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INFORMATION QUALITY MANAGEMENT: REVIEW OF AN EVOLVING RESEARCH AREA

(Research Paper)

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ABSTRACT: The importance of quality is widely acknowledged throughout the world, not only for avoiding failure and reducing costs but also for gaining competitive advantage. This article reflects on two approaches of quality management that have gained popularity during the last decades: Total Quality Management (TQM) and Information Quality Management (IQM). The goal of this study is to illustrate the links between TQM and IQM. We will trace the roots of Information Quality to the Total Quality philosophy of the quality gurus that gained popularity in the 1960's and show how TQM underpins IQM. We also suggest that IQM is coming of age and a new research area in its own right.

Keywords: Information Quality Management; Data Quality; Total Quality Management

1. INTRODUCTION

It is becoming increasingly evident that information quality (IQ) is important and highly sought after not only for decision making but also for avoiding failure, reducing costs and gaining competitive advantage. Professionals rely on information to successfully carry out their work and the quality of their information source impacts their decisions. Poor IQ costs the typical company from 10% to 20% of revenue [37]. 'Wrong price data in retail databases may cost American consumers as much as $2.5 billion in overcharges annually [14]. Quality pioneer W. Edward Deming declared that Japanese firms regard their employees as their most significant competitive asset and

therefore provide them with good training in specific skills. The goal of IQM is to increase the value of high quality information assets [17].

Barriers to providing useful information for effective decision making are caused by IQ problems. On a daily basis the media reports on the impact of poor IQ in the healthcare sector [11,12,23,27,28,30,31,32,33,34,45]. Both of the Institute of Medicine (IOM) reports 'To Err Is Human' and 'Crossing the Quality Chasm' alerted health care professionals and managers to system defects and a redesign of the health care system, when they concluded that between 48,000 and 98,000 Americans die annually in hospitals as the result of medical errors [4, 20,21,40]. An understanding of the processes that generate, use, and store data are essential to understanding information quality. The traditional approach to quality predominantly focuses on the technical aspects of quality paying little attention to the soft systems (human side) [3]. However, quality cannot be measured in purely technical terms by some characteristics of the product or service. The quality gurus reviewed in this study each offer definitions of quality but it is evident that there are substantial differences between them [3].

From the literature available a variety of approaches claim to provide solutions to the problems of poor quality. This article reflects on two quality approaches that have gained popularity during the last decades: Total Quality Management (TQM) and Information Quality Management (IQM). The goal of this study is to show how TQM underpins IQM and illustrate how IQM is an evolving research area in its own right. Some criteria for a new research area are as follows: have own well accepted models and frameworks; have a significant core of university researchers working in the area; demonstrated support for increasing research in the area; case studies, references to information quality leaders and academics, conferences; journal articles, and books publications; organisations available to partner the research area to help exploit research results.

The interchange of the words data and information is widespread but there are some differences between the two. Data is normally described as raw facts used for analysis that has to be interpreted to derive meaning, and information described as data that has been processed in some way. However, this paper will use *data and* information interchangeably. The rest of the paper is organized as follows: Section 2 outlines philosophical underpinnings; Section 3 discusses Total Quality Management; Sections 4 explains Information Quality Management; Section 5 discusses methodology and findings; Section 6 gives a brief summary and conclusion.

2. EVOLUTION OF QUALITY

The phases of the quality evolution are as follows: Quality Control, Quality Management Approach and Quality Processes. Quality control can be traced to the pre Industrial Revolution era, when inspection committees enforced rules for marking goods with a special quality mark. Late in the 19th century the United States adopted a new management approach developed by Frederick W. Taylor. Taylor's goal was to increase productivity by assigning inspectors which led to a remarkable rise in productivity but had a negative effect on quality [18, 42]. In the early 20th century, manufacturers began to include quality processes in practice [1]. In the 1950's Japanese businesses welcomed the input of Quality Management Pioneer W. Edwards Deming [10, 48]. Rather than concentrating on inspection they focused on improving all organizational processes [3, 9]. Juran arrived in Japan in 1954 with his new insights into management's responsibility for improving quality in production [10] and with the help of Ichiro Ishikawa, Japanese quality improved dramatically and they captured markets the world over. By the 1970's, the U.S. also embraced approaches that involved the entire organization: this became known as Total Quality Management (TQM) [1]. Since the turn of the century new management systems such as IQM have evolved underpinned by the teachings of Deming and Juran [15].

From the literature reviewed a universal definition of quality is difficult to achieve. There are as many definitions of quality as there are quality leaders, but some commonly accepted definitions of the quality pioneers and their emphasis are outlined in Table 1. The Deming approach lies in the use of data analysis tools such as control charts. His PDCA is a four-step process for quality improvement. Step 1: develop a plan to effect improvement; Step 2: carry out the plan; Step 3: observe and check effects of the plan; Step 4: study results to determine what was learned. Crosby' concept, "*do it right first time*" emphasised culture change and identified areas in which quality can be improved: improving awareness; instituting teams; setting goals; giving recognition; and continuously repeating the quality improvement cycle [3, 8]. Feigenbaum divided quality costs into four categories as follows: Internal failure

costs associated with defects found before the customer receives the product or service; External failure costs, representing costs associated with defects found after the customer receives the product or service; Appraisal costs, representing costs incurred to determine the degree of conformance to quality requirements; Prevention costs, representing costs of all activities specifically incurred to keep failure costs to a minimum [3]. Juran divided the quality effort management into a three-legged approach: Quality planning: developing products and processes to meet the customer's needs by discovering who the customers are and their needs; Quality control: improving quality levels by lowering defects thus reducing costs, improving customer satisfaction and meeting goals; Quality improvement: continuously improving the quality process [3, 42]. Ishikawa believed a culture of continuous improvement is born from management responsibility [3] and in 1943, developed the cause and effect (fishbone) diagram to assist quality improvement [2, 42].

