Data quality issues in implementing an ERP

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Abstract
Data quality is a critical issue during the implementation of an enterprise resource planning (ERP) system. Data quality problems can have a significant impact on an organisation's information system. Therefore, it is essential to understand data quality issues to ensure success in implementing ERP systems. This paper uses SAP as an example of an ERP system and describes a study, which explores data quality problems with existing systems, and identifies critical success factors that impact data quality. The study resulted in the development of a framework for understanding data quality issues in implementing an ERP, and application of this framework in a case study in two large Australian organisations. The findings of the study suggest that the importance of data quality needs to be widely understood in implementing an ERP, as well as providing recommendations that may be useful to practitioners.

Introduction

Organisations have often erred in maintaining existing information systems, when those systems were no longer manageable or profitable. A significant investment is required, however, to implement an enterprise resource planning (ERP) system and the supporting technology required to become more competitive and to obtain company-wide control and integration information. For organisations considering implementing an ERP, it is essential that data quality (DQ) issues be thoroughly understood. Thus, organisations should obtain knowledge of the critical success factors essential to ensure DQ during the implementation process.

There is strong evidence that DQ issues have become increasingly prevalent in practice (Redman, 1998; Wand and Wang, 1996) with most organisations experiencing some level of DQ problems within their firm (Huang *et al.*, 1999). The quality of data is critical to an organisation's success, however, not many of them have taken action to deal with these issues. DQ issues have become more important for organisations to perform well, obtain competitive advantage, and/or survive in today's global economy. In particular, when organisations are implementing an ERP, such as SAP, it is imperative that DQ issues are a high priority.

This paper describes an empirical study of DQ issues during the implementation of ERP systems within organisations. A model was designed to illustrate DQ issues in implementing an ERP. It also attempts to identify the critical success factors that

organisations should focus on to ensure DQ during systems implementation. Case studies in two large Australian organisations were used to provide useful insights into the nature of DQ issues in implementing an ERP. This paper describes and analyses case studies, and then discusses the practical implications of the findings.

Background

DQ issues
Following the general quality literature, DQ is defined as data that is fit for use by data consumers (Huang *et al.*, 1999). Many DQ dimensions have been identified. Commonly identified DQ dimensions are:
* accuracy,
* timeliness,
* completeness, and
* consistency (Ballou and Pazer, 1982, 1985, 1987; Ballou *et al.*, 1987, 1993).

Four other DQ dimensions have been identified that are also widely accepted:
1 intrinsic,
2 contextual,
3 accessibility, and
4 representational.

The dimensions that have been identified by Ballou and Pazer (1982, 1985, 1987) and Ballou *et al.* (1987, 1993) will be adopted in this research because they include the most important dimensions that have been addressed in information system literature and have been reasonably accepted in the DQ field. Therefore, quality data in this research means accurate, timely, complete, and consistent data. Although the meaning of data and information are different, this study uses the terms DQ and information quality synonymously.

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Computerised databases continue to proliferate and as organisations become increasingly dependent upon their databases to support business process and decision making, the number of errors in stored data and the organisational impact of these errors are likely to increase (Klein, 1998). Information research has demonstrated that inaccurate and incomplete data may adversely affect the competitive success of an organisation (Redman, 1992). Poor quality information can have significant social and business impacts (Strong *et al.*, 1997). For example, *NBC News* reported, "dead people still eat!" It was found that, because of outdated information in government databases, food stamps continued to be sent to recipients long after they died. Fraud from food stamps cost US taxpayers billions of dollars. Business and industry often have similar DQ problems. For example, a financial company absorbed a net loss totalling more than $250 million when interest rates changed dramatically, all because the company database was lacking in quality and simple updates (Huang *et al.*, 1999).

In order to ensure DQ in information systems, it is important to understand the underlying factors that influence DQ. There have been some studies of critical success factors in information systems and quality management, such as total quality management (TQM) and just-in-time (JIT). Some of the DQ literature has also addressed the critical points and steps for DQ.

