Information Quality and Diverse Information Systems Situations

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed   ID No.: 56122501 Date: June 2011

To Daddy.

Whose pursuit of knowledge for the sheer joy that understanding brought, never ceased to amaze me.

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Contents

List of Figures

List of Tables

Abstract

Information quality is a recurring problem that many organisations contend with. Despite investment in both technology, and the refinement of information systems, the problem persists. Information systems deployment has; in recent years undergone radical change; the traditional deployment where the architecture, user and access device were known at the time of development, have been replaced by more diverse situations. These diverse situations include web interfaces, traditional client server and a mobile devices revolution.

The aim of our research is to improve information quality assessment by catering for diverse information systems situations by the design and construction of a method. Several information quality frameworks have been developed to cater for these new and evolving information systems. The expansion of frameworks across a large number of domains presents problems with respect to: framework choice, appropriateness, validity and users perceptions of information quality.

Through the application of gap analysis techniques, experiments and domain expertise the method has the potential to provide additional knowledge for information systems' stakeholders. Our method contributes to information quality as a field of research by allowing for refinement of the application of information quality frameworks for diverse information systems situations and also provides the basis for consolidation of information quality frameworks.

1

Introduction

1.1 Overview

High quality information is a key requirement for any society to function effectively and efficiently; appropriate decision-making for enterprises cannot take place otherwise. This applies across all organisations and at every level. Therein over the last thirty years these decisions have more and more relied upon information generated by Information Systems (IS). The rapid expansion of IS to every section of an enterprise places a requirement for the generation and management of information of high quality. The need to manage, study and research underlying processes, models and methods associated with the generation, management, control and access of information has never been more acute. A more recent revolution has also taken place; the manner in which IS are now accessed and the situations that cater for their deployment has become much more diversified [107]. Contemporary IS access involves the same information being viewed from many diverse situations.

The expanded range of access devices, combined with the diversifications of IS, situations have ensured that these technologies are now truly becoming ubiquitous. The processes, procedures and frameworks employed to measure Information Quality (IQ) must also reflect this reality. Our research examined the challenges of defining, measuring and improving IQ for diverse IS situations. Specifically this research focused on, the impact of a diverse IS situation on the users perceptions of IQ. Many IS have underlying databases that are accessed from a diverse range of situations. Therefore the same information, in a modern enterprise, is most likely accessed by users from PC, desktop, notebook and a mobile environment. Obtaining a true measure of IQ for an IS that reflects these diverse situations presents many significant opportunities in the field of IQ research.

The last fifteen years have heralded the development and implementation of many IQ frameworks and methodologies in response to the challenge of obtaining and maintaining high quality information that is fit for purpose [15].

These frameworks are employed in order to facilitate the measurement of IQ. This research examined some of the challenges associated with the implementation of an IQ framework for diverse IS situations. This involved the construction of a novel method to cater for the application of an IQ framework for diverse IS situations. In conjunction with a Library and Airline IS we examined and outlined in detail an approach to catering for these new diverse IS situations. We demonstrate a practical application of the method and evaluate its utility as an approach that can be employed to assist in IQ measurement for diverse IS situations.

1.1.1 The Pervasiveness of Information Systems

Interfacing with a multiple of IS in order to conduct their affairs is now a daily routine for many people. These IS exist across every aspect of their personal and professional lives: including email, internet banking, stock control systems, complex financial IS and many more. They allow for the efficient completion of both routine and complex tasks, and a common theme across all these IS is a requirement for them to produce information of a high enough quality that allows for the successful completion of the associated tasks.

The situations that these IS operate from, especially the IS access methods, have diversified over time [2, 36, 128]. The relatively simple mainframe workstation configuration has evolved and is now accompanied or replaced in its entirety. IS situations have also become more complex; a typical IS is most likely now accessed via a number of different tiers, applications and platforms. Consequently the situation has changed from a homogeneous one of a single database and access method to a heterogeneous and complex one resulting in many databases and access methods. This landscape will continue to evolve with the ever increasing deployment of Service Oriented Architectures (SOA)[126].

The IS situation comprises multiple factors; including the user role, application tasks, access devices and associated services. These situations have evolved over time and are now in a constant state of flux. The workstation model was predominant in the late 70s and early 80s [36], followed by widespread deployment of the client server model [128] and then the rapid expansion of internet services [2]. More recently this expansion has continued with the pervasive availability of mobile devices and wireless technologies [2, 3, 46]. Virtualization has also made an impact especially with the widespread implementation of unplanned solutions [60].

This changing complexity of IS situation has in many cases occurred independently of the underlying databases that are accessed [2]. Applications designed, built and tested with a mature software development methodology for a particular IS situation may within a very short period of time be accessed, and predominantly employed, from a different situation [3]. Data models have also evolved [36] and a considerable number of IS in use today have data models designed prior to the IS situations that are employed to access them; resulting in multiple accesses from diverse and complex situations.

1.1.2 Problem Statement

Concurrent with this changing IS situation are the associated IQ problems. This stems from user dissatisfaction with the quality of the information produced by the IS [120]. As IS situations have evolved there has also been a rapid growth in the amount of data that enterprises store and access [3, 36, 92], creating significant IQ problems. Several enterprises have invested considerably to clean up their information which is being used increasingly for critical decision making at all levels of the organisation [121]. It is estimated that poor quality information costs American business some $611 billon a year [111]. The cost of poor IQ is however not merely a financial one; as many as 98,000 people die in the USA each year because of IQ errors associated with medical records [42].

Academics and practitioners have addressed the IQ challenge broadly from two perspectives; improving IQ and software quality. Consequently research in the area of IQ has evolved as a discipline in its own right within the broader field of IS research [76, 144, 146, 147]. This has seen the evolution of key constructs within IQ; including frameworks, dimensions and assessment methodologies. For the purpose of our research data and information are considered the same, i.e. output from an IS. This is in keeping with IQ research [88, 120, 144, 147]. The assessment of IQ ranges across many different sizes and types of IS with the critical concern being the fitness for purpose of the information [15]. Whilst much of the focus for IQ research has concentrated on the accuracy and completeness of data more recently the widespread availability of the internet has being the subject of research [71, 83].

Users are now frequently required to rate the IQ of IS, and the evaluation of IQ via subjective survey instruments is in many organisations progressively deteriorating [42]. Consequently more and more IS resources are required to check perceived IQ deficiencies. Research in recent years has been focused on IQ dimensions and assessment approaches, with some researchers developing an increasing number of IQ frameworks, criteria lists and approaches for assessing and measuring IQ [15]. Several studies have confirmed that IQ is a multi-dimensional concept and consequently IQ frameworks are multidimensional in nature [88, 120, 144, 147]. None the less, research and discussions with practitioners as well as recent studies indicate that assessing and managing IQ in organisations is still challenging [15].

Figure 1.1 illustrates our research problem, where an IS is accessed from three diverse situations, there is a requirement to ascertain if the diverse situation impacts on the IQ. The evolution of new IS situations and its impact on user satisfaction has also been examined with respect to the usability and acceptance of small screen devices such as mobile phones [1]. Similarly our research examines diverse situations and the fitness for purpose for the information post the development of the IS. The importance of the context of data and problem resolution requires that practitioners examine established business rules and reflect on their experiences and use this knowledge to improve IQ as IS evolve [85], likewise our

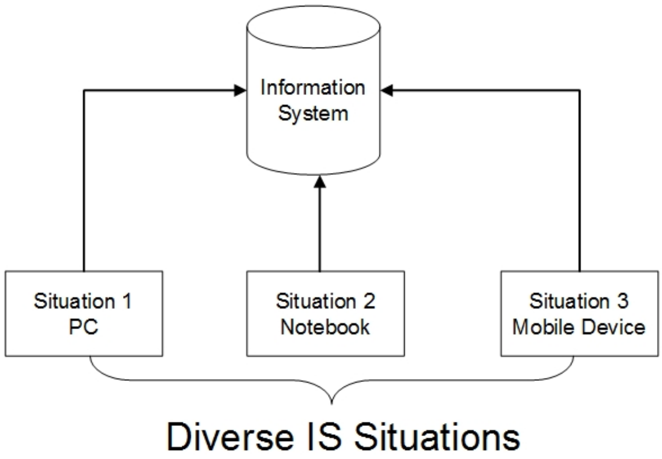


Figure 1.1: Diverse IS Situations

research examines the need to consider the diversity of the IS situation and the assessment of IQ.

Following prominent definition of *"quality"* as *"fitness for use"* [147], most researchers acknowledge the subjective nature of data and IQ. Table 1.1 outlines definitions of IQ from various frameworks illustrating this. Consequently the perceptions of stakeholders are central for IQ assessment. The assessment of the same information from different situations is not specifically catered for with foremost frameworks and assessment techniques. This has presented the challenge of accurately reflecting the IQ of an IS with existing well defined and validated measures across diverse IS situations.