	DEMING	JURAN	CROSBY	ISHIKAWA	FEIGENBAUM
Methodology	14-points	10 Steps to Quality Control	14 steps for Quality Improvement	15 effects of Company-wide Quality Control	4 Categories of Quality Costs
Key Concepts	PDCA Cycle	Project Management	Zero Defects - do it right first time	Cause and Effect	Total Quality Control
Philosophy	Customer Focused	Management Responsibility - Quality Costs	Cost of Quality	Continuous Improvement from management responsibility	Cost of Non-conformance
Quality Definitions	Meeting the customers needs	Fitness for Use	Conformance to Requirements	Continuous Improvement	Customer Satisfaction
Approach	Use of data analysis tools such as control charts	(Trilogy) 3 step process ▪ planning ▪ control ▪ action	Company-wide	Quality Circles	Systems Management

Table 1: Key Concepts of the Quality gurus

3. TOTAL QUALITY MANAGEMENT

Deming introduced Total Quality Management (TQM) in the 1980's with the help of other quality leaders, Juran and Crosby [26]. Although, there is no universal definition some common accepted principles are as follows: TQM, can be thought of as a management philosophy, a corporate culture and an organisational wide activity fundamentally based on the participation of all members of an organization in improving processes, products and services; transforming organisational culture in order to meet or exceed customer needs and expectations, by means of consistent leadership and continuous improvement [18, 22, 25, 30]. In essence, the three basic principles of TQM are: focus on customer satisfaction; seek continuous and long term improvement in all the organization's processes and outputs, and ensure full involvement of the entire work force in improving quality. Identifying and satisfying the needs of the customer start with the external customer and work backwards so that quality at each stage is defined in terms of the next customer in the process [8, 36]. Juran defines the customer as '*anyone that is impacted by the product or process external or internal*' [13]. The way in which organizations are organised can be viewed as a supplier customer relationship involving internal and external customers.

The ultimate goal of a TQM effort is to satisfy not only the shareholders but also the customers, staff, business partners, and suppliers. An effective total quality effort will require the participation of everybody in the company or organisation [30, 41] and good communication with other departments is important to get richer information [41]. Communication clarifies expectations and is supported by continuous improvement effort from all in the organisation to meet those expectations [3]. In a TQM effort, all members of an organization participate in improving the processes, products, services and the culture in which they work. Every employee has valuable and valid knowledge of how their particular job could be done better, and when these ideas are appreciated in a supportive environment then, and only then, can there be a total organization awareness of the employee's effect on the product or service. This helps prevent resistance to change, as employees feel empowered to improve their condition instead of feeling trapped in a situation where their suggestions are not valued. However, the entire total quality effort must be planned and managed by the company's management team [42]. Most quality management

leaders agree that the biggest ingredient and most critical issue in quality is management commitment to support employees who in turn will support the customer [3, 5].

4. INFORMATION QUALITY MANAGEMENT

It is difficult to define information quality in a way that is conceptually satisfying. After an extensive review of IQ literature we found that the definition of information quality is also the subject of much debate [35, 43, 44, 47]. There are a number of theoretical frameworks for understanding data quality, as outlined in Table 2. Redman, Orr and others have presented cybernetic models of information quality. The cybernetic view consider organizations as made up of closely interacting feedback systems that link quality of information to how it is used, in a feedback cycle where the actions of each system is continuously modified by the actions, changes and outputs of the others[3, 35,38].

Data quality has many attributes and Wang and Strong outline various attributes from the perspectives of those who used the data [46]. Data is of high quality 'if it is fit for its intended use' [7, 24 29]. However, the same database for one use could have poor data quality and for another use be considered high data quality [29]. Therefore, data can not be separated from its uses. Alternatively, data is deemed of high quality if it '*correctly represents the real-world construct to which it refers so that products or decisions can be made' [36]*. Wang and Strong proposed a data quality framework that includes the categories of intrinsic data quality, accessibility data quality, contextual and representational data quality [47].

Key Concept of IQM	Wang & Strong (1996)	Orr (1998)	Wang (1998)	Redmond (2004)
IQ Dimension	✓			
Information Manufacturing Systems		✓	✓	
Impact on Decision Making		✓		
Cybernetic Model		✓		✓

Table 2: Summary of key IQM models

Potential for misinterpretation of data rests on two levels of understanding language (1) the syntactic (signs) and (2) the semantic (meaning). According to Olson, accurate information is '*the most important dimension'* of good quality information systems, yet many information systems contain inaccuracies and most organisations lack the basic understanding of the concepts of information quality [29]. To ensure adequate IQ or improve IQ, a frequently mentioned approach is IP manufacturing. Product manufacturing can be viewed as a processing system that acts on raw materials to produce physical products and can be viewed as processing system acting on raw data to produce information products. Wang's model is shown in Table 3.

	Product Manufacturing	Information Manufacturing
Input	Raw Materials	Raw Data
Process	Assembly Line	Information System
Output	Physical Product	Information Product

Table 3 : Products Vs Information Manufacturing (Source: Wang 1998)

An information manufacturing system is a system that produces information products (IP). The concept of an IP is that the information output from an information manufacturing system has value that is transferable to the customer. Four roles are identified as follows:

- Information suppliers are those who create or collect data for the IP
- Information manufacturers are those who design, develop, or maintain data and systems infrastructure for the IP
- Information consumers are those who use the IP in their work
- IP managers are those who are responsible for managing the entire IP production process throughout the IP life cycle.

The information product becomes the supply material or input for many other business processes. This implies supplier customer roles [3]. As a product of a process, the same principles of quality improvement that Deming, Crosby, and Juran, applied to manufacturing processes to improve product quality can be applied to business processes to improve information quality. One of the basic principles of quality is accountability by persons

performing work. If I create information others need, then, I should capture it to meet their needs as well as my own. In order to hold information producers accountable they must be trained [3, 25], and a quality culture requires that resources are maximised by developing a structured training programme which will result in improved products or service [6]. Deming has training as two of his 14 points of quality which stresses the continuous improvement in the system of production and service [3, 19].

