An empirical investigation of quality outcomes in the software industry: A gap analysis approach

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ABSTRACT

The assessment of quality is pervasive but vital in organisations. It is particularly important in the design of an effective quality management system. The assessment is often considered from the perspective of fulfilling customers' requirements; however, the level of compatibility between the producers' perceptions of what to deliver and the customers' desires and expectations is often uncertain. This paper describes an empirical study evaluating, within the software industry in Egypt, the extent to which differences may exist between software provider perceptions and customer expectations regarding the levels of ideal performance, as well as differences between their perceptions of the actual performance delivered, across multiple dimensions of quality.

The study involved a survey of 142 software developers and 111 software customers. Differences, or gaps, were found across all nine measured dimensions of quality. These *quality gaps* were found to be both statistically and practically significant. These gaps must be recognised, and measured by an organization so that it can formally address any "*flaws*" within the design and implementation of its quality management program.

Keywords**:** Quality Management, quality performance, quality performance gaps, perceptions and expectation gaps.

Introduction

An organization's, or indeed an individual's, performance may be considered to be simply the outcomes resulting from a specific job, function, activity or behaviour during a specific time period (Bernardin and Beatty, 1984). From this broad perspective, performance includes a reflection or '*measurement*' of the results obtained from a certain process or job. According to Rose (1995, p.64), performance measurement is a powerful behavioural tool as it communicates to the workforce what is important and, thus, what should be done. Therefore, performance appraisals can be used in different fields to determine the level of functioning of certain activity. In this context, an effective product quality assessment system is part of an effective quality management system (Saravanan and Rao, 2007). For example, product quality performance aims to measure the degree to which this product implements its certain function (Prajogo and Sohal, 2003).

Dunk (2002, p.720) argues that quality performance focuses on the assessment of a firm's product relative to its competitor's product. Adam et al. (1997, p.844) add, "we accept performance measurement as critical in determining quality levels". According to Soliman and Youssef (2003), performance measurement is one of the key critical components of the enterprise knowledge management and to some extent is dependent on the way the quality

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performance outcomes and measures are adopted by the organisations. For example, the philosophy, methods and quality measures vary considerable depending on whether the quality assessment is in service or manufacturing industries (Abdul-Rashid and Normah, 2004, Dunk, 2002, Stewart et al., 2001). In addition, different authors have presented different conceptions of quality and quality assessment which can be summarized in five main approaches: customer-, manufacturing-, product-, value-focused or transcendent approach (Alexander et al., 2005, Andreu et al., 2006, Maiga and Jacobs, 2005). Table 1 identifies the key quality focus of the approach, the quality measures to reflect performance relative to the desired focus, the suggested approach in assessing quality performance, and the authors who have promoted these approaches.

TABLE 1
Perceived quality performance and quality parameters

Quality focus	Quality measures	Quality performance approach	Author(s)
Customer	Customer loyalty Employee turnover Number of complaints	Non-conformance cost of quality	(Chen et al., 1997, De Toni et al., 1995, Saravanan and Rao, 2007)
Manufacturing process	Prevention and appraisal costs	Conformance cost of quality	(Willis and William, 1996)
Product	Product quality dimensions; differ according to industry	Product quality attributes	(Agus, 2005, Flynn et al., 1995, Prajogo and Sohal, 2003)
Value	Time to market Cost of the product	Process quality attributes	(Fynes and Voss, 2001)
Transcendent	Ranking quality	Quality rating	(Johnson, 2001)

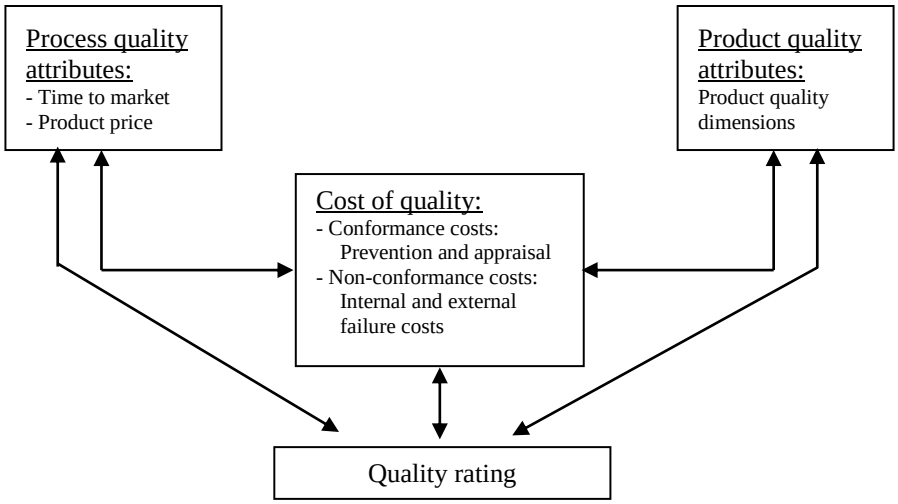
Quality in a customer-based approach can be measured, for example, through customer loyalty and employee turnover. In a manufacturing-focused perspective, quality can be measured through prevention and appraisal costs. Product-focused quality performance may be assessed by product characteristics which reflect product effectiveness. Time-to-market and total cost to the customer take a value-focused perspective to quality. Transcendent approach in defining quality which suggests that quality cannot be defined unless recognised may be measured through a quality ranking or a quality rating of the organization or in other words different grades in quality.