Even though IQ has recently emerged as a discipline, it has already gone through an evolution in scope and meaning. Originally research and practice was concerned with data cleaning, this moved on to prevention of errors followed by viewing information in product terms. Information is now viewed as an enterprise asset that must be of the highest quality and fitness for purpose. Figures 1.2 and 1.3 illustrate the evolution in the concept of IQ and the scope of the challenge [139].

In the following section the research problem addressed by our work is illustrated by an Airline IS. This IS has been in use for many years and different categories of users are required to interface with the IS on a regular basis for

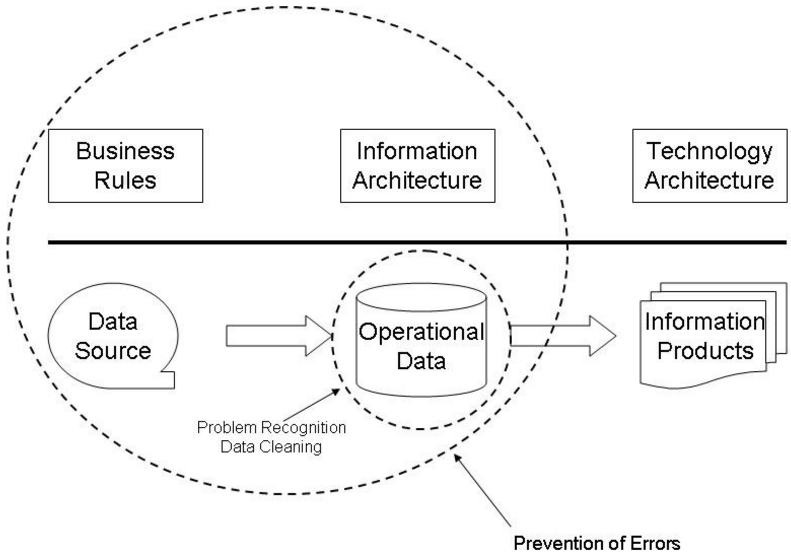


Figure 1.2: Data Cleaning and Problem Recognition [139]

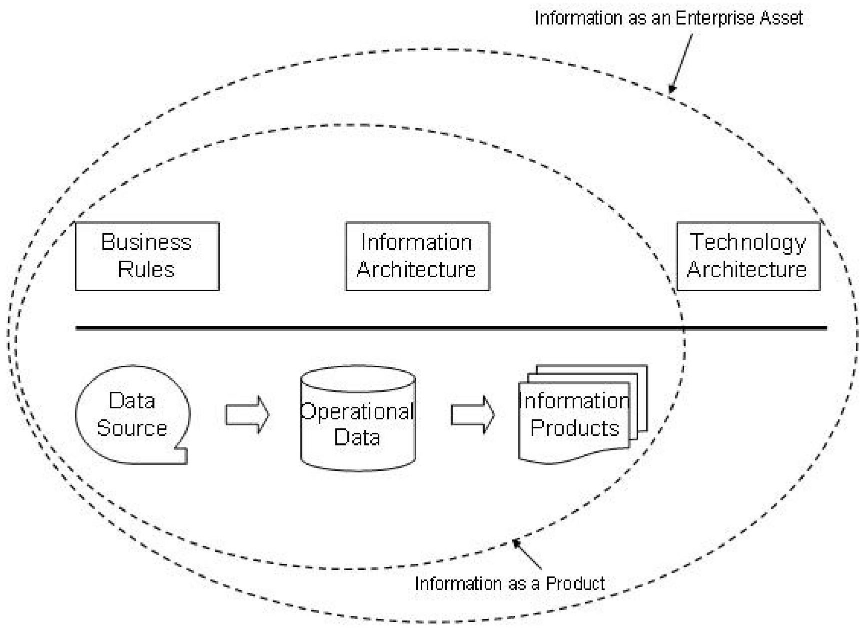


Figure 1.3: Information as a Product and as an Enterprise Asset [139]

Table 1.1: IQ Definitions

Definition	**Reference**
IQ is defined as information that is fit for use by data consumers.	[147]
IQ is defined as the information that meets specifications or requirements.	[76]
Information has quality if it satisfies the requirements of its intended use.	[111]
IQ can be thought of as information's inherent usefulness to customers in assessing utility.	[80]
Information is of high quality if it is fit for its intended uses in operations, decision making and planning.	[122]
IQ is defined as information which consistently meets knowledge worker's and end-customer's expectations.	[41]
IQ is defined as the degree to which information has content, from and time characteristics which give it value to specific end users.	[24]
IQ is the characteristic of information to meet functional, technical, cognitive, and aesthetic requirements of information producers, administrators, consumers and experts.	[43]

the performance of their duties. Pilots, engineers, administrators and technicians have various requirements (quality control and legal) to rate the IQ of the IS against. The MIS (Management Information Systems) department have experienced a dramatic increase for requests to verify IQ of the IS. This has become a very resource intensive exercise with many of the requests, requiring no alteration to data values. Concurrent with the increase in IQ requests the IS situations have also changed. The single point of access via data entry personnel has evolved over time to the point where many users interface with the IS from a number of diverse situations these include desktop PCs, laptops or notebooks and mobile devices over wireless networks. The users are accessing the same information from a range of diverse situations in an ad-hoc manner, but the level of IQ is not uniform across these situations. The dimensions of IQ in Wang and Strongs [147] IQ framework were identified but the true nature of the overall IQ rating of the IS was difficult to measure accurately. The impact of the diverse IS situations required not only a completed analysis but also a mechanism for remedying the situation.

1.1.3 Research Objectives

The literature review outlined in Chapter Two indicates that a considerable amount of research with respect to the IS situation focuses upon the growth in the number of data sources in terms of size and scope [15]. Much of the research concentrates on dimensions such as accuracy or completeness of data [83]. Although the context of information and its use is acknowledged by foremost research as important [85], the impact of viewing the same information from diverse situations has yet to be fully examined. Furthermore the diversity that now exists with respect to access devices and IS needs to be fully examined [107]. Many IS such as the ones associated with our research have been designed, developed, tested and deployed for a particular situation yet they are primarily accessed from a different one. We contend that these changes need to be acknowledged and accounted for when measuring IQ.

The initial observations outlined in our problem statement required further analysis. They indicate that the users perception of IQ is affected by the IS situation, however the particular dimensions and the extent of the effect required examination, consequently we proposed an experiment where the IS situation is varied and its corresponding effect on user perception is measured. The outcome of these experiments formed the basis for our workshop themes with users, where a variety of reasons for poorer IQ perceptions from the mobile situation in particular were addressed.

As technology evolves with more diverse IS situations IQ will become a recurring problem with organisations investing heavily in resources in attempts to improve IQ. A typical suggestion is to improve the data values (e.g. correctness, consistency, completeness, etc.). Despite the investment in IQ and technology, IS users increasingly rank IQ lower [42, 58]. This research postulates that perceptions of IQ may alter as the result of evolving diverse IS situations and existing IQ frameworks should be enhanced to reflect this reality. This contention that IS situations are becoming more diverse leads us to the main research questions addressed:

- What is the relationship between diverse IS situations and IQ?
- How can IQ frameworks be enhanced to cater for this diversity?

Since both IQ and the situation of the IS are in themselves multidimensional and complex concepts, further analysis was required in order to generate a set of questions that allow us to comprehensively address the main research questions.

Many IQ frameworks have been constructed in an effort to offer a definitive set of dimensions that cater for the many aspects of IQ. Seminal work in the area was undertaken in the mid nineties by Wang and Strong [147] who conducted extensive research among practitioners and academics; the culmination of which was an IQ framework identifying independent dimensions, the sum of which is a single measure for IQ. These dimensions have been categorised into four classifications and have formed the basis for much of the research in the area of IQ.

This IQ framework is widely used today and much of the subsequent IQ research have their origins in this piece of work [15, 41, 116, 145]. Table 1.2 outlines the dimensions identified together with their classification. The IS situation like IQ is comprised of a number of factors: including users, the role group, and the

Table 1.2: Information Quality Framework [147]

Intrinsic	Contextual	Representational	Accessibility
Believability	Value Added	Interpretability	Accessibility
Accuracy	Relevancy	Ease of Understanding	Access Security
Objectivity	Timeliness	Representational Consistency	
	Completeness	Concise Representation	
	Appropriate Amount of Data		

interface including access devices. The situation of the IS also requires analysis in order to ascertain the true nature of IQ for an IS. This multi-dimensional nature of the definition of IQ and IS situation also presents us with a number of sub-questions, to be addressed throughout the thesis:

- What is the relationship between IQ dimensions and the IS situation?
- How does a variation in an IS situational factor affect IQ?
- How can existing IQ frameworks be enhanced and extended?

