a). *Juran's quality control handbook*. New York: McGraw-Hill.

Juran, J. M. (1988b). *Quality control handbook* (4th ed.). New York: McGraw-Hill.

Kanji, G. K., and Tambi, A. M. A. (1999). Total quality management in UK higher education institutions. *Total Quality management,* 10(1): 129-153.

Kirkland, J. (2005). Towards an integrated approach: university research management in an institutional context. *International Journal of Technology Management and Sustainable Development,* 4(3): 155-166.

Koch, V. J. (2003). TQM: why is its impact in higher education so small? *The TQM Magazine,* 15(5): 325-333.

Korunka, C., Carayon, P., Sainfort, F., Scharitzer, D., and Hoonakker, P. (2003). Quality in public sector from an employee's perspective: results from a transnational comparison. *Total Quality management,* 14(5): 537-548.

Lee, Y. S. (1996). Technology transfer and the research university: a search for the boundaries of university-industry collaboration. *Research Policy,* 25: 843-863.

Lembaga Akreditasi Negara. (2006). *Kod amalan jaminan kualiti IPTA di Malaysia*. Retrieved 18 July, 2006, from http://www.lan.gov.my

Liu, H., and Jiang, Y. (2001). Technology transfer from higher education institution to industry in China: nature and implications. *Technovation,* 21: 175-188.

Logar, C. M., Ponzurick, T. G., Spears, J. R., and France, K. R. (2001). Commercializing intelectual property: a university-industry alliance for new product development. *Journal of Product and Brand Management,* 10(4): 206-217.

MASTIC. (2004). *National survey of research and development: 2004 report*. Kuala Lumpur: MASTIC.

Meyers, L. S., Gamst, G., and Guarino, A. J. (2006). *Applied multivariate research: Design and Intrepretation*. California, USA: Sage Publication, Inc.

Nunnally, J. C., and Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). New York: McGraw-Hill, Inc.

Oakland, J. S. (2004). *Oakland on quality management.* London: Elsevier Butterworth-Heinemann.

Oii, K. B., Veeri, A., Yin, L. K., and Vellapan, L. S. (2006). Relationships of TQM practices and employees' propensity to remain: an empirical case study. *The TQM Magazine,* 18(5): 528-541.

O'Shea, R., Allen, T. J., O'Gorman, C., and Roche, F. (2004). Universities and technology transfer: a review of academic entrepreneurship literature. *Irish Journal of Management,* 25(2): 11-29.

Osseo-Asare, A. E., Jr, and Longbottom, D. (2002). The need for education and training in the use of the EFQM model for quality management in UK higher education institutions. *Quality Assurance in Education,* 10(1): 26-36.

Owen-Smith, J., and Powel, W. W. (2001). To patent or not: Faculty decisions and institutional success at technology transfer. *Journal of Technology Transfer,* 26(99-114).

Owlia, M. S., and Aspinwall, E. M. (1997). TQM in higher education- a review. *International Journal of Quality and Reliability Management,* 14(5): 527-543.

Owlia, M. S., and Aspinwall, E. M. (1998). A Framework for measuring quality in engineering education. *Total Quality management,* 9(6): 501-518.

Prajogo, D. I., and Sohal, A. S. (2006). The intergration of TQM and technology/R&D management in determining quality and innovation performance. *The International Journal of Management Science,* 34: 296-312.

Pratt, M., Margaritis, D., and Coy, D. (1999). Developing a research culture in a university faculty. *Journal of Higher Education Policy and Management,* 1(1): 43-55.

Roa, A., Carr, L. P., Dambolena, I., Koop, R. J., Martin, J., Rafii, F. (1996). *Total quality management: A cross-functional perspective*. New York: John Wiley and Sons.

Samson, D., and Terziovski, M. (1999). The relationship between total quality management practices and operational performance. *Journal of Operation Management,* 17(4): 393-409.

Santoro, M. D., and Gopalakrisnan, S. (2001). Relationship dinamik between university research centers and industrial firms: Their impact on technology transfer activities. *Journal of Technology Transfer,* 26: 163-171.

Saraph, J. V., Benson, P. G., and Schroeder, R. G. (1989). An instrument for measuring the critical factors of quality management. *Decision Sciences,* 20(4): 457-478.

Scmitdt, E. K., Graversen, E. K., and Langberg, K. (2003). Innovation and dynamics in public research environment in Denmark: a research-policy perspective. *Science and Public Policy,* 30(2): 107-116.

Sekaran, U. (2003). *Research method for business: A skill-building approach* (4 ed.). New York: John Wiley and Sons.

Siegel, D. S., Waldman, D., Atwater, L. E., and Link, A. (2004). Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: Qualitative evidence from the commerciallization of universities technologies. *Journal of Engineering and Technology Management,* 21: 115-142.

Siegel, D. S., Waldman, D., and Link, A. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research Policy,* 32: 27-48.

Siegel, D. S., Waldman, D. A., Atwater, L. E., and Link, A. (2003). Commercial knowledge transfers from universities to firms: improving the effectiveness of university-industry collaboration. *Journal of High Technology Management Research,* 14: 111-133.

Stackhouse, J., and Day, R. (2005). Global and regional practices in university research management. *International Journal of Technology Management and Sustainable Development,* 4(3): 189-205.

Steele, L. W. (1988). Selecting R&D programs and objectives. *Research Technology Management,* 31(2): 17-36.

Stevens, J. P. (2002). *Applied multivariate statistics for social sciences* (4th ed.). Hillsdale, N.J.: Erlbaum.

Taguchi, G. (1986). *Introduction to quality engineering*. Tokyo: Asian Productivity Organization.

Thursby, J. G., Jensen, R., and Thursby, M. C. (2001). Objectives, characteristics and outcomes of university licencing: A survey of major U.S. universities. *Journal of Technology Transfer,* 26(1-2): 59-72.

Weggeman, M. P., and Groeneveld, M. J. (2005). Applying the business excellence model to a research organization. *Research Technology Management,* 48(4): 9-13.

Winn, B. A., and Cameron, K. S. (1998). Organizational quality: an examination of the Malcolm Baldrige national quality framework. *Research in Higher Education,* 39(5): 491-512.

Youssef, M. A., Libby, P., Al-Khafaji, A., and Sawyer, G. J. (1998). TQM implementation barriers in higher education. *International Journal of Technology Management,* 16(4/5/6): 584-593.

Zairi, M. (1994). Leadership in TQM implementation. *The TQM Magazine,* 6(6): 9-16.

Zeitz, G., Johanneson, R., and Ritchie, J. E. (1997). An employee survey measuring total quality management practices and culture-development and validation. *Group and Organization Management,* 22(4): 414-444.

Zink, K. J., and Schmidt, A. (1995). Measuring universities against the European quality award criteria. *Total Quality Management,* 6(5&6): 547-561.