Quality performance indicators can be categorised then in four main measures; process quality attributes, product quality attributes, cost of quality (both conformance and non-conformance costs), and quality rating. As shown in Figure 1, product and process quality attributes can affect ‘quality costs’ and vice-versa. Also, the three indicators; product quality attributes, process quality attributes, and cost of quality can directly affect the quality rating and quality rating would affect the three of them.

In this matter, Sousa and Voss (2002) proposed, based on Garvin (1986) and Fynes and Burca (2005), an approach of quality performance indicators where internal process quality and operational performance affects product quality performance in general, and the three specific processes: internal process quality, operational performance, and product quality performance;

all these processes affect overall business performance. The next paragraphs introduce these quality performance indicators and give more specification with respect to the software industry.

FIGURE 1
Quality performance indicators



Product quality attributes and the software industry

Product quality attributes are regularly used by organisations to measure the quality of products (Agus, 2005, Flynn et al., 1995, Prajogo and Sohal, 2003). However, authors tend to divide product quality attributes according to types of products produced. These types of products include goods, services, or knowledge products (Mehrez, 2010). One of the most used dimensions in evaluating product quality dimensions in goods or services is the one presented by Garvin (1987) who proposed eight critical dimensions or categories of quality performance in manufacturing. These dimensions are known by the terms: performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality (Garvin 1987, p.104).

While Garvin's model has been recognised as the most acceptable dimensions in goods (Agus, 2005, Flynn et al., 1995), a variety of approaches has been applied to explain the multi-dimensional nature of services. Evans and Lindsay (1999, P.52), for example, provide a list of six service dimensions. These dimensions included: time, timeliness, completeness, courtesy, consistency, accessibility and convenience, accuracy, and responsiveness. Parasuraman et al. (1988) provide a list of five dimensions that were empirically-tested; namely, tangibles, reliability, responsiveness, assurance, and empathy, which they referred to as the SERVQUAL.

In the software industry, several measures of determining software product quality performance to reflect the multidimensional nature of the software product have been suggested (Barbacci et al., 1995). Five models are proposed to be primary frameworks (Fitzpatrick, 1996, Gillies, 1993, Tian, 2005), namely, McCall's, Boehm's, FURBS, Dromey's and ISO 9126. In ISO 9126, for example, six attributes, consisting of twenty one sub-characteristics were developed to determine software product quality performance. Functionality, reliability, usability, efficiency, maintainability, and portability were deemed as the main product quality dimensions in the software industry.

Process quality attributes and the software industry

Process quality attributes have also been adopted by several authors as a measure for quality performance outcomes (Corbett and Rastrick, 2000, Fynes and Voss, 2001). An organization's process refers to what takes place during the conversion of a set of inputs into a desired output, or set of outputs; these may in turn become the input/s for a new process until a final goal is achieved (Soliman, 1988).

According to this definition, process quality attributes/indicators can be measured by a number of approaches depending on the type of the industry. Despite the debate around the distinction between process indicators and outcomes indicators (Mant, 2001), Collier et al. (2001) argues that process quality attributes can be measured by the results obtained from executing the particular processes. For example, process quality attributes can be reflected by the frequency of "on time" response or by the frequency that schedules are met. Collier et al. (2001) add that firms can also measure the cycle time of a process or the time to perform an activity; alternative measures include the level of availability of a resource and the waiting time to start an activity (Collier et al., 2001). An improved process usually leads to cost reduction, and thus process performance can be measured by comparing the gap between the actual costs of doing business to the planned costs. Therefore, process efficiency measures may also include the total time to release a product and the cost of the product, as proposed by Constantine and Robert (2004).