1.1.4 Thesis Organisation

Chapter Two will outline in detail the literature review. IQ definitions, analysis and measurement are examined with an emphasis on their robustness and ability to adapt. This is followed by an analysis of the most prevalent IQ frameworks and methodologies. The research conducted by the IS community and others addressing the problems associated with IQ are also examined in the context of diverse IS environments and IQ.

Chapter Three will discuss and defend the research methodology adopted. Design Science is the chosen methodology, and we outline a justification for this choice. A number of approaches were adopted; experimental, method engineering and action research. These are explained and justified in the context of our research.

Chapter Four will outline an experiment that we conducted with a Library IS. The purpose of the experiment is to test the hypothesis that the perception of IQ is affected by diverse IS situations namely the access device. This is broken down into a number of sub-hypotheses where individual dimensions are further examined. Standard statistical techniques are employed to analyse the data and a rationale is offered for the adoption of particular techniques.

Chapter Five will describe the design and construction of our method. We initially describe our application of the Design Science research approach to the problem domain. A detailed outline of how we employed method engineering to construct a meta-model that caters for diverse IS situation analysis of IQ then follows. Those individual businesses processes required to implement our meta-model, via a comprehensive method, are then proposed. It allows those who are required to analyse IQ; a method that caters for diverse IS situations.

Chapter Six will outline the evaluation of our method. This is completed by examining the practicality of our artefact. An action research approach is adopted where we employ Susman and Evered's model [138] to evaluate the utility of our method. Both role group gap and situation gap analysis are also completed.

Chapter Seven will provide an evaluation of our work. Limitations of our research are outlined, and the novelty of the method and its relevance to IS as a research field is also discussed. We also outline the particular significance of the research to IQ. Finally we set out our conclusions and future research opportunities that potentially may be of use to both practitioners and academics alike. Possible commercial applications of our research are also discussed.

Figure 1.4 illustrates the sequence of the thesis along with the topics associated with each of the chapters.

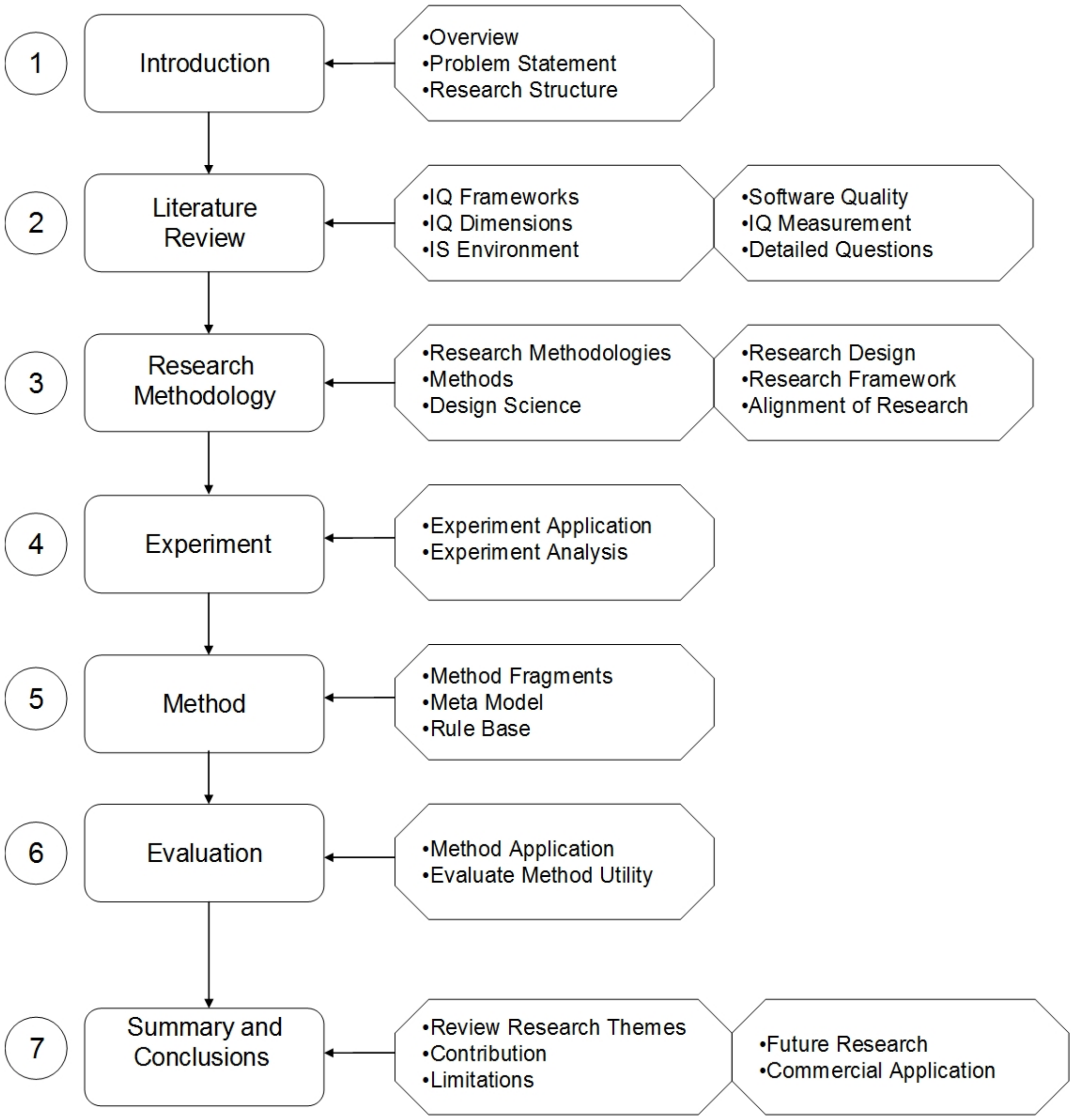


Figure 1.4: Thesis Structure

2

Literature Review

2.1 Overview

This chapter will frame our research within the fields of IS and IQ. In order to conduct academic research in a thorough and professional manner Webster and Watson [150] posit that it is essential that a methodical review of past literature be completed. There is a need to unearth what is already known about a particular field in order to identify gaps in the literature, prior to completing any studies. Hart [63] commenting on literature reviews believes that the emphasis on quality is also important; it must be of enough breadth and depth; contain rigour, consistency, clarity and brevity and critically contain effective analysis and synthesis. The literature review must provide a solid framework for advancing the body of existing knowledge. The literature review must facilitate the development of theories and have the potential to close a plethora of open questions while at the same time open many new avenues for future research [150]. Levy et al [89] suggest that an effective literature should have the following characteristics.

- Methodically analyze and synthesize quality literature
- Provide a firm foundation to a research topic
- Provide a firm foundation for selection of research methodology
- Demonstrate that research contributes to the overall body of knowledge

As the field of IQ research encompasses a number of disciplines, our literature review will initially examine IS as a field of research with an emphasis on how software quality emerged as an important field of research, and more recently how the IQ domain has become established as a distinct area of research in its own right. These theoretical explorations will then be followed by a discussion of the challenges facing IQ research. The approaches employed to classify and quantify IQ are then examined. Discussing the pervasiveness of the phenomenon and examining how it impacts on many diverse areas of IS research. The literature review then concludes by examining the challenges posed by diverse IS environments to the central research question the challenge of measuring the relationship between diverse IS situations and IQ. Models such as DeLone and McLean [39] that measure IS service are extensively employed in practice focusing on service success and dependent variables, but do not specifically consider the impact of the evolution of diverse situations and environments.

The rapid advances in wireless network deployment combined with the ubiquitous nature of mobile access devices makes consideration of this literature a very real requirement in order to understand diverse IS situations and environments.

2.2 The Perpetual Evolution of Information Systems

Much IQ research finds it origins in IS research and has over the last fifteen years has become an established discipline in its own right. The demand for information and the insatiable desire for instantaneous timely delivery are now a very real imperative. The fact that ninety three per cent of corporate documents are created electronically has brought this into the focus of many researchers within IS, but also from many other disparate disciplines [42, 46]. The interest of the research community in IQ is increasing across a range of IS; with recent work from a range of disciplines placing IQ at the research's centre [65, 78, 93, 148].

Electronically generated information is now performed by more people, and used for more tasks and decisions than ever before [42]. This continuous growth and technological development will ensure that more users will demand this information. The constant need to redesign and rebuild IS as a direct result of advances in technologies such as hardware, networks, communications technology and software. This also creates budgetary pressures with IT departments required to devote significant amounts of resources to cater for this constant desire for information [111]. This cycle of innovation, technological change and IS obsolescence is a major challenge that faces many organisations directly or indirectly; it is perpetual. No organisation has managed to keep fully abreast of these advancements.

Simon [132] suggests that the advent of IS over half a century ago promised much with respect to optimisation of business processes and reduction in the vast amounts of associated paper work. At the meeting of the American Management Association in 1950 it was predicted that organisational tasks, financial planning and forecast analysis would be entirely completed by digital computers [34].