One of the pervasive causes of non quality applications is using on time and within budget as the sole performance measurement criteria. There are many root causes of IQ problems, including: ill-defined processes, untrained information producer as well as defective data design, redundant databases and defective application design [17], and broken or out of control processes[16]. The goal of information quality management is: to increase business effectiveness by eliminating the costs of non-quality information and increasing the value of high quality information assets [17].

5. LINKAGES FROM IQM TO TQM

The object of this research is to show how TQM underpins IQM and how IQM is evolving into its own research area. We selected 45 papers, three from each year, using the keywords 'Information quality' and 'Data quality' from the ACM database from 1993 – 2007. We constructed a data set of three of the most relevant papers to achieving the stated project goals from each year and counted the number of references to TQM authors (Deming, Juran, Crosby, Ishikawa, and Feigenbaum) and IQ authors (Wang, Ballou, Strong, English and Redmond). Authors were credited with a reference count if they appeared only as the primary author on any given paper see appendix 1. Papers were classified as most relevant if they included a referenced to either a TQM author or a referenced to an IQM author. From this data-set we identified authors that did not reference any of the TQM gurus tabled in appendix 2. From this table we traced linkages to TQM by references to some other author who had referenced some of the TQM gurus. For Example, if A did not reference a TQM guru but did reference B, and B referenced a TQM guru, then, we can say that A indirectly referenced the particular TQM guru that B actually referenced, thus retaining the link between IQM and TQM.

5.1.ANALYSIS

In Figure 1 we grouped the years into three 5 year intervals and have shown the total number of references for TQM and IQM authors for each interval. From 1993-2000 the number of references to TQM authors continued to climb with a steady drop thereafter. The total references to IQM showed a stable trend from 1993 to 2000 with an inclining trend until 2007. A considerable gap exists from 21 references to TQM and 65 references to IQM authors in the 2003-2007 intervals.

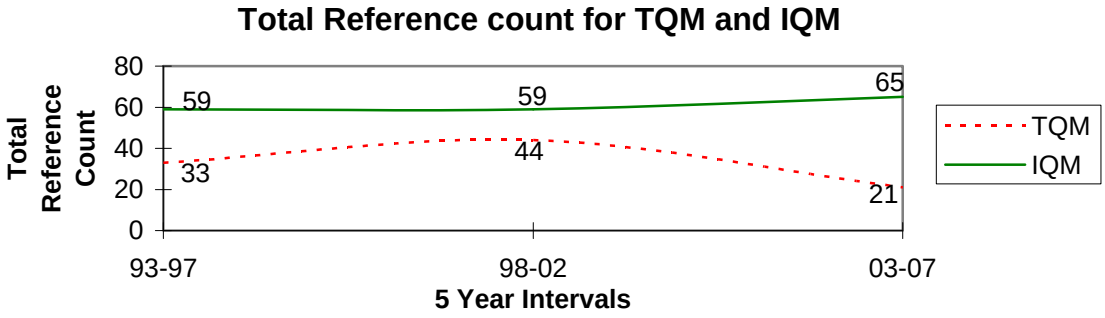

Figure 1: TQM and IQM references at 5 yearly intervals from 1993-2007

In figure 2 we show the pattern of referencing for the TQM and IQM authors each year. The TQM authors show a steady trend over the years except for the reasonably high peak of 17 in 2002. This indicates a relatively stable referencing to a well established research area. The IQM authors have a sudden drop in 1994 with a massive

increase to 21 in 1995. There is a gradual drop each year to 10 in 1998 and rising to 14 in 1999 and dropping once more to 6 in 2000. The following 3 years shows a steady increase to 18 in 2003, with a falling rate to 7 in 2006. However, this declining trend reversed with a massive increase to 20 in 2007. The IQM authors fell below the TQM authors three times, illustrated by the grey bars and rose above TQM authors ten times illustrated by the white bars and falling even twice in the fifteen year period.

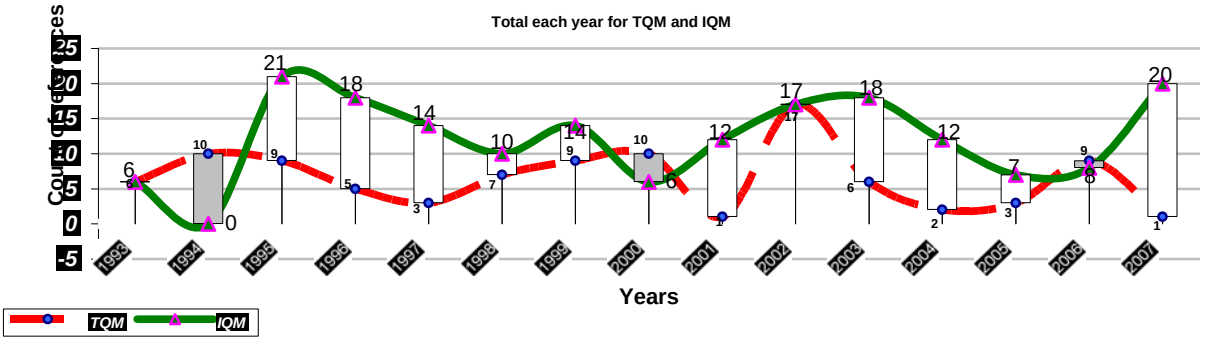

Figure 2: Timeline of total IQM and TQM references

In Table 4, we see the distribution of references to the TQM and IQM authors. We can see that Wang is the most cited author in the Information Quality research field with Ballou as the second most cited over the past 15 years. Deming is the most cited TQM author with Juran in second place.

	1993-97	1998-02	2003-07	Total
Juran	9	12	7	28
Deming	12	16	7	35
Crosby	8	8	6	22
Fegenbaum	2	6	1	9
Ishakawa	2	2	0	4
Ballou	17	11	10	38
English	2	15	2	19
Strong	8	7	9	24
Wang	29	17	36	82
Redmond	3	9	8	20

Table 4: TQM and IQM references from 1993 – 2007 grouped into 5 year intervals

In Figure 3, we demonstrate the inter-referencing between IQM authors. As can be seen by self-loops English self referenced 13 times but has not reference any other IQM author. Wang self referenced 35 times but, also referenced Strong, Ballou and Redmond. Redmond self referenced 3 times but has also referenced Strong, Redmond and Wang. Strong did not self reference in the selected papers but did referenced English, Wang and Ballou. Redmond did not reference any of the selected IQM authors under analysis.