Table I shows the related research efforts and reflects issues or elements of critical success factors for DQ.

ERP-SAP

ERP systems use relational database technology to integrate the various elements of an organisation's information systems. They provide a number of separate, but integrated modules. The use of an ERP avoids the costs of maintaining many separate "legacy" systems and overcomes the problems associated with interfacing different systems. It is quite expensive to implement an ERP system, requiring multimillion-dollar budgets and large project teams. Despite the expense, such systems are becoming very widely used in the world's largest companies (Scapens *et al.*, 1998). SAP is one of the well-known ERP packages on the market, with strengths in finance and accounting.

SAP is an integrated business system, which evolved from a concept first developed by five former IBM systems engineers in 1972. It is a software package designed to enable businesses to effectively and efficiently run a variety of business processes within a single integrated system. SAP stands for systems, applications and products in data processing. It is produced by SAP AG, based in Walldorf, Germany, which employs more than 22,000 people in more than 50 countries. SAP AG is the third-largest software company in the world. SAP software is deployed at more than 22,000 business installations in more than 100 countries and is currently used by companies of all sizes, including more than half of the world's 500 top companies (SAP AG Corporate Overview, 2000). Therefore, SAP is an excellent system to study in an effort to evaluate ERP environments.

Table I
Summary of literature review identifying factors influencing (data) quality

Factor	Saraph *et al.* (1989)	English (1999)	Firth (1996)	Wang (1998) Huang *et al.* (1999)	Segev (1996)	Zhu and Meredith (1995)	Orr (1998) Cushing (1974)	Yu and Neter (1973) Fields *et al.* (1986) Nichols (1987)	Bowen (1993)
Training	*	*		*		*	*		
Top management support	*	*	*	*	*	*			
Organisational structure (communication)		*				*			
Manage change		*							
Employee/personnel relations	*			*		*			
DQ control									
Internal control								*	
Input control									*

Source: From Xu, 2000

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Research issues

The purpose of this research is to investigate DQ issues in implementing an ERP system. In this study, SAP is the specific ERP system studied.

The main research issues are:
- whether DQ is one of the reasons leading to a decision to implement an ERP;
- what the critical success factors are for DQ when implementing an ERP.

A framework for understanding DQ issues in implementing ERP

In order to help understand DQ issues in implementing an ERP, the underlying problems with old systems need to be investigated. After organisations have made a decision to move to the new system, they should plan extensively and be aware of critical factors that impact on DQ during the implementation process. Finally, a determination should be made as to whether implementing an ERP will help increase the level of information quality within the organization.

The framework for understanding data quality issues in implementing an ERP in this paper combines the information quality problem pattern concept (Strong *et al.,* 1997) and critical factors concepts in DQ and quality management (Saraph *et al.*, 1989; English, 1999; Firth, 1996; Wang, 1998; Segev, 1996; Huang *et al.,* 1999; Bowen, 1993).

DQ problem patterns include:
- *Intrinsic DQ pattern*: multiple sources of same data, questionable believability, judgement involved in data production, questionable objectivity, poor reputation, and little added value, leading to data not used.
- *Accessibility DQ pattern*: lack of computing resources, poor accessibility, access security, interpretability and understandability, concise and consistent representation, amount of data, and timeliness, leading to barriers to data accessibility.
- *Contextual DQ pattern*: operational data production problems, changing data consumer needs, incomplete data, poor relevancy, distributed computing: inconsistent representation, and little value added, leading to data utilisation difficulty (Strong *et al.*, 1997).

The framework components are illustrated in Figure 1.

Research method

Qualitative case study data collection and analysis techniques were used for this study. Case study research is used to study the contemporary phenomenon in its real-life context (Yin, 1994) and it can be used where the research and theory are at their early, formative stages (Benbasat *et al.*, 1987). Because little research has been conducted on DQ issues in relationship to ERP systems, there is a need to examine whether the DQ issue is one of the reasons that drive organisations to reach a decision to implement an ERP and what the critical success factors are to ensure DQ during ERP implementation. Therefore, case study research appeared to be appropriate for this study.