The evolution of IS has not negated the need for expertise in these areas but the successful completion of the multitude of associated tasks is heavily reliant on the electronic information generated by IS. The day to day running of organisations, from strategic planning to operational management, all rely on IS. The advent of widespread internet access and the ability to conduct commerce on a large scale on-line has added further to IQ problems. The advantages of pushing IS into more and more business processes is a compelling argument [34]. However despite forty to fifty years of IS experience, organisations in many cases are less satisfied with the information that they obtain from these systems. This is despite the constant improvement and refinement of the processes that are involved in analysing, constructing, testing and maintenance of IS [46].

Advances in IS also reflect the environment in which they operate, business and commerce is a dynamic and therefore IS must reflect this dynamic [91]. Changes to tax laws and accounting standards for example are constantly introduced; these changes are generally required in a short period of time, in many instances not allowing for the complete software development lifecycle. This can become a very expensive process as in many cases the software development requires a complete revisit at a later date, leading to an IS not reaching the end of a life-cycle and becoming a legacy system, which are costly to maintain and can dictate the business rules of the organisation [117]. The ultimate desire for quality information eventually forces many organisations to reengineer their IS, this but rarely if ever provides for information of the desired quality. In many instances the development of a new IS becomes the only option.

The planning for enterprises at all levels is intrinsically linked to IS, and a failure to have a coherent strategy leaves an enterprise at a distinct disadvantage to its competitors. Whilst IS were initially considered as enablers for an enterprise, they have within a comparatively short period of time become intertwined in every section and at every level of an enterprise. Ward and Peppard's model [149] in figure 2.1 illustrates the relationship between business strategy, information technology strategy, IS architectures and processes and organisational structure. The pervasiveness of IS influence and direct impact on IQ is across the entire organisation not just an information technology management process.

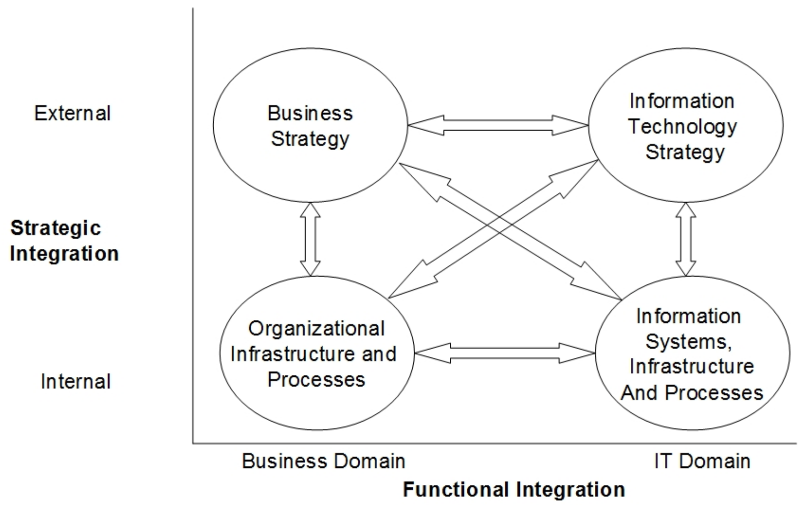


Figure 2.1: Information Systems and Business Strategy [149]

Initially the deployment of IS, catered for the production of large banks of information in a relatively short time period compared to manual systems [115]. The availability of this information soon conferred commercial advantage to those organisations that invested in this new technology [94]. The novelty of large banks of information was in itself regarded by many as a phenomenal progression [132] radically altering how commerce would be conducted forever.

The organisation, control and development of these new IS evolved in an ad-hoc manner; early attempts to put a structure around them involved mainly accountants and computer specialists. The focus of these professionals was on what reports could be produced and what parts of the enterprise could employ these reports. The concentration of their efforts was on the production of the information, rarely if ever according to Simon [132] were questions such as *"What will the recipients of our reports do with them?"*, or *"How are the data in these reports relevant to the decisions they have to make?"* ever asked. This led to some disillusionment with IS, there now existed vast amounts of information but no clear method for the mapping of this information to the needs of the enterprise.

The IS revolution has impacted on every facet of the modern enterprise, prompting research in many areas. Technical approaches to IS research include management science, computer science and operations research while behavioural approaches can include psychology, economics and sociology. The technical approaches emphasizes mathematical models to study IS along with the physical capabilities of the infrastructure and technology. The behavioural approach has recently become a central tenet of much IS research, with many arguing that it is absolutely essential as these systems have become socio-technical systems [34].

The value and need for information and the associated IS has also been recognised by government, there now exists much legislation and standards to ensure information is protected and preserved in an integral manner [109]. This has resulted in large amounts of information being kept for longer periods of time, the challenge to maintain the information, while at the same time generate business intelligence is significant. Although many large corporations have introduced bespoke lifecycles in reaction to government legislation, a major challenge exists for small to medium size enterprises where the same level of infrastructure and support are not available. There is an argument proffered by some that modern IS are so complex and in many cases cumbersome in their operation that accidents and errors are simply unavoidable [42]. The level of importance attached to electronic information generated by IS warrants a comprehensive examination, this involves more than just the development of the software for IS. In the next section we outline how the IS environment has undergone transformation with particular attention on IS access and diverse situations.

2.3 The Evolution of Diverse IS Situations

IS situations have in recent years undergone radical change [2, 36, 60]. Advances in technologies have had far reaching ramifications beyond the actual devices allowing access to a vast range of systems and services. Some of these systems are designed specifically for these new technologies, however many are required to interface with a myriad of legacy systems. This evolution of access has ensured a far wider audience for IS, which when combined with advancements in wireless technologies, broadband, user proficiency and relatively cheap hardware has led to an insatiable demand for access to more information from diverse situations. These advancements do not negate the necessity for high quality information; however the relationship between the IS situation and IQ is now more important. Not only must there be validation of data from these many disparate sources [15] but account of the new diverse situations must also be considered.

The initial design of an IS allowed software developers to test the quality of user access in a relatively straightforward manner. The consistent nature of IS access device catered for this at the development stage of the IS. The process allowed for iterative consultation with users, the construction and reconstruction of prototypes and extensive testing of the chosen IS access method [117, 133]. However this is no longer the case for many IS, where the possibility now exists that multiple access devices and methods may be employed to access the same information. The relationship between this new reality and IQ requires examination. Workstations, client-server configurations, internet and mobile access are among the various methods that may now be employed. Associated with these are also a multitude of software services and user interfaces.

Diverse IS situations can also be classified according to their software architecture, which has been described as the "functional appearance" of the computer, or *"what should it do"* [112]. Various layers are associated with the architecture, these can be defined in terms of rules or protocols and topologies. The Open Group Architectural Framework has described it as a *"set of elements, depicted in a model, and a specification of how these elements are connected to meet the overall requirements of an IS"* [141]. Software architecture design is distinct from module or algorithm design, it endeavours to ensure that best practice prevails in the deployment of IS [112, 142].

This process is conducted at the design phase of many software projects, and allows for the construction of various architectural scenarios. Initially IS can be deployed for a specific scenario but as the IS evolve some of these architectures may emerge in ad-hoc manner and require redesign. We describe the user perspective of these different architectures scenarios as diverse IS situations. The IQ assessment associated with a particular IS situation may ultimately lead to enhancements or redesign of architectural scenarios for an IS. Our research examines IS post deployment that in many instances the user has no input to or control of.

The growth in use of mobile device has in just over a decade and a half reached market penetration of 90% in most developed countries [32]. These devices were initially used for voice communication, short message services soon followed, and finally developments in software technologies and data exchange formats in a relatively short time period allowed these device interface with IS. This ability to interface multiple access devices poses many challenges to the designers, developers and users of IS. The ability to access the same information from a variety of diverse situations presents challenges with respect to the measurement of IQ.

The pervasiveness of IS that we have outlined demonstrates the central part that they occupy in the modern enterprise. The quality of their design and operation is now examined. The Compact Oxford English dictionary defines quality as *"the degree of excellence of something as measured against other similar things"*. Quality, in industry terms, as noted by Wang [146] is widely accepted as a conformance to requirements. Where a product has a description of what the consumer needs and when the product meets the consumers requirements it is said to have achieved quality. We analysed this definition from the broad perspective of software quality where many of the concepts such as quality frameworks and process models are also to be found among the IQ community. An in-depth examination of IQ concepts reveals how frameworks and models have been employed to varying degrees of success. We place IQ research in terms of the main research issues and application domains focusing on the degree to which diverse IS situation and IQ are referenced.

2.4 Improvement and Usability

When discussing process of improvement it is important to mention some aspects surrounding usability and accessibility. While not being an exhaustive review there are some particular areas in the author′s opinion worth mentioning.