The research problem

Software quality has often been described as a poorly developed concept (Willacy, 2010). Kenett and Baker (1999, p.13) argue that software quality is often seen as an 'elusive and mysterious subject' and add that 'it is perhaps the most ignored topic in the world of software development'. Hong and Goh (2003, p. 364) confirm this by stating, 'Of all the mysteries of producing software, none are more obscure than those relating to quality'. This accumulated evidence of software problems has resulted in an increasing need for managing software quality. In solving these problems, several authors propose different scenarios and approaches like TQM, Six Sigma, Statistical process control and even ISO through which this required quality might be achieved (Antony & Fergusson 2004; Bamford & Deibler 2004; Bellini & Storto 2006; Galin & Avrahami 2006; Jovanovic & Shoemaker 1997; MacMillan 2000).

However, even after applying quality management models, quality-related problems will still be observed in software products (See Toyota quality crisis for example (Canning, 2010)). That means that software quality problems may be deeper than just developing a new model or program, and may their roots in the existence of several gaps in the design and implementation of these quality management programs. However, the key and starting point in developing any quality management program, it is the determination of the required level of performance (Mehrez, 2010).

This constitutes a key consideration that has not been addressed in previous studies and it has not been considered in the development of many QM models in the software industry. Therefore, it is important to identify the level of compatibility between software developers' perceptions of how the product should perform the customers' expectations of what the product

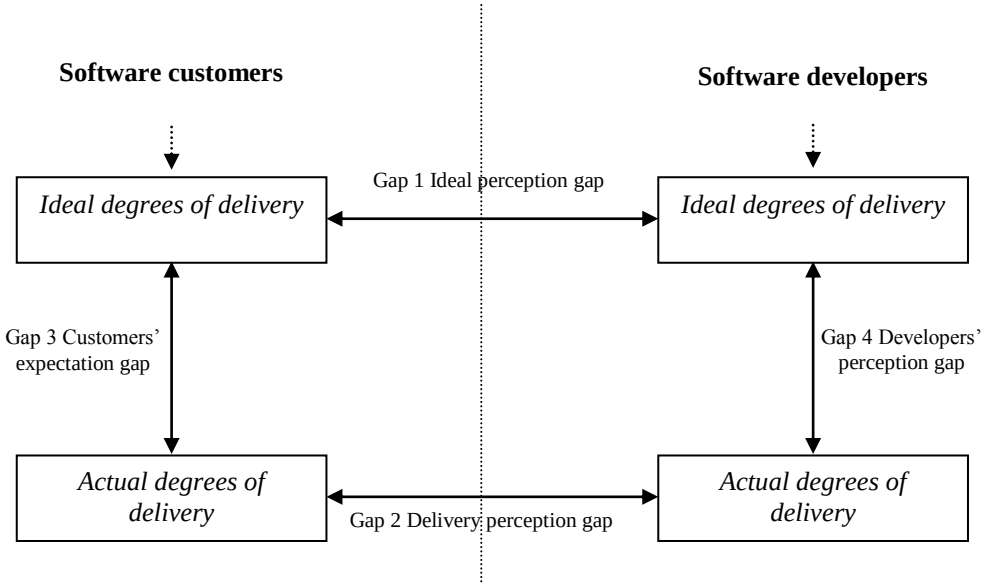
should do; it is also important to determine any discrepancies between the perceptions of software developers and customers on how the product actually performs.

This research investigates whether differences, or *gaps*, may exist between these four viewpoints, and, if so, the magnitude of such differences, in order to help with developing and implementing an effective quality management model in software firms. For example, software developers may think that it is very important for customers to receive software on time while software customers may believe that it is more important to receive software on budget. This conflict in expectations may result in gaps while designing and implementing quality management programs in software firms. Thus, the general question being addressed in this paper is "***Do significant quality performance gaps exist between developers' and customers' in assessing ideal and actual levels of delivery of a product for a given set of quality measures?***" Where 'quality performance gaps' refer to differences between what software customers perceive and expect to receive from software products *and* what software developers perceive and expect to deliver. The research problem could further be stated as:

1. Is there any difference (gap) between software developers and software customers in rating quality performance outcomes with respect to (a) degree(s) of ideal delivery and (b) degree(s) of actual delivery?
2. Is there any difference (gaps) between what software developers perceive as ideal degrees of delivery and what these software developers perceive as degrees of actual delivery with respect to quality performance outcomes?
3. Is there any difference (gaps) between what software customers perceive as ideal degrees of delivery and what these software customers perceive as degrees of actual delivery with respect to quality performance outcomes?