The ERP project at each organisation and the systems' major stakeholders' interaction with the development of the projects were analysed in this case study.

In DQ studies, four types of stakeholders have been identified:
1. data producers;
2. data custodians;
3. data consumers; and
4. data managers (Strong *et al.*, 1997; Wang, 1998).

To apply this stakeholders concept into an ERP environment:
- Data producers are those who create or collect data for the ERP system.
- Data custodians are those who design, develop and operate the ERP system.
- Data consumers are those who use the information in their work activities.
- Data managers are those who are responsible for managing DQ in ERP systems.

Data collection of this study involved semi-structured interviews and unstructured interviews with key stakeholders of ERP projects, which included data producers, data custodians and data consumers. The reason why there were no interviews conducted with data managers was because the two organisations used for this case study did not have a data manager, as such, involved in their ERP project. Data collection sources also included relevant documents, such as position descriptions, policy manuals, organisational structure charts, training documents and some published information about the organisations, such as financial statements and annual reports. The purpose of the case study was to investigate what was actually happening in real-world organisations before and during the

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Figure 1
Framework for understanding DQ issues in implementing an ERP
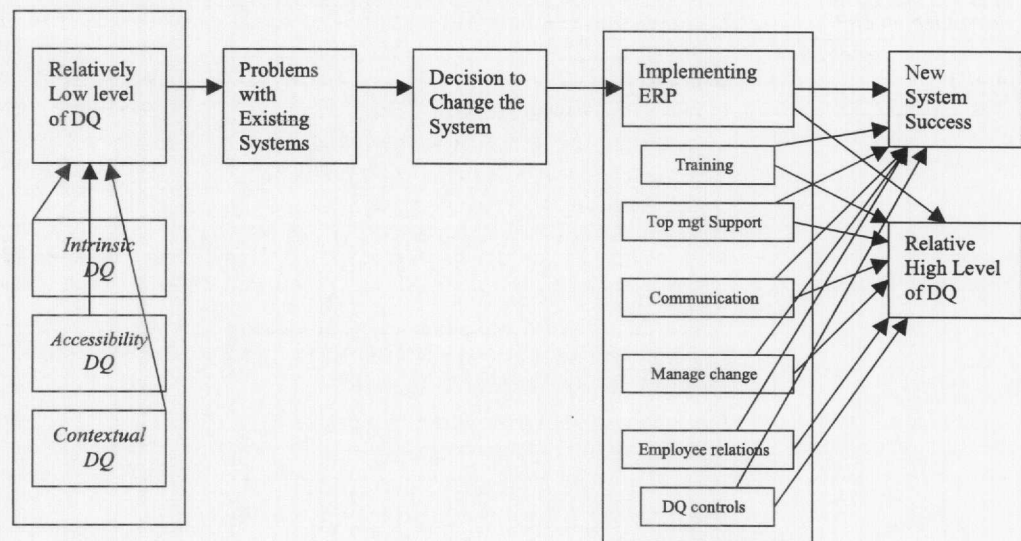
implementation of an ERP system in relation to DQ issues.

Case studies

This research studied SAP projects as the specific ERP from two large Australian organisations. Organisation A is a large government transport company, and organisation B is a large private mining company. Both are aware of DQ issues and are actively addressing those issues, in contrast with many other organisations, that often fail to address issues of data quality.

Basic characteristics of the two organisations are listed in the Table II.

Company A had two financial objectives:
1   to enhance the accounting data's integrity; and
2   to improve the financial capabilities of the organisation.

Although it is a large system – SAP R/3 across the organisation, there were only 25 employees in the finance branch. They did outsource the processing of their accounts payable, accounts receivable, and some of the fundamental operating systems.

In company B, the information system was divided into two major systems:
1   core systems, and
2   support systems.

Core systems are the systems like marking systems and systems that monitor production. Accounting systems were part of the support systems, because they were regarded as common everyday operations. Company B had a role called "the systems administrator" for each system and that person's responsibility was based on the user side so that would be an accountant or paymaster. It was their job to make sure the system worked exactly how users wanted it.