Early usability concerns argued that usability is fundamentally concerned with raising the level of abstraction of the user interface in an appropriate and coherent manner - with the emphasis on appropriate and coherent [35]. In the early 1980's attention was focusing upon improving user interfaces, semantics and handling new types of data. Curl et al [33] investigated the effect of individual differences and spatial visualisation on database query performance. Their evidence, which was theoretically derived and empirically tested, suggested that database navigation is spatially oriented much like geographical navigation, and subjects, using a spatial database view performed better than those who didn't.

Jagadish et al. [74] assert that the usability of a database is as important as its capability. They investigate, through large industry case studies, why database systems today are so difficult to use, and explore a variety of ways to query databases such as queries, keyword search, and natural language search. They conclude that difficulties in database interaction cannot be fixed simply by improving the query interface. They argue for a rethink of database architecture as a whole and suggest a framework comprising of a presentation data model as a distinct layer above the usual logical data model.

2.5 Software Quality Research

The need for quality was recognised from the earliest stages of software development [8]. An examination of how software quality has evolved demonstrates a move towards a more user centric approach. The necessity to examine quality beyond the functionality of the software has become the central focus of many software development methodologies [22, 40, 69, 119]. Similarly the necessity to examine more than just data values in IQ has also become very important. The move towards user centric approaches in software quality facilitates a comparison of how the IQ research community have moved beyond the traditional data approach to measuring the correctness of data values [147]. It is within this context we examine process improvement frameworks such as the capability maturity model [130]. The importance of quality in the software process has seen the development of maturity models where organisational processes and procedures associated with the development of software are assessed for their maturity, similar approaches have come to the fore in IQ research [123, 127, 130].

The evolution of technology and concepts follow a distinct pattern; theories and concepts are presented and eventually become formalised and put into practice; followed by deployment and refinement. An initial phase of acceptance of new technology precedes issues with respect to quality. An examination of the development of IS clearly demonstrates that early attempts to formalise and establish quality processes also came post their deployment [101]. Initial attempts at putting some flow or structure on computer programmes stemmed from problems directly associated with the quality of output. The over reliance by programmers on the GOTO statement led to unmanageable programmes, and efforts at placing structure and design in a formal way commenced. A process of rooting out spaghetti code and replacing it with structured programming then began [64]. This in turn motivated researchers to put in place processes and procedures that would lead to the elimination of programming errors prior to software development. The concept of structured flowcharts was another effort at improving software and ultimately the output from IS. Formal design and outline in a structured process it was argued would lead to common set of standards universally understood by the software development community [106]. Structured programming was the first of many techniques aimed at improving quality, and many more followed such as data validity checks, check digits, test and conversion strategies, inspections and computer assisted software engineering tools [46].

There has also been in recent years a very conscious effort to place the user at the centre of the development process, leading to the development of processes such as Rapid Application Development and Joint Application Development [128]. The concept of usability and how it aims to achieve improvement by placing the user at the centre of the process is central to these processes, as the requirement to manage not only the process of development but also the management of the quality process. A fundamental assumption of quality management is that the quality of the development process directly affects the quality of delivered products. Process quality management involves defining process standards, monitoring the development process and reporting the software process to project management [22, 133].

Processes associated with the development of software have also become more sophisticated and again the aims of these refinements is an improvement in quality. Research has led to the evolution of techniques for application development often modelled on engineering development processes. For instance the concept of statistical quality control introduced to the Japanese car industry after the Second World War is based on the measurement of product defects with respect to the process. Its aim is to reduce the number of product defects by improving the process until it is repeatable [133], and the process then becomes standardised and further improvement can commence. Process improvement and negating the necessity for mass inspection are core concepts that led to the success of process improvement in the car manufacturing industry [143]. The application of these techniques in the field of software development are not as tangible as those in manufacturing [117].

Figure 2.2 below illustrates software processes that are in existence across organisations; they can be very informal in nature, managed or be methodically employed. There are a range of tools that can be associated with them.

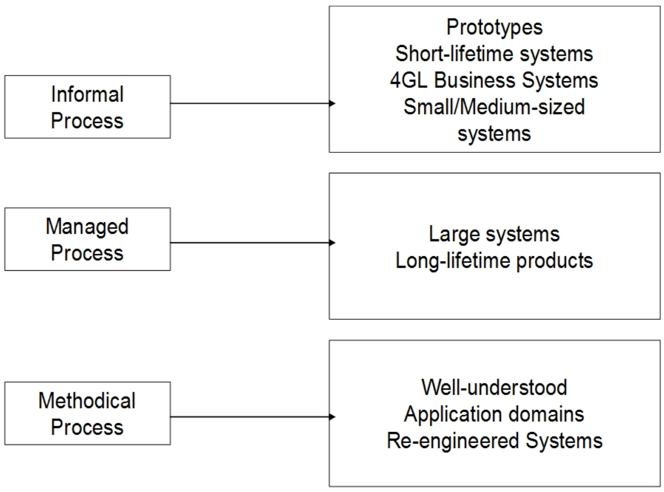


Figure 2.2: Software Process Improvement [117]

The optimisation of software processes requires that they are measured; which in itself is not an easy task because identifying exactly what to measure is not always tangible and hence not straight forward. The Goal Question Metric (GQM) [11] attempts to overcome this problem by identifying what measurements should be taken and how they should be used. This approach uses metrics to improve the software development process while simultaneously maintaining alignment with organisation business and technical goals.

The key concepts involved an examination of the organisations products, processes and resources. The model also attempts to examine the software process as it pertains to the organisations goals, followed by the identification of appropriate metrics to measure how successful the achievement of the identified goals are. This paradigm therefore can be viewed as an acknowledgement by the software engineering community that the success of software implementation is not the exclusive remit of the software developer [117].

2.6 Process Improvements Frameworks

The pervasiveness of software and the constant striving for a higher quality product prompted software engineers to further collaborate. The need to improve the capabilities of the software industry as identified in the US software industry led to a formalisation of collaboration groups. The constant motivation was the need to improve quality. The Software Engineering Institute (SEI) was formed at Carnegie Mellon as a direct result of quality issues with software development. The mission of SEI is to advance software in order to provide it in a more reliable and predictable manner. The SEI from its establishment in 1984 identified that the key to success was to work in close cooperation with the wider community to improve software. This was a further acknowledgement that the achievement of quality software is not possible without a wide engagement of interested parties.

2.6.1 Capability Maturity Model Integrated - CMMI

The CMM was first introduced in 1993 and has undergone many refinements since. Building on the concept of process improvement the SEI established a very detailed model that allowed for an analysis of the processes employed in the construction of software. The model was expanded to include the plethora of ancillary processes associated with software, not merely its development. These include project management, people management, procurement, system engineering, software maintenance, risk management and many others. Emphasis is placed on the quality of the process of development or completion of the software. The aim of these not insignificant processes is to improve overall quality. Its impact on the software engineering community has been significant; customers seek out software companies that have obtained CMMI certification [31]. Many government contracts, especially American Defence ones now include this as a standard requirement [130].

The model further recognises that all processes in an organisation may not be of a standard level of quality and provides a mechanism for measurement of multiple processes thus allowing an organisation to measure quality and strive for improvement. These processes are generic in nature not technical but are associated with the institutionalisation of good practice. The initial version of the model set out six levels of competency ranging from level zero where no formal processes exist to level five where a very proactive set of processes exist with respect to software development [153]. The levels in the model are progressive and allow for an organisation to aim for improvement. The SEI is very aware that many organisations only engage with the framework when severe problems of quality present themselves.

The model is very comprehensive in nature and over its lifetime has significantly evolved with some 24 process areas and over 1000 pages of description. This has led some to view the model as overly cumbersome and critical of the practical implementation in anything other than very large enterprises [73]. The complexity of the model requires that staffs are properly trained in its application, this is expensive and consequently some organisations do not employ it. Also some organisations it is argued merely seek to comply with the framework in an effort to obtain software contracts, they do not engage with its spirit and ethos [73]. Even though the framework allows for measurement the true nature of the quality of the product may not always be accurately reflected.

2.6.2 Software Quality Standards

In addition to the evolution and refinement of software development methodologies, software quality standards have emerged in an attempt to ensure best practice is achieved regardless of the development methodology employed. A number have been developed including IS0 9126, IEEE 730-2002 and ISO IEC 8631[133].These afford procurers of software a degree of reassurance with respect to the quality of the processes and procedures employed in the development of the software. Theses standards provide for the measurement of quality factors for each phases of the software development lifecycle. The overall goal is to produce reliable software that meets the requirements as provided for by the user.

The quality factors that are measured by these standards include security, reliability, consistency, maintainability, testability and portability. These are predominately concerned with the software prior to and immediately post deployment. Metrics have been developed for these factors that are of both qualitative and quantitative nature.