The above research problem has led to the formulation of the conceptual research model shown in Figure 2.

FIGURE 2
Quality Gaps



Research hypotheses

The above research problem has led to the formulation of the following four hypotheses to address the research problem:

1. It is hypothesised that *ideal quality perception gaps* are found in the Egyptian software industry between software developers and software customers.
2. It is hypothesised that *quality delivery perception gaps* are found in the Egyptian software industry between software developers and software customers.
3. It is hypothesised that *quality expectation gaps* are found in the Egyptian software industry between what software customers assess as ideal degree of delivery and actual degree of delivery.
4. It is hypothesised that *quality performance perception gaps* are found in the Egyptian software industry between what software developers assess as ideal degree of delivery and actual degree of delivery.

Methods

A survey approach has been adopted in this research to investigate the research problem and an internet survey was considered the most appropriate method to reach the large number of possible respondents among the software developers and software customers in Egypt (Forrest, 2003). A questionnaire was built upon Prasad's (2005) feedback form that was used primarily by IBM. The questionnaire consisted of nine questions of which seven are related to software product quality dimensions and two to process quality dimensions. Developers and customers were asked to assess degrees of importance of ideal delivery and actual delivery associated with each of these nine quality dimensions. Table 2 indicates definitions, questions and references of the constructs used in this survey questionnaire, including the components of product quality performance indicators and of process quality performance indicators.

TABLE 2
Constructs definitions

Performance indicators	Definitions	References
Product quality	- Product performance: Ability of product to execute its functions. - Product capabilities: Ability of product to meet its requirements. - Product usability: Ease of use - Product reliability: Degree of accuracy (frequency of errors) - Product installation: Ease of installation - Product portability: Ease of transfer from one environment to another. - Product documentation: Adequacy of documentation and how easy to understand.	Prasad 2005
Process quality	- Timing: Ability of product to be released in time. - Cost: Ability of product to be presented within budget	Prasad 2005

Each dimension of product or process quality in this questionnaire was measured using a 5-point rating scale to assess the respondents' perceptions of:

a) the level of importance of ideal delivery (where 1=very low importance, 2=low importance, 3=moderate importance, 4=high importance, 5=very high importance); and
b) the level of satisfaction with actual delivery (where 1=not satisfactory, 2=satisfactory, 3=good, 4=very good, 5=excellent).

Research procedures and data analysis

This study focused on Egyptian software companies, more specifically on stand-alone software firms that produce software for sale and not software embodied in another product or industry. The target population includes international companies as well as national and in-house companies as long as they are located in Egypt and serve the Egyptian market. The questionnaire was sent electronically during a three months period in the Spring of 2011 to the 937 companies from different sectors that are listed in the IDSC (the Egyptian Information and Decision Support Centre) in order to get customers' perceptions with respect to quality performance indicators. These companies were sent electronic invitations to participate in the survey. In this invitation, it was clarified that (1) only companies who buy and use software products from the Egyptian market are targeted, and (2) respondents include any employee responsible for buying and/or operating the software program. Surveys were collected over the three months with three reminders. A total number of 132 respondents confirmed participation in this internet survey which corresponds to about 14% of the firms targeted.

Additionally, the same questionnaire was sent to the 602 software developers listed in the IDSC as software firms in Egypt during the same three months period and seeking information about software developers responsible for quality management program design and/or implementation. This list included CEOs, quality managers, and project managers as long as they were responsible for designing or implementing quality management programs inside the company.

Results

From the group of software customers, 111 companies sent a valid reply, which represents a percentage of about 84% of the 132 companies who confirmed buying and using a software product from an Egyptian software company. From the group of software developers, 142 software developers out of the 602 initially targeted provided replies, representing a response rate of about 24%. Table 3 presents the mean and standard deviations of the data collected highlighting the perceptions and expectation gaps between software developers and software customers.

It can be noticed from Table 3 that gaps can be identified between the means of developers and customers using simply means of gaps under a significance of 1%. Clearly, Figure 3 shows a scatter diagram of both respondents' perceptions with respect to quality performance (a) ideal degrees of delivery, (b) actual degrees of delivery.