Table II
Organisation characteristics

Characteristics	Organisation A	Organisation B
Industry	Transport-services	Mining manufacture
Number of employees	4,000	50,000
Attention to DQ	One of two top priorities	Systems administrator
Time to move to SAP	Last year	Next year
Employees want to change?	No	No
	Reluctance to change because people lack confidence in the new system	People tend to focus on the problems with the new system rather than its benefits
Top management want to change?	Yes	Yes
How long will (did) it take?	12-16 months	12-15 months
How many systems merge to SAP	All old systems (MSA) to new SAP R/3	6 systems
IT role in systems changing process	IT division had little involvement in DQ issues, but focus on system issues	Provide technique expertise to load the data in But will not do checking

When it came to DQ issues, systems administrators were responsible and they were also the liaison for the information system division.

Research findings

The key stakeholders of the ERP were interviewed about their perceptions of DQ issues in implementing an ERP. Additional information was obtained from secondary data including reports and internal and external documents.

The outline of the research findings is summarised in the Table III and Table IV. Table III describes the difference between the old systems and the ERP (SAP) implemented system. Table IV shows what organisations have done in relationship to the critical success factors identified in the research framework while implementing the ERP.

Company A

Company A moved into SAP R/3 in 1999. It was its parent company's decision to implement SAP. Before they moved into SAP,

there was another company that did the systems functional ticking on an outsourcing basis. At the time that SAP was first introduced, company A was financially consolidated with its parent company. Together, they designed and had one system. At the same time they were converting from the old system to the new system, the parent company decided to divide the company into two. However, they still only run the one SAP client with releases and upgrades to the system done as joint exercises by the two companies.

DQ problems
They had some difficulties in the last couple of years with information systems:

> We had some difficulties because all our parent company reporting was actually done on cash but our financial statement reporting was done on accrual terms. So we had a lot of difficulty with actually producing some reporting out of this module (SAP R/3), which is obviously designed to be an accrual carrying system – that was the line-by-line type of level data in cash terms for the parent company. We had a couple of years – we've had quite a lot of difficulty with the reconciliation. We actually had to run two

Table III
Comparison between old systems and ERP (SAP) systems

	Old systems	ERP (SAP)
Interface	Different	Integrated
Information systems	Different packages	Integrated system
Cost		
Maintain	High	Low
Development	Low	High (easily over-budget)
Information flow	Might have problems when information crosses boundaries of different systems	Likely to have smoother information flow within the integrated ERP

Table IV
What organisations have done in relation to the critical success factors while implementing ERP (SAP)

	Company A	Company B
Training	Diverse range of courses related to SAP	Will have large scaled training
Top management support (who made the decision?)	Parent company	The heads of the organisation and the Board
Communications (members of the project team)	Business people and IT people (project team didn't provide adequate documentation of the ERP system for users to follow)	Business people (2/3) IT people (1/3) (more business than IT, because business people would know the requirements of the ERP system)
Manage change	Few months parallel run	A couple of months parallel run, and then move to SAP
Employees relations (how to persuade people to move to an ERP system)	No actions (employee turnover may cause DQ problems)	Don't bother arguing, just say: "it's been decided"
DQ controls (who makes sure of DQ before changing systems?)	Business people: checking DQ in the old system, and implementing DQ controls during ERP implementation	Business people: will have much more checking and reporting during the systems changing process

mirrored ledgers; one that's a cash ledger, one that was an accrual ledger. From a systems perspective it was very, very difficult and very, very complicated. Also, we did have some difficulties with the reconciliation between those ledgers for the last couple of years, which did compromise the delivery of our financial ...

Training
Company A conducted a diverse range of training in relation to SAP usage, such as how to enter data into accounts payable and accounts receivable and how to actually report information out of the system. There were a number of courses that were available in relation to ERP systems.