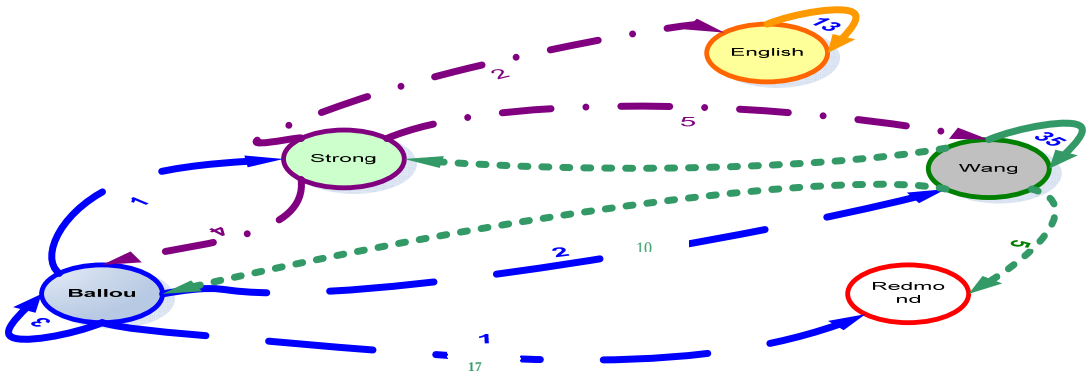

Figure 3: Self and inter- referencing among IQM authors

We now show how papers that did not directly reference TQM authors can be linked back to TQM and is detailed in appendix 3. Figure 4 shows the result of first and second level references to TQM gurus by IQM authors. The TQM authors were referenced by the IQM authors (in the Triangles) who in turn were referenced by the authors on the timeline. Now we can say that although the authors on the timeline did not directly reference the TQM authors they referenced them indirectly.

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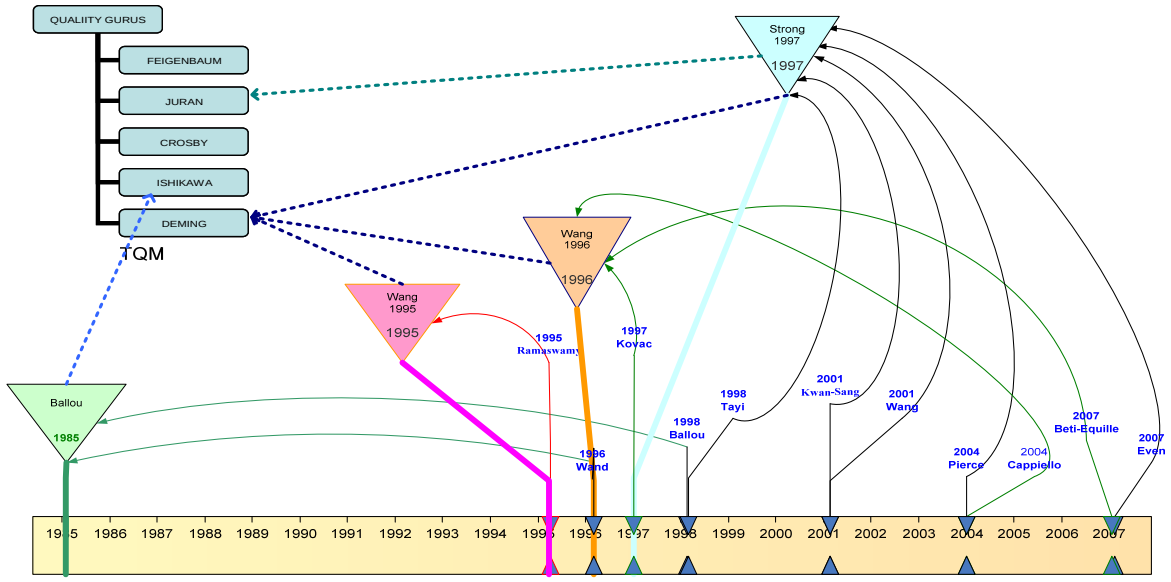

Figure 4: Indirect References to TQM authors

Figure 5 shows the distribution of indirect referencing to the quality gurus. Indirect percentage references are as follows with direct references shown between curly brackets: Deming 40% {36%} Juran 23% {29%}; Crosby 19% {22%}; Feigenbaum 11% {9%} and Ishikawa 7% {4%}. This study shows that both directly and indirectly Deming was the top referenced guru, followed by Juran, Crosby, Feigenbaum and Ishikawa.

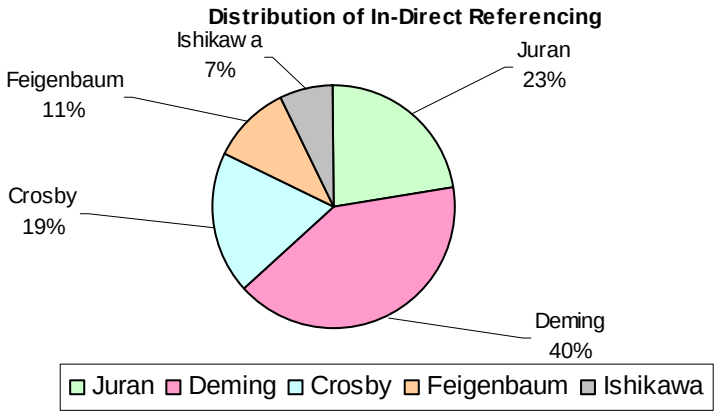

Figure 5: Percentage of Indirect referencing to TQM gurus by IQM authors who did not reference the gurus directly in the selected papers.