One such standard is International Standards Organisation ISO 9126. This work build on models designed by Mcall and Boehm [117]. The standard is comprised of four parts; quality model, external metrics, internal metrics and quality in use of metrics. For example part one outlines six main quality characteristics of software:

- Functionality: In essence this measures the purpose of the software and the existence of the functions can be measured in a Boolean fashion for existence or otherwise.
- Reliability: This can allow for a measurement of acceptable levels of fault tolerance and systems recovery.
- Usability: The ease of use of the IS for a given function and the ability to learn the operation of the system by the user can be measured during user acceptance testing.
- Efficiency: The efficient use of IS and computer resources with respect to memory, hardware and performance can be defined and tested, for example the amount of time or resource required to process a data set.

- Maintainability: The ability to identify and rectify faults, this is directly related to readability of code as well as complexity of module design along with the ability to verify and test the system.
- Portability: This characteristic is affected by module design and their ability to adapt to new and evolving environments. The ability to reuse modules is greatly enhanced by tightly written modules and object oriented design.

It is argued that employing the ISO 9126 or other quality models brings greater clarity of purpose and operating capability [7].

2.7 Overview of Information Quality Research

Our review of the software engineering literature has revealed that this community addresses quality at each stage of the software development life-cycle. However the fitness for purpose of the information, post development, is also a very real concern [42, 120, 135, 147]. In our examination of IQ research we focused on the definitions, classifications, frameworks and assessment of IQ. We compared the various approaches and techniques through out the IQ life-cycle, where we are primarily concerned with the manner by which they cater, if at all, for the assessment of IQ from diverse IS situations.

IQ research encompasses many areas of research which in the past may not have been classified strictly as IQ research. This research is therefore reviewing a broad body of research from many disparate IS subject areas. IQ research finds its origins in the areas of statistics, management and computer science. Statisticians in the 1960s proposed mathematical models for identification of duplicates in large data sets; this was followed by researchers in the field of management in the early 1980s who focused on the quality of information from a manufacturing systems perspective. The early 1990s heralded the advent of IQ as a field of research in its own right; computer scientists began considering problems associated with definition, measurement and improvement of the quality of electronic data stored in databases, data warehouses and many other systems [16]. Figure 2.3 illustrates the overlap between distinct disciplines and IQ, our research is applicable in these environments as we are concerned with the diverse access to IS, which is not confined to any particular discipline as outlined in our discussion of the pervasiveness of IS. We contend that there is a requirement to facilitate IQ measurement from diverse IS situations in these disparate disciplines.

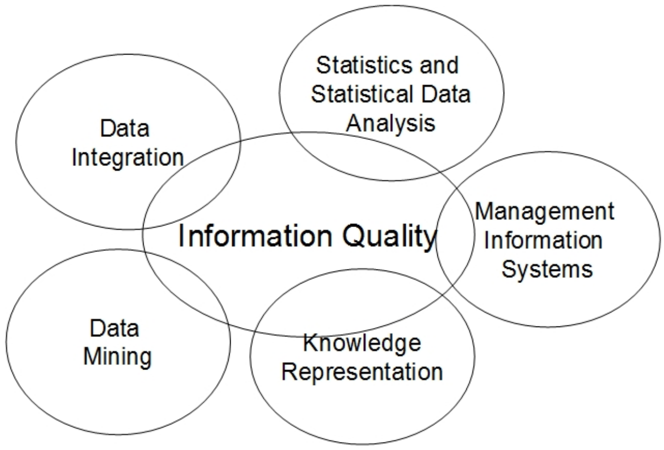


Figure 2.3: Research Areas Related to IQ [16]

Madnick et al [96] contend that the field of IQ research can be classified into four areas:

- Definition
- Measurement
- Analysis
- Improvement

These areas utilise the continuous data quality improvement cycles from the Total Data Quality Management (TDQM) framework [95]. Under these headings research is said to either, define concepts or terminology, measure information quality of a particular information system, analyse results from empirical studies or improve IS. Concepts and terminology have been refined from early intuitive based research, whereby attributes important to data consumers have superseded earlier findings [120].

Early definitions of IQ emphasised quality as fitness for use from the data consumer's viewpoint. Dimensions of data quality, according to this definition, were identified through the implementation of a systematic two-stage survey and two-stage sorting phase [147]. Factor analysis was performed on the results of the survey to reveal key quality dimensions which were then categorised into four data quality categories, accessibility, contextual, representational, and intrinsic illustrated in table 1.1 (page seven). Kahn et al. [77] point out that while fitness for use captures the essence of quality information, IQ in itself is an inexact science as it is difficult to measure quality in such broad terms. Previous studies such as Pipino et al.[116], have also confirmed that IQ is a multidimensional concept that leads to the area of IQ measurement.

A citation relationship between IS research and IQ research as illustrated in figure 2.4 enabled us to place our work in context. Building on work completed by Ge [58] and following a visualization and timeline approach we expand the citation map. We illustrate the citation relationships between the prevalent and most referenced literature. There are a number of seminal papers that researchers in the IQ community have referenced in particular Wang and Strong [147] along with seminal papers in the IS field. The citation relationship clearly demonstrates interdependence between IQ and IS research and the significance of the dimensions in Wang and Strongs [147] IQ framework, were examined in terms of assessment across domains.

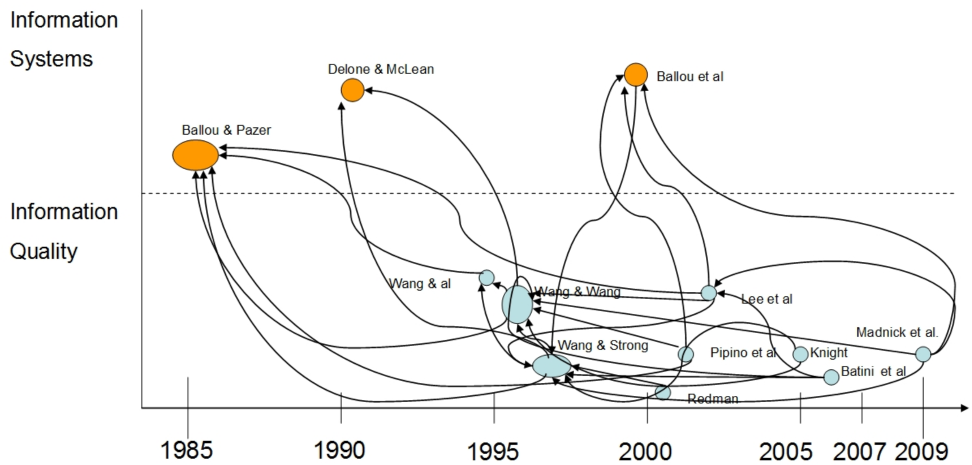


Figure 2.4: Citation Relationship IS and IQ - Extension of Ge [57]

These separate disciplines involve the study of many application domains including life sciences, health care and e-government. The widespread introduction of e-government across many countries has pushed the issue of IQ to the fore. These systems involve multiple databases managed by a myriad of government agencies and departments that in many instances have no history of collaboration let alone a formalised approach to process and systems integration. This expansion of IS deployment in conjunction with the need for IQ measurement across a multitude of domains provides the basis for our examination of IQ and diverse IS situations. We examine how current research has tackled the problem from the perspectives of IQ frameworks and dimensions, models, measurement and improvement techniques, measurement and improvement tools and frameworks, and methods. Batini et al [16] illustrate the relationship between research issues and application domains.

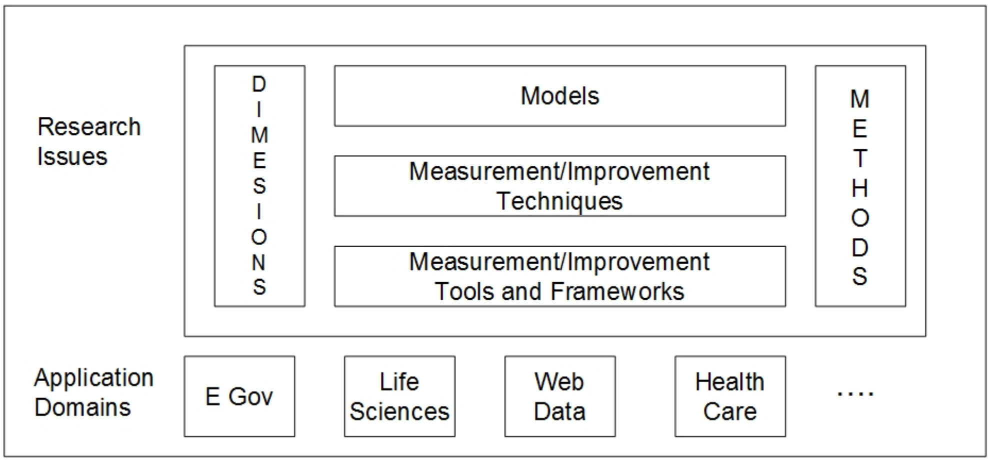


Figure 2.5: Research Issues in IQ [16]

A considerable body of research [15, 98, 131, 147] has been conducted with respect to both IQ dimensions and IQ frameworks, many of these aspects have been examined and consolidated. The research concerns models, tools and techniques making it a multidisciplinary area of investigation. Several real life topics and application areas are involved including life sciences, financial systems and the rapidly expanding area of health care systems [16]. A common theme across much of this research is the fact that IQ is a multi-dimensional concept. A review of theses places our research across application domains and the key measurement models and techniques. We focus on the enhancement of measurement and improvement techniques for diverse situations and in particular its importance to application domains. We examine IQ frameworks, dimensions and their relationships.