Employee's skills will affect the quality of data, and DQ is also related to the quality of training that is available to support employees:

> The process that people follow to put data into a system will influence DQ. Our processes, including the skills of our payroll people, are not at a sufficient level to guarantee the input of consistent quality data.

Although company A did a lot of training before the new system was implemented, one manager thought the training was inadequate because it just taught people how to operate the system in the ideal situation. However in the real world, there were problems, and people did not have the level of skills or understanding of the system to correctly deal with those issues. They had to guess how to do things with no available support.

One manager emphasised that documentation is very important for personnel to follow. It was suggested that the project development team should provide documentation to a standard that would be useful for the operators to follow. Organisations should not just test the system, but also the documentation that goes with the system.

Top management support
Difficulties caused by DQ problems aroused top management awareness of the system and DQ issues, and put DQ as one of the top priorities of the company's information systems. A decision was also made to put more budget and more skilled people into the development of the ERP system:

> This is probably on the top, it is certainly well up there in the organisation's view at the moment because of the fact that we've had difficulties with our financial statements over the last few years. We've told our financial branch, "one of the two things that we want to deliver this year is

improved data integrity". It's been supported by senior management from both the resources and everything else.

Employees' relations
Employees' turnover within the organisation may also cause DQ problems. Skilled staff have been attracted to the SAP systems development project because more money was received in that area. However, financially they could not afford to retain the high skilled staff in the business area where there was a need for skilled personnel to implement and develop the system.

DQ controls
The expenses of DQ controls were a concern in company A. The financial manger in company A stated:

> We really probably would like to move more resources into doing data integrity controls but I mean it's obvious the more you put into it the more its going to cost you so we don't really plan on doing that.

SAP: solve DQ problems
Integration of the new system was highly addressed by the manager:

> The system should have the same data in it. Before, we had one system that didn't talk to the other one. Now, we've got system integration.

Problems with SAP
It was found that although SAP is very powerful, organisations are hardly able to use all of its functions:

> Our system is very powerful and quite massive and SAP itself has huge capabilities, but we're probably not using as much of the capabilities of the system as we possibly can.

The findings revealed that SAP lacked flexibility; it was very hard to modify the SAP's existing configuration. SAP provided a centralised and structured approach to business processes and functions, which didn't necessarily match the organisation's needs. It was also very costly to modify the system.

SAP is too complex for some operating work. An example was given of one simple change to records which took half an hour using SAP, while with the old system it only took a couple of minutes.

Company B
Company B is going to move to SAP next year and the following year convert six additional systems to SAP. The initial changeover is anticipated to take 12 months. People within the organisation are not looking forward to this change. Because an ERP requires the same computer system throughout the whole company, the change

affects everybody in the entire organisation. People have a tendency to resist changing to a new system. They would prefer working with the old system because introducing the new system sometimes means more problems initially.

DQ problems: reasons for change – top management support
The reason why the board and heads of company B made the decision to move to SAP was, within the company at a high level, they ran into problems due to the fact that each segment of the company had totally different systems, and they wanted to have consolidated reporting. It was very difficult to achieve this with separate systems. There was some conflict of interest between the decision makers and the operating employees:

> Regarding our little area of the world, although we're happy with what we've got, one area that management isn't happy with is that we have totally separate systems with interfaces between them running all the time.

The information system manager in company B explained this situation as:

> …[because] they are different packages, we've got downloads and uploads between them running all the time and what managers want to get out of SAP is it's all integrated and you put your data in one spot and everybody sees it. You don't have to have overnight interfaces. So that's what they are looking for.

The old systems in company B had three major subsystems, and they were different packages. The reason for this was at the time their policy was to buy the best package in a particular area rather than go for integration. Top management assumed the IS department would make those packages integrate with each other. However, there were DQ problems between the different systems.

> We have problem areas, for example one is we constantly have problems between HR and Payroll because that's where you get added in one and not in the other and terminated in one and not in the other and the checking there just isn't as good. But when it comes to dollars, they keep a very close eye on it.