The percentage distribution of references to all authors is shown in figure 6. It shows Wang 29% as the most cited followed by Ballou 14%; Deming 12%; Juran 10%; Strong 9%; Crosby 8%; Redmond and English jointly 7%; Feigenbaum 3% and Ishikawa 1%.

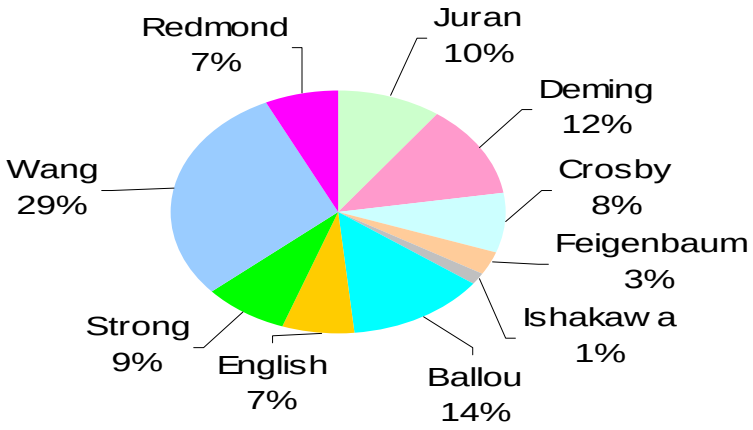

Figure 6: Percentage of referencing to TQM and IQM authors directly in the selected papers

Findings from Table 4 also show Wang as the most cited of the IQM author's with 82 references from the selected papers. Ballou has 38 references, Crosby, Redmond and English, 24, 20 and 19 respectively. From further analysis of our papers we found that Deming is the most cited TQM author with 35 references. Juran is second with 28 references followed by Crosby, Feigenbaum and Ishikawa with 22, 9 and 4 respectively.

In Table 5, we outline some conceptual links between IQM to TQM, but this reference list is in no way exhaustive. We see root cause analysis, continuous improvement training, quality measurement and customer focus are tenets of TQM, which are also at the core of IQM. (Note: due to the very large number of authors only a selection of seen in this table).

D = Deming; J = Juran; C = Crosby; F = Feigenbaum and I = Ishakawa.

Tenets of TQM	D	J	C	F	I	Redmond (2004)	Wang (2003)	English (2002)	Galetto (1999)	Wheeler (1999)	Wang (1997)
PDCA Cycle	✓	✓									✓
Customer Focus	✓	✓	✓					✓	✓	✓	
Cost of Quality	✓	✓	✓	✓		✓		✓	✓	✓	
Meeting Customers Expectations			✓	✓				✓	✓		
Statistical Approach	✓	✓			✓		✓	✓			
Root Cause Analysis	✓				✓			✓		✓	
Continuous Improvement	✓	✓	✓				✓	✓	✓	✓	
Fitness For Use	✓	✓		✓		✓		✓	✓	✓	
Quality Maturity Model			✓					✓			
Total Quality Control				✓				✓			
Meeting Customer Requirements			✓	✓				✓	✓	✓	
Process Improvement	✓							✓			
Training	✓				✓			✓			
Culture Transformation	✓	✓			✓			✓	✓		
Quality Measurement					✓			✓			
Management Behaviour	✓	✓	✓							✓	
Zero Defects		✓	✓							✓	
Company-wide				✓	✓					✓	

Table 5: Cross reference of key concepts between IQM to TQM authors

6. SUMMARY AND CONCLUSION

TQM is a management philosophy embracing all activities through which the needs and expectations of the customer and the objectives of the organization are satisfied in an efficient and cost-effective way. The same premise is true for IQ. IQ is constantly meeting the customer's expectation through information and information services enabling them to perform their jobs effectively [8]. High IQ is a critical enabler to TQM and serves as a key to quality success. However, from the literature reviewed, TQM authors have not explicitly focused on IQ as a very important element in quality management. Better quality and productivity may not be the issue, but rather better IQ [39]. Successful implementation of the quality management process depends to a large extent on the quality of data and the ability to convert the data into information [30]. From analysis of our findings we found that 73% of the papers under analysis directly referenced TQM and 27% indirectly referenced TQM. Therefore, we conclude that IQM is underpinned by TQM.

From our research into this area we conclude that IQM, is in the process of evolving into a new research area in its own right having satisfied the 'new research criteria': it has a significant number of university researchers working in the area i.e.; has yearly ICIQ conference proceedings; has demonstrated support for increasing research in the area by way of journal articles, and books publications; and has the IAIDQ (International Association for Information and Data Quality) available to partner the research area and help exploit research results. Analysis of Figure 1, Figure 2 and Figure 3 show from the year 2000 a declining trend of references to TQM authors and the rising trend in referencing IQM authors, which further suggest that even though TQM underpins IQM, IQM is maturing into a new research area, building up a repository of literature quite distinct from the TQM authors to which the IQM authors make reference to. This can also highlighted in Figure 3, where we demonstrated the inter-referencing between IQM authors. There is an already a steady trend of IQM authors directly referencing the IQM knowledge base and only indirectly referencing the TQM gurus. From the literature reviewed we find that IQM fulfils the basic criteria of a new research area and conclude it also fulfils the referencing criteria as proven in this paper.