In our research the IQ dimensions are examined with respect to their frameworks with a particular focus on the IS environment and situation. Wang and Strong [147] have defined data quality dimensions *"as a set of data quality attributes that represent a single aspect or construct of data quality"*. This research initially examines some of the more widely used frameworks with a view to ascertaining the extent to which IS situation and environments are considered.

IQ research can be classified [58] by three approaches: intuitive, theoretical and empirical approach. The intuitive approach is based on the researchers experience or intuitive understanding about what attributes are most important, and this will vary depending on the area of research. For example in the area of accounting, reliability is a key attribute in studying IQ [82]. The theoretical approach focuses on how data may become deficient during the data manufacturing process. Wang and Strong [147] point out that although this approach is recommended there is limited empirical evidence. Wand and Wang [144] use an ontological approach in which attributes of data quality are defined as deficiencies between the real world system and the IS.

Wang and Strong [147] also contend that both the intuitive and theoretical approaches are inadequate for improving IQ as they fail to consider the concept from the information user′s perspective. This has led to the development of the empirical approach, where the views of the user are collected and the data analyzed with respect to the information′s fitness for use. The empirical approach put forward IQ dimensions that are of concern to the user. Both Wang and Strong and Kahn et al [76, 147] are examples of frameworks that are empirical in nature.

Ge and Helfert [58] have reviewed this area of the literature and have concluded that each of the approaches can be viewed from a data perspective for the intuitive approach, from a real world perspective for the theoretical approach and from the user′s perspective for the empirical approach. Figure 2.6 illustrates this. Each approach has its own merits, the data perspective allows for objective measurement of IQ that in most instances can be automated. The view of IQ from a real world perspective enables it to be considered as a product that also allows for objective measurement. The main drawback of these approaches is the lack of user input; therefore from a user′s perspective the empirical approach has much to offer.

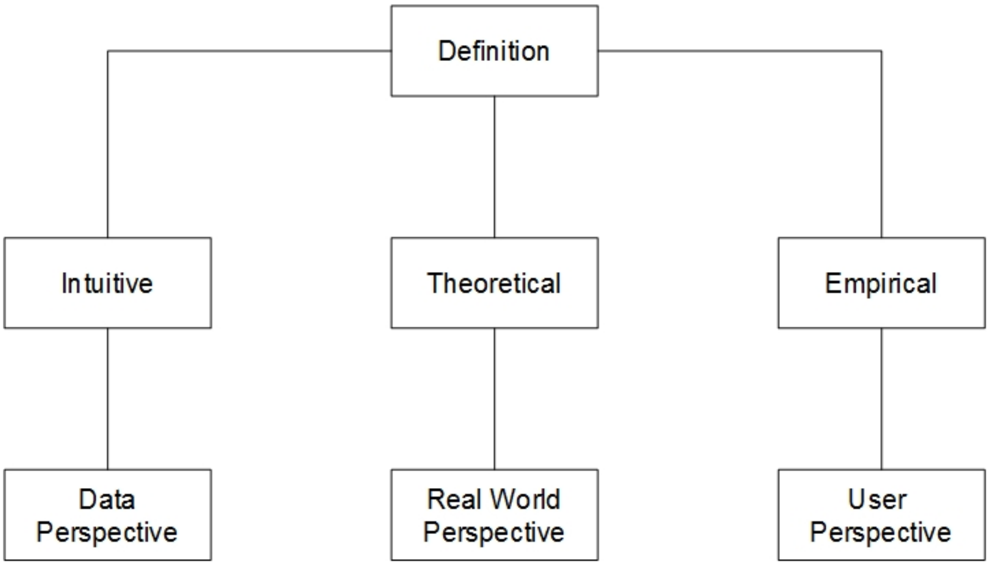


Figure 2.6: IQ Perspectives [58]

Pipino et al [116] suggest that IQ can also be classified in terms of assessment as either being subjective or objective. Subjective measures are concerned with the user and stakeholder opinion while objective measures analyse databases for consistency and integrity. The stakeholders of the IS assess IQ as it pertains to their roles [140]. The expectation of the user is central to this approach. The diversification of IS situations has the potential to impact on the users expectations of IQ as the technologies of the various situations accessing the data is diverse. It therefore is imperative that this expectation not be overlooked. The difference between the users expectation of the quality of information versus the current quality is measured by survey instrument.

Ge and Helfert [58] further decompose the objective assessment into two categories: intrinsic and real-world IQ assessment where the intrinsic view examines the quality of the data in the database while the real world view focuses on IQ deficiencies for system design and data production. Objective assessment of the database can be completed automatically via scripts analysing data sets for dimensions such as completeness or accuracy.

Pipino [116] et al contend that best practice should be a combination of both subjective and objective techniques which offer a more comprehensive view of IQ; they provide a framework to combine both objective and subjective IQ assessments. Kahn et al [77] propose the Product and Service Performance (PSP) /IQ model, in which they assign two views of quality: conforming to specifications (objective) and meeting or exceeding consumer expectations (subjective). The diversity of IS situations also require an analysis prior to assessing IQ. Service availability and accessibility are therefore critical and need to be considered prior to subjective IQ assessment. A comparison between both subjective and objective techniques [58] provides us with a basis for assessing best practice for diverse IS situations. Table 2.1 illustrates methods that are associated with objective and subjective measurement of IQ.

Table 2.1: Objective and Subjective IQ Assessment [58]

Method	**Objective**	**Subjective**
Tool	Software	Survey
Measuring Object	Data	Information
Standard	Rules, Patterns	Use Satisfaction
Process	Automated	User Involved
Result	Single	Multiple

2.8 Information Quality Frameworks

The review of the literature presented us with a number of definitions of IQ. Some of these definitions are context specific with a focus on particular applications and domains. Table 1.1 outlines the most prevalent definitions for IQ. They cater for a view of the concept and allow us an understanding of IQ at a high level. These definitions can act as a point of reference for many of the frameworks and that have been developed, with a view to accurate measurement of IQ. The evolution of these definitions reflects the dynamic nature of IS and also highlight the problem of diverse IS situations.

As IS situations have evolved academics and practitioners have endeavoured to facilitate them and present new definitions of IQ that reflect these new realities, this has led to an expansion in IQ frameworks and dimensions. Those who wish to employ the frameworks are faced with the challenge of framework validation as it pertains to a specific situation.

IQ has been investigated for many years and numerous frameworks and criteria lists have been proposed. Although claims are made to provide generic criteria lists [147], on closer examination most research has been focused on investigating IQ within a specific context. We reviewed prominent frameworks and summarized their application context as shown in table 2.2. This presents a critical challenge for diverse IS situations as the dynamic alters the boundaries of the IS. The need to build or adopt frameworks as IS situations evolve has the potential to dilute the validity of seminal contributions to the field of IQ research.

Analyzing some popular IQ frameworks further as outlined in table 2.3 we discovered a large number of dimensions and criteria associated with IQ. One of the most popular and referenced frameworks was proposed by Wang and Strong [147], and since then has been applied to many contexts and research. This seminal work provides a comprehensive set of dimensions that are applicable to many IS environments and situations. The need to have a core reference point for IQ measurements as IS situations evolve we believe is critical as the practicality of developing more and more frameworks to suit evolving IS situations does not seem feasible.

2.9 Information Quality Assessment

IQ assessment has become more organised and conclusive as the dimensions important to data consumers have been revealed. Pipino et al. [116] ascertain that: *"Experience suggests a one size fits all set of metrics is not a solution. Rather,*

Table 2.2: IQ Frameworks and Context

Context	Reference	Context	Reference
Management	[104]	Knowledge Management	[72]
Databases	[120]	Decision Making	[29]
IS	[102]	Databases	[147]
Information and Management	[37]	Customer Relationship Management	[67]
Data Warehousing	[9]	Finance	[6]
World Wide Web	[83]	Supply Chain Management	[91]

assessing data quality is an on-going effort that requires awareness of the fundamental principles underlying the development of subjective and objective data quality metrics".

Pipino et al. [116] presented three functional forms for developing objective data quality metrics. These are (1) simple ratio, (2) minimum or maximum operation and (3) weighted average. Each functional form is appropriate to a specific quality dimension for example: simple ratio would be applied to the completeness dimension. Also presented are three steps they believe are necessary for organisational data quality improvement. The first step is performing subjective and objective data quality assessments. Secondly the comparison of assessment results, identifying discrepancies and determining root causes. The final step is determining and taking necessary actions for improvement. Pipino et al. [116] also suggest the use of a questionnaire to measure stakeholder perceptions of data quality dimensions lending further substance to this research's initial posit of the importance of an empirical approach.