Training
There will be a large training exercise when company B actually moves to SAP. Training will be part of the upgrade process. Management is aware of the importance of training in the implementation of the new system:

> You have to get it [training] right or else people are just lost the first day of the new system, aren't they?

Communications: project team
Company B's SAP project team was large, and had many personnel involved in the project. The team members on the project team made the decisions on how the business was going to use SAP. At the planning stage, they had two-thirds business and one-third technical people on the project team. They wanted to set up the templates within SAP, and wanted to get that right the first time, because it would be very difficult to change it afterwards. More business people's involvement could help make decisions on how the templates were going to be set up. When it comes to implementing SAP, more technical people will then be needed.

Manage change
Although company B will do a couple of months parallel run, it is basically going to be the "big bang" from the old systems to SAP, and then turn off all the old systems. This could cause potential problems, as ERP is a large integrated system across the organisation that may impact many aspects of business. A quick cut off from the old system without sufficient training in place could cause DQ problems in the new system.

Employees' relations
While people's reluctance to change to the new system could cause less cooperation from employees in the systems implementation process, and might lead to DQ problems, company B simply did not bother with this:

> There'll be a lot of loath, reluctance and not just changing the system but what we're talking about here – cooperation along the whole information flow is going to happen …. Well, what made it easy in this case is we just shrug and say: "Well the company decided. We can't do anything about it guys – we're just going to do it." And we don't even bother arguing or justifying. We just say: "It's been decided."

> I can remember back in the very early days when the systems were new, things fell over much more frequently than they do now and we had much more data corruption. I can't think of an episode in the last four years of any corruption or anything falling over. Things are very stable and mature now.

DQ controls
Business people rather than information systems are responsible for DQ controls in the systems implementation process. Business people check the DQ during the changing process to make sure data is moved into SAP with a high level of quality. Information technology (IT) personnel provide the facilities to load the data in but

they will not be doing the checks to ensure that the data is reconciled back to the old system.

DQ problems: SAP solves problems
One of the DQ issues with the old system was when the information flow crossed different divisions and systems, DQ problems were sometime encountered; and when problems occurred, people tended to blame each other. SAP should, however, resolve this problem because it has one integrated system:

> Well I know I hear complaints wherever you have information, data, crossing a functional boundary. There are always inter-department … "Oh, it's them" and "They got the data wrong", and "Oh, they were too late", there is always that sort of thing going on.
> Well this is going to have to change with SAP because it works on the idea of information flow.

Discussion

DQ problems
The case study findings showed that DQ problems are one of the major reasons organisations implement an ERP. Before implementing an ERP, with old systems, there were intrinsic, accessibility and contextual DQ problems. Old systems normally had separate subsystems; therefore, organisations kept multiple sources of the same data. In addition, because of the different interfaces between the old systems, information was represented inconsistently throughout the organisation. Accessibility DQ problems also existed in old systems, for example, it was hard to access the data that existed in another subsystem. There was lack of the capacity to communicate between subsystems that often led to unsatisfactory and confusing data.

'…findings showed the DQ problems are one of the major reasons organisations implement an ERP…'

SAP solves problems
Implementing an ERP could possibly resolve some of the DQ problems, because, for example, the SAP suite is an integrated financial application that provides organisations with useful information in a timely manner. Integrated ERP systems require less time to gather useful information. The information only needs to be entered into the system once and then it is available throughout the system in a consistent manner. While using separate

legacy subsystems, it takes a significant amount of time to find the necessary information. Because ERP has an integrated interface, the representation of information is consistent throughout the entire organisation.

Manage change
There are some important issues that need to be considered when organisations are making the decision of whether to change to an ERP. The new system's advantages and benefits can easily be addressed. However, individual employees often emphasise the weaknesses of an implemented ERP and its disadvantages. An ERP is very expensive, it requires a large number of skilled personnel with technical expertise, and it takes extensive time to develop and implement. For example, the price of the cutdown version of the SAP software is "200-400 per cent more expensive" than offerings from other mid-market players such as Systems Union (Reed Elsevier Business Publishing, 1998).