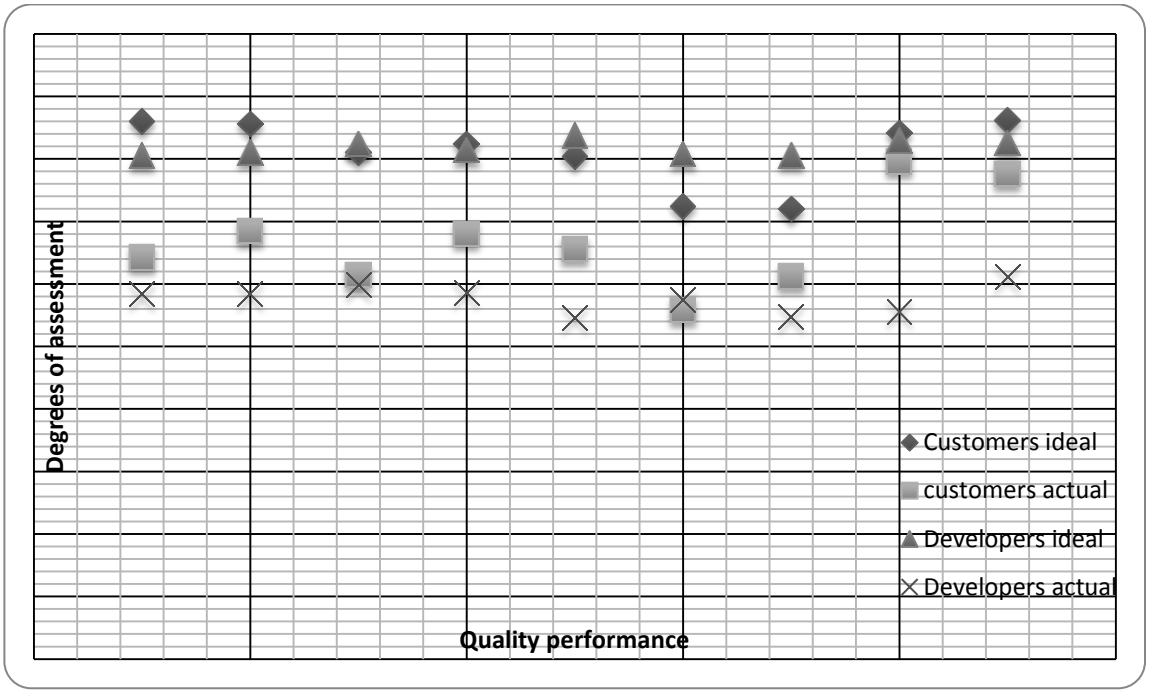
TABLE 3
Quality performance perceptions and expectations gaps

QP indicator	Degrees of importance and actual delivery								Gaps			
	Customers' ideal		Customers' actual		Developers' ideal		Developers' actual		Gap 1 Ideal perceptions gaps	Gap 2 Delivery perceptions gaps	Gap 3 Customers' expectations gaps	Gap 4 Developers' perception gaps
	M.	S.D.	M.	S.D.	M.	S.D.	M.	S.D.	M.	M.	M.	M.
Prod.Perf.	4.30	.827	3.21	1.129	4.03	.914	2.92	1.155	0.27	0.29	1.09	1.11
Prod.Cap.	4.28	.741	3.42	.920	4.05	.878	2.92	1.170	0.23	0.5	0.86	1.13
Prod.Usa.	4.05	.913	3.07	.970	4.12	.911	2.99	1.152	-0.07	0.08	0.98	1.13
Prod.Reli.	4.12	.902	3.40	1.073	4.07	.864	2.93	1.264	0.05	0.47	0.72	1.14
Prod.Inst.	4.02	.874	3.28	1.207	4.19	.858	2.73	1.243	-0.17	0.55	0.74	1.46
Prod.Port.	3.62	1	2.79	1.229	4.04	.895	2.87	1.216	-0.42	-0.08	0.83	1.17
Prod.Doc.	3.60	.984	3.06	1.081	4.03	.922	2.74	1.303	-0.43	0.32	0.54	1.29
Proc.Tim.	4.21	.810	3.98	1.027	4.15	.842	2.78	1.294	0.06	1.2	0.23	1.37
Proc.Cos.	4.31	.818	3.88	1.033	4.13	.836	3.06	1.207	0.18	0.82	0.43	1.07

Figure 3 shows that significant gaps exist between software developers and software customers especially between ideal degrees of delivery and actual degrees of delivery. It can also be noticed that developers' perceptions of performance delivered are lower than all the other means, as customers' ideal expectations top all other means. Thus, it can be safely assumed that significant gaps can be found between developers and customers with respect to assessing quality performance in the Egyptian software industry. This assumption can be statistically tested with respect to the following research hypotheses:

Hypothesis 1: It is hypothesised that quality performance (ideal) perception gaps exist in the Egyptian software industry between software developers and software customers.