REFERENCES

[1] American society for quality 1998, URL (consulted March 2007): http://www.asq.org

[2] Bauer J.E., Duffy G.L., Westcott Russ, *The Quality Improvement Handbook*, ASQ Quality Press, 2006
[3] Beckford J, *Quality*, Rutledge Taylor & Frances Group, London and New York 2nd edition, 2005,
[4] Berwick D.M., A user's Manual for the IOM's Quality Chasm' Report, Hope project- the people to people health foundation, inc., Health Affairs, 21, (3) 2002
[5] Blades M, Development of a simple model for analysis of quality, MCB University press, 3, (1), 1995
[6] Bowen, P.W., *The need for quality cultures*, MBC University press- issn 0968-4875, 4, (2), 1996, pp 16.
[7] Bugajski J, Grossman R.L., Tang Zhao, *An event based framework for improving information quality that integrates baseline models, casual models and formal models*, IQIS 2005 ACM 1-59593-160-0/5/06
[8] Crosby P.B., *Quality Without Tears*, The Art of Hassle Free Management, McGraw Hill, Inc New York 1995
[9] Dale B.G., Bunney H, 2003, *Managing Quality*, Blackwell Publishing, ISBN 0631236147
[10] Deming, E. W, *Out of the Crisis*, MIT press, 1995
[11] Donnellan E, *60% of A&E patients had errors in their prescriptions*. In: Irish Times, Thursday 18th January 2007
[12] Duggan B, *Family of young suicide victim criticise HSE*. In: Irish Independent, Sunday 23rd December 2006
[13] Endres Al, Endres Al C., *Implementing Juran's Road Map for Quality Leadership*: *Benchmarks and Results*, 2000, John Wiley and Sons, ISBN 0471296198
[14] English L, *Information Quality: Meeting Customer Needs*, DM Review, Vol 3, number 1 (1996/ 2004)
[15] English L, *TIQM Methodology*, DM Review September 2003
[16] English L,*Total Information quality management: A complete Methodology for IQ management*, DM Review September 2003
[17] English L, *The Essentials of lnformation Quality Managemen*t, DM Review September 2002b
[18] Fox, C., Frakes, W., *The quality approach is it delivering*, ACM, 40, (6), 1997, pp 25-29
[19] Galloway L, Ho S, *A Model of service quality for training* MCB university press, 4, (1), 1996, pg 20-26.
[20] Institute of Medicine: *To Err is Human: Building a Safer Health System.* Washington, D.C.: National Academy Press, 1999.
[21] Institute of Medicine: *Crossing the Quality Chasm: A New Health System for the 21st Century.* Washington, D.C.: National Academy Press, 2001.
[22] Kelemen M.L., *Managing Quality: Managerial and Critical Perspectives*, 2003, Sage Publications Inc ISBN 0761969047
[23] Keogh E. *Mother died after ambulance went to wrong address*. In: Irish Independent, Friday 15th December 2006
[24] Kumar G, Tayi, Ballou, Guest editors, *Examining data Quality*, Communications of the ACM, 41, (2), 1998 pp 54-57
[25] Lee, T.H., Gharajedaghi, J 1998, *Leadership in TQM: What does it mean? Center for Quality Management* Journal, 7, (1), 1998
[26] Madu C.N, *Competing on Quality and Environment***,** Chi Publishers Inc 2003
[27] Mc Bride L, *Reports claim health workers systematically neglect children*. In: Sunday Business Post, Sunday 26th November 2006
[28] Mc Kenna J. *Surgery cancelled for over 40,000 patients*. In: Irish Independent, Wednesday 6th December 2007
[29] Olson J., E Data Quality: *The Accuracy Dimension, Morgan Kaufmann*, ISBN 1558608915, *2003*
[30] Omachonu, V, K. J. A. Swift, Joel E. Ross, *Principles of Total Quality*, 3td edition, 2004, CRC Press ISBN 1574443267
[31] O'Meara A, *Deadly delays for cancer patients*. In: Irish Business Post, Sunday 14th January 2006
[32] O' Regan E, *Children find it hard to alert nurses for basic help*. In: Irish Independent, Tuesday 28 November 2006
[33] O' Regan E, *One in 10 patients is a victim of hospital blunders*. In: Irish Independent, Wednesday 17th January 2007
[34] O' Regan E, *Quarter of patients 'unhappy with A &E'*. In: Irish Independent, Friday 19th January 2007
[35] Orr Ken, *Data Quality and Systems*, Communications of the ACM, February, vol. 41, (2), 1998 pp 66-71
[36] Pike R.J., Barnes R *TQM in Action: a practical approach to continuous performance improvement*, 1996, Springer, ISBN 0412715309
[37] Redmond, T.C, *Data: An Unfolding Quality Disaster*, DM Review Magazine 2004,
[38] Redmond, T.C, *Improve Data Quality for Competitive Advantage*, Sloan Management Review, 36, (2), 1995, p 99-107
[39] Ross, J Elmore, Perry S, *Total Quality Management: Text, Cases and Readings*, 1999, CRC Press, ISBN 157444266X
[40] Sadler Blair L. J.D., *Journal on Quality and Patient Safety*, 32, (1), 2006
[41] Soin, *Total Quality Essentials: Using Quality Tools and Systems to Improve and Manage Your Business*, Published 1998 McGraw-Hill Professional, ISBN 0070595518
[42] Stephens, K.S., Juran J.M, , *American Society for Quality*, 2005
[43] Strong, D.M., Lee Y.W., Wang R.Y., *Data Quality in Context* Communications of the ACM, 40, (5), 1997 p103-109
[44] Stylianou A.C., Kumar R.L, *An integrative framework for IS Quality management*, Communications of the ACM, 43, (9), 2000 pp 99-104
[45] Walley R, *Out health-care is in meltdown*. In: Irish Independent, Friday 19th January 2007
[46] Wang, R.Y. and Strong, D.M. *Beyond accuracy: what data quality means to data consumers*, Journal of Management Information Systems 12, (4) 1996, p 5–34.
[47] Wang R Y.,) *A product perspective on Total Data Quality Management*, Communications of the ACM 41 (2) 1998, p 58-65
[48] Wheeler, S, Duggins, S., *improving software quality* ACM 1998