The cost of an ERP system is not only in the price of the software. In order to ensure DQ in the systems implementation process and to enhance DQ in the new system, organisations must invest a significant amount in training staff with the necessary skills. The cost of the software could be only a minor portion of the total cost of implementing an ERP. The ERP project team and the training process require a heavy investment. It was found that in real-world cases ERP projects as a rule exceed the original budget. An entry-level system costing $100,000 can cost $1,000,000 to get up and running. "The price of the software can be as little as 10 percent of the total cost", warned Dave Lyone, chairman of the UK's SAP user group, and project manager of Unilever's R/3 project, adding that the product worked well but was large and complex (Vowler, 1994).

This case study shows that real-world organisations often under-estimate the cost and time of implementing an ERP, and from the case study organisations, it is very clear that poor skills of managing change could cause potential DQ problems.

DQ training
From a DQ perspective, training in real world cases seemed to be insufficient.

Implementing an ERP requires all aspects of training as well as appropriate documentation of the new system. It was found that organisations tended to focus

more on the new systems' development, the "hardware" part of the new systems' implementation process, putting less effort on the "soft" part, that is, the training of how to implement the new system. The people's skills, people's abilities to use the new system efficiently are very critical to ensure DQ in an ERP system. There should be more support to personnel utilising the new system or else they may be reluctant to the change over which takes a significant amount of time, money and skills.

Some of the other factors in the research framework were also found important to DQ in implementing an ERP.

Employees relations
As mentioned above, organisations have emphasised the technical part of the new systems development and implementation. Organisations invested large amounts of money on the SAP project; therefore skilled people had been attracted to the SAP project team, which would help ensure the high quality of new system implementation from the technology side. However, because there were not enough skilled employees who were using the new system, users of the system had less support than necessary to ensure DQ.

> '... *Although case study organisations were aware of DQ checking before moving data into the new system, there are not enough DQ controls in real-world organisations...* '

It was found that employees in the organisations did not really want to move to the new system. The people's reluctance to change could cause potential problems of DQ in implementing ERP systems. For example, if there is a DQ problem in implementing an ERP, people tend to blame the new system saying that the same problem did not occur while working with the old system, rather than trying to find what caused the problem in the new system and resolving it. Good employee relations in the systems changing process are important to ensure DQ in the ERP system. With good employee relations, and more support to them, however, employees would likely have less reluctance to move to the new system. Therefore, they would make some contributions to the new systems' implementation and actively resolve problems during the changing process. Unfortunately, case study organisations did not put much effort into involving employees in the decision to change to an ERP. Employees were just told that the decision had been made.

Communication
Because lack of communication in the old system caused DQ problems when the information passed through the boundaries of the different systems, it became important in the ERP implementation process. Understanding and communications between different systems, and different functional divisions are essential to the success of ERP implementation. Another communication issue exists between the IT professionals and other business professionals; they need to communicate and understand each other to make the implementation of an ERP a success. The findings from case studies show that business people's involvement in ERP development project teams could help IT people better understand the new systems' needs. The systems' administrator role that existed in the case study organisation was a very good example of building the communication bridge between IT and other business professionals.

DQ controls
The business people would like to conduct the DQ checks before moving data into the ERP system. Although case study organisations were aware of DQ checking before moving data into the new system, there are not enough DQ controls in real-world organisations. DQ controls, such as internal controls, input controls, performance reviews, and segregation of duties, should be emphasised when implementing an ERP.

Top management support
It was interesting to find that obtaining top management support was not addressed as an issue in implementing an ERP. This may be because top management made the decision to implement an ERP; therefore it is obvious that they would support their own decisions.