FFIGURE 3
A scatter diagram of customers and developers perceptions and expectations



This hypothesis assumes that a significant difference can be found between software developers and software customers in assessing quality performance ideal degrees of delivery. To statistically test this assumption, an independent sample t-test was conducted for all the nine dimensions of quality outcomes. Results obtained indicates that no statistical significance can be found between customers' assessed ideal degrees of delivery and developers' assessed ideal degrees of delivery. Both developers and customers have assessed ideal degrees of delivery similarly. Accordingly, the first hypothesis is to be refused as no statistical significant differences could be found.

Hypothesis 2: It is hypothesised that quality performance (actual) perception gaps are found in the Egyptian software industry between software developers and software customers.

This hypothesis assumes that significant differences exist between software developers and software customers in assessing quality performance delivered. In order to statistically test this hypothesis, a paired sample t-test was conducted, and results show that statistical significance can be found between both customers' and developers' perceptions of actual quality delivered. Accordingly, the second hypothesis is to be accepted as statistical significant can be found. It is interesting to note that customers' perceptions of quality delivered are generally higher than the perceptions of developers.

Hypothesis 3: It is hypothesised that quality performance expectation gaps are found in the Egyptian software industry between what software customers assess as degrees of importance and degrees of actual delivery.

This hypothesis assumes that significant difference can be found between what customers assess as degrees of ideal delivery and what these customers assess as degrees of actual delivery. Therefore, another independent sample t-test was used to test this hypothesis. Results suggest that statistical significance can be found between customers' assessed ideal

degrees of delivery and these customers' assessed actual degrees of delivery. Customers were expecting to receive software product in better performance degrees than actually happen. Accordingly, the third hypothesis is to be accepted as statistical significant can be found.

> *Hypothesis 4: It is hypothesised that quality performance (developers) expectation gaps are found in the Egyptian software industry between what software developers assess as degrees of importance and degrees of actual delivery.*

This hypothesis assumes that significant difference can be found between what developers assess as degrees of ideal delivery and what these developers assess as degrees of actual delivery. Therefore, a paired sample t-test was used to test this hypothesis. Results indicate that statistical significance can be found between developers' assessed ideal degrees of delivery and these developers' assessed actual degrees of delivery. That means that developers think that they *do not* present software products in what software customers expect or even in what it has been planned to. Accordingly, the fourth hypothesis is to be accepted as statistical significant can be found.

Findings and Summary

The aim of this paper is to investigate if differences can be found between software developers and software customers in assessing quality performance ideal degrees of delivery and quality performance actual degrees of delivery.

An empirical study took place in the software industry in Egypt where certain quality performance dimensions were assessed by two groups of respondents; software developers and software customers. The main result indicates that discrepancies/gaps exist between software developers and software customers in assessing quality performance degrees of ideal delivery and degrees of actual delivery.

While this gap analysis approach in analysing quality-related problems in the software industry has never been presented in the software industry, this paper seek to shed the light on the importance of such analysis which may affect the development and implementation of quality management programs.

A number of issues have been raised also during this paper. Firstly, software developers as well as software customers tend to think the same way in assessing quality performance ideal degrees of delivery. However, developers and customers believe that the actual delivery is much less than it should be and that raise the inquiry of the possibility of quality management strategic and/or implementation gaps while designing and/or implementing quality management program.

Secondly, it is also important to investigate if quality-related problems may be related to the existence of knowledge gaps resulted from ineffective design and/or implementation of knowledge management activities. The existence of such knowledge gaps may lead to the existence of strategic gaps (Soliman and Spooner, 2000). It may be possible to identify various types of gaps with respect to customer expectations and developers perceptions (Soliman, 2009 and Soliman and Mehrez, 2009).

Thirdly, more investigation may be required with respect to differences between importance and performance from the perspectives of each quality performance dimension. While this paper presents a general conclusion of the existence of perceptions and expectation

gaps, more investigation is likely to dive deeper into each quality dimension and how significance are differences between importance and performance.

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