APPENDIX 1 IQM articles showing references to TQM and IQM

Date	Author	J	D	C	F	I	B	E	S	W	R	Publication
2007	Lee, Pierce, Wang, Zhu		✓							✓✓		A curriculum for a master of science in information quality
2007	Berti-Equille						✓✓	✓		✓✓ ✓✓	✓	Data quality awareness A case study for cost optimal association rule mining
2007	Even , Shankaranarayanan						✓✓ ✓		✓	✓✓ ✓✓ ✓	✓	Utility driven Assessment of data Quality
2006	Slone	✓	✓	✓✓			✓			✓✓ ✓✓	✓ ✓ ✓	IQ Strategy Assessing the relationship between information quality and organizational outcomes
2006	Blair, Sadler	✓	✓	✓								To the class of 2005: will you be ready for the quality revolution
2006	Sower	✓		✓								Quality management text manuscript Chapter 1
2005	Bugajski, Grossman, Tang		✓						✓		✓	An event based framework for improving information quality that integrates baseline models, casual models and formal models
2005	Martin		✓	✓					✓	✓		Measuring and improving data quality – Part 3: improving Data Quality
2005	Martinez, Hammer,						✓		✓	✓		Making Quality count in Biological Data Sources
2004	Lee, Pipino, Strong, Wang	✓	✓				✓		✓	✓✓ ✓		Process embedded data integrity
2004	Cappiello, Francalanci, Pernici						✓			✓✓	✓	Data quality assessment form the users perspective
2004	Pierce								✓	✓	✓	Assessing data quality with control matrices
2003	Lillrank	✓ ✓						✓	✓	✓		The Quality of information
2003	Wang , Allen, Harris, Madnick		✓				✓		✓✓	✓✓ ✓✓ ✓✓ ✓✓ ✓✓ ✓✓		An information Product Approach for total information Awareness
2003	Sower , Quarles	✓		✓	✓							Cost of quality: Why more organisations do not use it effectively
2002	Khan, Strong, Wang	✓					✓		✓	✓✓		Information Quality Benchmarks; Product and Service Performance
2002	English	✓	✓✓	✓	✓ ✓			✓✓ ✓✓				Plain English n data quality the term user has no place in the information age
2002	English	✓	✓ ✓✓✓✓	✓✓	✓	✓		✓✓ ✓✓ ✓✓ ✓✓ ✓				The essentials of information quality management
2001	Wang						✓		✓	✓✓	✓ ✓	Data Quality challenges in enabling E-Business Transformations
2001	Helfert	✓					✓	✓		✓	✓	Managing and measuring Data Quality in Data Warehousing
2001	Kwan-Sang ,Doo-Kwon, Pan-Koo								✓		✓	A practical approach for modelling the quality of multimedia data
2000	Currie, Hlupic	✓	✓	✓								Simulation modelling: the link between change management Panaceas
2000	Neave		✓✓✓									The Deming Dimension: management for a better future
2000	Helfert	✓ ✓ ✓	✓				✓	✓		✓✓ ✓	✓	A strategy for managing Data quality in Warehouse systems

Date	Author	J	D	C	F	I	B	E	S	W	R	Publication
1999	Khalil;, Strong, Khan, Pipino	✓	✓		✓				✓✓✓	✓✓	✓ ✓	Teaching information quality in information systems Undergraduate education
1999	Galetto	✓ ✓	✓	✓	✓ ✓							The golden integral quality approach from management of quality to quality management
1999	Ballou, Tayi						✓✓ ✓		✓	✓✓	✓	Enhancing Data Quality in Data Warehouse Environments
1998	Wheeler, Duggins	✓	✓	✓✓✓		✓						Improving Software Quality
1998	Wang		✓				✓✓ ✓			✓✓ ✓✓		A product perspective on Total Data Quality management
1998	Tayi, Ballou						✓			✓	✓	Examining data quality
1997	Strong, Lee, Wang	✓	✓				✓	✓✓		✓✓		10 potholes in the road to information quality
1997	Strong, Lee, Wang		✓				✓✓ ✓			✓✓ ✓		Data Quality in Context
1997	Kovac, Lee, Pipino								✓	✓✓		Total Data Quality Management: the case of IRI
1996	Wand, Wang						✓			✓✓ ✓		Anchoring Data Quality Dimensions in ontological foundations
1996	Bowen		✓✓									The need for quality cultures
1996	Wang, Strong	✓ ✓	✓				✓✓ ✓✓		✓✓✓	✓✓ ✓✓ ✓✓	✓	Beyond accuracy: what data quality means to consumers
1995	Wang, Storey, Firth	✓	✓✓	✓✓	✓		✓✓ ✓✓ ✓✓ ✓		✓✓✓ ✓	✓✓ ✓✓ ✓✓	✓ ✓	A framework for analysis of data Quality research
1995	Robinson, Pidd	✓	✓	✓								Service Quality in the management of simulation projects
1995	Ramaswamy									✓✓		On the phenomenon of information dilution
1994	Khalil	✓	✓	✓	✓	✓						Information systems and total quality management: Establishing the link
1994	Palumbo, Bradley, O'Hara, Herbig	✓	✓	✓								Total quality and the human resource profession
1994	John van der Pijl	✓	✓									Quality of information and targets of the organisation
1993	Axlerod		✓									Application of TQM For User Services
1993	Krishnan	✓		✓								Cost Quality and user satisfaction of software products An Empirical analysis
1993	Wang, Kon, Madnick		✓	✓✓		✓	✓			✓✓ ✓✓ ✓		Data Quality Requirements Analysis and Modelling

J = Juran; D = Deming; C = Crosby; F = Feigenbaum; I = Ishakawa; B = Ballou; E = English; S = Strong; W = Wang ; R = Redmond

APPENDIX 2 **Direct referencing of IQM authors to TQM gurus**

J- Juran; D – Deming; C- Crosby; F- Feigenbaum; I- Ishikawa; DTQM- directly referenced TQM; D/ ITQN- Directly or indirectly referenced TQM.