DQ problems with ERP
Although ERP can solve some of the DQ problems in the old systems, such as integration issues, it can also potentially introduce some "new" DQ problems as well, including access security issues in sensitive business information, information overload, and the need to store large amounts of information. ERP was also found too complex and inflexible, which requires more DQ controls and more skills to operate. Lack of DQ controls could cause a disaster by using an ERP, while in a non-integrated system it might cause only minor problems. For example, if someone input a wrong price of a

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company's product without anyone else checking on it, the company could end up receiving $3 for a $3,000 product. Because the system is integrated, this error could pass through the whole system unnoticed. Thus, many customers could order this $3,000 product for the price of $3. Another example is authorising cheque payments. In the past, managers signed the cheque to control the authorisation. Under the integrated system, cheques are issued through the system. There is no paper work needed to authorise the payment.

Therefore, critical factors that contribute to the high level of DQ in the new system including appropriate and sufficient training support from top management, communications, good employees relations, and DQ controls should be addressed during or after implementation of the ERP system.

Implications for practice: recommendations

There are some implications for real-world practitioners, which emerged from this case study.

The following recommendations were drawn from the case study findings.

Understand DQ issues when implementing an ERP

DQ issues are critical to the success of ERP implementation. The framework proposed in this paper provides a useful tool for planning the establishment of an awareness of DQ issues in implementing an ERP. The discussion of this paper highlighted some DQ problems, which existed in the old systems, such as intrinsic, accessibility and contextual DQ problems, and the critical success factors that impact on DQ while implementing an ERP. DQ issues need to be widely understood to ensure successful implementation of an ERP.

'... The framework proposed in this paper provides a useful tool for planning the establishment of an awareness of DQ issues in implementing an ERP...'

Conduct a cost/benefit analysis before making the decision to implement an ERP

Financial analysis requires that existing employee skills both in designing and implementing an ERP system must be considered. In addition, the time required for implementation should be taken into account before organisations make the decision of whether to implement an ERP. A cost/benefit analysis should be used to compute the possible cost savings after implementing an ERP. The increase of productivity and the probability of the possible elimination of jobs should also be taken into account. The cost/benefit analysis is essential in this stage, as implementing an ERP is very costly. Issues discussed in this paper will help practitioners to perform a cost/benefit analysis in relation to DQ issues when making a decision regarding the implementation of an ERP.

Understand the critical success factors that impact on data quality while implementing an ERP

There are certain factors that influence data quality when implementing an ERP. Organisations should focus on those critical factors as defined by the framework in this paper, which include training, top management support, communication, manage change employee relations, and DQ controls. Understanding the critical factors should lead to high-level DQ management practices, which is a key to successful implementation of an ERP. The knowledge of specifications of the critical success factors of DQ management in ERP permits organisations to obtain a better understanding of DQ management practices, and perform better DQ controls in implementing ERP systems.

Establish a knowledgeable ERP project team and conduct sufficient training in the content and usage of ERP systems

Particularly important critical success factors for DQ in implementing an ERP from the case study are:
- communication within the development team; and
- adequate training.

Implementing an ERP requires an effective project team that works together. Both business and IT personnel perform very important roles in the implementation process to ensure that the project is on the right track. Quality communication between business and IT people will significantly reduce DQ problems.

Adequate training on DQ for all personnel involved in implementing an ERP is important for ensuring and improving DQ. People's ability to use the system is equally important to ensure a relatively high level of DQ in implementing an ERP. Sufficient training should be provided to all employees

to obtain a broad understanding of the new system as a whole, as well as providing particular personnel with adequate documentation and specific training in their relevant functional areas in relation to the new system.

Conclusions

DQ is a critical issue in the ERP implementation process. This study examined the implementation of SAP as an example of an ERP system, and proposed a framework for understanding DQ issues during the implementation of an ERP. Identified were a number of DQ problems that should be addressed when implementing an ERP. Critical success factors for DQ during the ERP implementation process were proposed and then examined empirically in case study format. The case studies provided a better understanding of DQ issues during the systems conversion process as well as providing useful practitioner findings from real-world practice. ERP implementation issues discussed and the use of the identified framework should help organisations obtain a better understanding of DQ issues throughout the process leading to activities which will help ensure DQ. Finally, the paper provided some recommendations with implications for practitioners.

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