		J	D	C	F	I	DTQM	NO	D / ITQM
2007	Lee, Pierce, Wang, Zhu		✓				Y		Y
2007	Berti-Equille							✖	Y
2007	Even , Shankaranarayanan							✖	Y
2006	Slone	✓	✓	✓✓			Y		Y
2006	Blair, Sadler	✓	✓	✓			Y		Y
2006	Sower	✓		✓			Y		Y
2005	Bugajski, Grossman, Tang		✓				Y		Y
2005	Martin		✓	✓			Y		Y
2005	Martinez, Hammer,							✖	Y
2004	Lee, Pipino, Strong, Wang	✓	✓				Y		Y
2004	Cappiello, Francalanci, Pernici							✖	Y
2004	Pierce							✖	Y
2003	Lillrank	✓✓					Y		Y
2003	Wang , Allen, Harris, Madnick		✓				Y		Y
2003	Sower , Quarles	✓		✓	✓		Y		Y
2002	Khan, Strong, Wang	✓					Y		Y
2002	English	✓	✓✓	✓	✓✓		Y		Y
2002	English	✓	✓✓✓✓✓	✓✓	✓	✓	Y		Y
2001	Wang							✖	Y
2001	Helfert	✓					Y		Y
2001	Kwan-Sang ,Doo-Kwon, Pan-Koo							✖	Y
2000	Currie, Hlupic	✓	✓	✓			Y		Y
2000	Neave		✓✓✓				Y		Y
2000	Helfert	✓✓✓	✓				Y		Y
1999	Khalil;, Strong, Khan, Pipino	✓	✓		✓		Y		Y
1999	Galetto	✓✓	✓	✓	✓✓		Y		Y
1999	Ballou, Tayi							✖	Y
1998	Wheeler, Duggins	✓	✓	✓✓✓		✓	Y		Y
1998	Wang		✓				Y		Y
1998	Tayi, Ballou							✖	Y
1997	Strong, Lee, Wang	✓	✓				Y		Y
1997	Strong, Lee, Wang		✓				Y		Y
1997	Kovac, Lee, Pipino							✖	Y
1996	Wand, Wang							✖	Y
1996	Bowen		✓✓				Y		Y
1996	Wang, Strong	✓✓	✓				Y		Y
1995	Wang, Storey, Firth	✓	✓✓	✓✓	✓		Y		Y
1995	Robinson, Pidd	✓	✓	✓			Y		Y
1995	Ramaswamy							✖	Y
1994	Khalil	✓	✓	✓	✓	✓	Y		Y
1994	Palumbo, Bradley, O'Hara, Herbig	✓	✓	✓			Y		Y
1994	John Van Der Pijl	✓	✓				Y		Y
1993	Axlerod		✓				Y		Y
1993	Krishnan	✓		✓			Y		Y
1993	Wang, Kon, Madnick		✓	✓✓		✓	Y		Y

APPENDIX 3 Articles that reference TQM authors, which were referenced by authors that did not reference TQM

B = BALLOU; E =REDMOND; R = REDMOND; S = STRONG; W = WANG

		Even , Shankaranarayanan '07	Berti-Equille '07	Martinez '05	Cappiello '04	Pierce '04	Wang '01	Khan-Sang '01	Ballou '99	Tayi '98	Kovac '97	Wand '96	Ramaswamy '95
B													
✖	Modelling completeness versus consistency trade offs in information decision context	✓	✓										
#	Designing information systems to optimise the accuracy timeliness trade off	✓	✓						✓				
✓	Modelling information manufacturing systems to determine information product quality	✓			✓								
✓	Modelling data and process quality in multi input and multi output information systems								✓	✓		✓	
✖	Methodology for allocating resources for data quality enhancement								✓				
#	Assuring information quality			✓									
E													
#	Improving data warehouse and business information quality		✓										
R													
✓	Data quality the field guide		✓										
#	Data quality for the information age	✓			✓		✓			✓			
#	Data quality management and technology								✓				
✖	The impact of poor data quality on the typical enterprise						✓						
S													
✓	Data quality in context	✓		✓		✓	✓	✓			✓		
✓	Exceptions and exception handling in computerised information processes								✓				
W													
✓	Data quality requirements analysis and modelling		✓									✓	
✓	A framework for analysis of data quality research	✓	✓				✓		✓			✓	✓
✓	A product perspective on total data quality management	✓	✓		✓	✓							
#	Journey to data quality		✓										
#	A polyfen model for heterogeneous database systems: A source tagging perspective	✓											
✓	Towards quality data: An attribute based approach	✓		✓								✓	
✓	Beyond accuracy: what data quality means to data consumers	✓			✓				✓	✓	✓		✓
#	Manage your information as a product					✓					✓		
#	Data quality: advances in database systems						✓						

APPENDIX 4 **Authors indirectly referenced TQM gurus**

J = Juran; D = Deming; C = Crosby; F = Feigenbaum and I = Ishakawa

Author	J	D	C	F	I	IQM Ref	Year
Berti-Equille		✓				Redmond	2001
		✓	✓✓		✓	Wang	1893
	✓	✓✓	✓✓	✓		Wang	1995
		✓				Wang	1998
Even , Shankaranarayanan		✓		✓		Ballou	1998
		✓				Strong	1997
	✓	✓✓	✓✓	✓		Wang	1995
						Wang	1995
	✓✓	✓				Wang	1996
		✓				Wang	1998
Cappiello, Francalanci, Pernici		✓		✓		Ballou	1998
		✓				Wang	1998
	✓✓	✓				Wang	1996
Pierce		✓				Strong	1997
		✓				Wang	1998
Wang , Allen, Harris, Madnick		✓		✓		Ballou	1998
		✓				Strong	1997
	✓	✓✓	✓✓	✓		Wang	1995
Kwan-Sang		✓				Strong	1997
Ballou, Tayi					✓	Ballou	1985
	✓	✓			✓	Strong	1995
	✓	✓✓	✓✓	✓		Wang	1995
	✓✓	✓				Wang	1996
Tayi, Ballou,					✓	Ballou	1985
	✓✓	✓				Wang	1996
Kovac, Lee, Pipino		✓				Strong	1997
	✓✓	✓				Wang	1996
Wand, Wang					✓	Ballou	1985
		✓	✓✓		✓	Wang	1995
						Wang	1995
	✓	✓✓	✓✓	✓		Wang	1995
Ramaswamy	✓	✓✓	✓✓	✓		Wang	1995
	✓✓	✓				Wang	1996