Kahn et al. [77] presented a two dimensional model to describe information quality, whereby information is treated both as a product and as a service. Information as a product focuses on the activities need to enter and maintain data in

Table 2.3: Selected IQ Frameworks and Dimensions

Framework	**Dimensions / Quality Category**
Wang and Strong [147] (A Conceptual Framework for Information quality)	Believability, Accuracy, Objectivity, Reputation, Value-added, Relevancy, Timeliness, Completeness, Appropriate Amount of Data, Interpretability, Ease of understanding, Representational consistency, Concise Representation, Accessibility, Access Security.
Zeist and Hendricks [153] (Extended ISO Model)	Functionality, Reliability, Efficiency, Usability, Maintainability, Portability
Alexander and Tate [5]	(Applying a quality framework in a Web environment) Authority, Accuracy, Objectivity, Currency, Orientation, Navigation.
Katerattanakul et al. [79] (IQ of individual web sites)	Intrinsic, Contextual, Representational, Accessibility.
Shanks and Corbitt [131] (Semiotic-based framework for IQ)	Well defined / formal syntax, comprehensive, unambiguous, meaningful, correct, timely, concise, easily accessed, reputable, understood, awareness of bias.
Dedeke [38] (Conceptual framework for measuring IS quality)	Ergonomic Quality, Accessibility Quality, Transactional Quality, Contextual Quality, Representational Quality

a database or IS. However, information as service focuses on activities occurring after storage such as obtaining and using information. These treatments are then defined under the two headings Conforms to Specifications and Meets or Exceeds Consumer Expectations as illustrated in table 2.4.

Lee et al. [88] present a comprehensive data quality assessment instrument developed for use in research as well as in practice to measure data quality in organisations. The instrument addresses each dimension with four to five measurable items in a questionnaire. The appropriate functional forms are applied to these items to score each dimension [116].

Analysis interprets measurement results and has improved with the refinement of the previous two areas; define and measure, thereby providing more appropriate recommendations. Lee et al. [88] employ gap analysis techniques to reveal perceptual differences between data dimensions and the roles involved with data. Analysis identifies the dimensions that most need improvement and thus the root causes of data quality problems such as the data quality problem patterns outlined by Strong et al. [136].

Improvements have come about with the sea change in opinions and treatment of information. Action is taken to improve upon processes that produce data as discussed in Ballou et al or as in Wang et al. [9, 145] where the necessary steps, as previously described, to manage information as a product are outlined. Such aforementioned studies strive to achieve the desired result of data which fulfils information consumers needs and complies with quality attributes.

2.10 Developing Research Themes

This literature review has presented a number of issues with respect to the relationship between diverse IS situations and IQ ranging across the main areas of IQ research. Baltini et al. [15] in their comprehensive comparison of methodologies for IQ assessment and improvement contend that the validation of methodologies is an open problem for IQ research. The paucity of research on experiments to validate the different emerging approaches impinges on their feasibility. Our research focuses on methodologies already validated and employed with a view to offering enhancements for diverse IS situations.

Table 2.4: Mapping the IQ Dimensions into PSP/IQ Model [77]

	Conforms to Specification	**Meets or Exceeds Consumer Expectation**
Product Quality	**Sound Information:** Free of Error, Concise Representation, Completeness, Consistent Representation	**Useful Information:** Appropriate Amount, Relevancy, Understandability, Interpretability, Objectivity
Service Quality	**Dependable Information:** Timeliness, Security	**Usable Information:** Believability, Accessibility, Ease of Manipulation, Reputation, Value Added

One of the most widely employed IQ methodologies for IQ assessment is the AIMQ. Critically it adopts an empirical approach placing the user at the centre of the methodology. Our work has the potential to allow for the extension of the methodology by introducing the ability to prioritise IQ dimensions in a dynamic fashion as IS situations evolve. The static nature of the methodology does not cater for the inevitable dynamic that occurs with most IS.

The need to involve the user on a continuous basis is central to IQ measurement. Although the methodology focuses on the user it does not cater for evolving IS that the user may be exposed to in ad-hoc fashion. The AIMQ methodology identifies the most significant dimensions of IQ but does not adequately cater for the either the IS or business dynamic. Adopting a TDQM philosophy our research allows for its extension by providing for a systematic re-prioritisation of IQ dimensions. The need to build a knowledge and rule base of an IS with respect to its IQ is not a feature of existing IQ frameworks. Our research aims to extends this by providing for a knowledge and rule base that over time allow for a more comprehensive and formalised view of IQ dimensions rather than just IQ scores of dimensions. For example the enhancement of the AIMQ methodology by allowing for comparison with objective measures of database integrity.

To fully explore issues raised we adopt an approach employed by Ge [57] where the research is developed along a number of *research themes*, which in turn led to the formulation of specific research questions. Madnick et al. [96] in their comprehensive study of IQ as a field of research provided us with a classification based on TDQM cycle [95] that allowed for the examination of IQ with respect to definition, measurement, analysis and improvement. We also employed this classification, as it allowed us to categorise our research questions into distinct areas of IQ research and enabled us to employ the most appropriate research methods in a holistic manner [86, 87]. Figure 2.7 illustrates these themes which are further elaborated upon below.

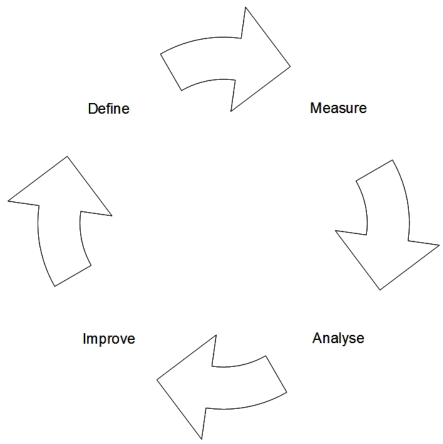


Figure 2.7: Total Data Quality Management [95]

Furthermore, the numerous discussions related to quality show that defining quality is at least as complex as the term information [66]. One approach, which is widely accepted in quality literature, is focused on the consumer and the products fitness for use [75]. This approach comprises of two aspects of quality. (1) Quality represents certain product characteristics, which meet customer needs and thereby provide customer satisfaction. (2) The absence from deficiencies that result in customer dissatisfaction [75]. In general, the first aspect refers to quality of design whereas the second aspect refers to quality of conformance [66]. Quality of design addresses the aspect of information requirements and information product design. How good are the requirements met by the information product design? The conformance of the final information product with the product design is addressed by quality of conformance. Quality of conformance takes the divergence of design with the final product into consideration. Because low quality of design and low quality of conformance have different causes and therefore different solutions, it is fundamental to consider both aspects separately. High quality of design does not mean high quality of conformance and vice versa. Increasing quality of design tends to result in higher costs, whereas increasing in quality of conformance tends to results in lower costs. In addition, higher conformance means fewer complaints and therefore increased customer satisfaction.

2.10.1 Research Theme 1 Definition of IQ

This theme presented three research questions with respect to the view of IQ definitions as put forward in many IQ frameworks as illustrated in our citation map (page 28). We believe that the evolving diverse IS situations challenge the static nature of many IQ frameworks. The citation map also illustrates that IQ literature cites many academic papers and journal articles form the late 1990s, which we felt were worthy of contemporary examination as the diverse IS situations were not as prevalent at the time of their development and deployment. The three research questions we consider are:

- How does an IQ framework definition cater for diverse IS situations?
- How do IQ frameworks consider user perception for diverse IS situations?
- How flexible are IQ framework enhancements?

2.10.2 Research Theme 2 Measurement IQ

The measurement of IQ and the diverse IS environment presented two main questions pertinent to our research. Firstly, the measurement of IQ can be done from a number of perspectives and is in most instances directly related to the choice of IQ framework. Secondly, the measurement of appropriate dimensions and their weighting in particular IS environments form the basis for critical examination. The research questions identified, for this theme are:

- How can IQ measurement be enhanced for diverse IS situations?
- What diverse situational factors need to be considered for IQ measurement?

2.10.3 Research Theme 3 Analyse IQ

The aim of this research theme was to analyse the IQ dimensions that were affected most by diverse IS environments. This included the relationship between various IQ dimensions when a change in IS environment was made. The corresponding effect on other dimensions was also examined. Theme three asked the following research questions:

- What IQ dimensions are affected by diverse IS situations?
- Do weightings need to be assigned to IQ dimensions for different IS situations?

2.10.4 Research Theme 4 Improvement IQ

The aim of this research theme was to examine procedures allowing for improvement and refinement in the application of IQ frameworks with particular reference to the re-prioritisation of IQ dimension selection in line with the diverse IS situations. The choice of IQ framework and dimensions in the traditional IS situation initially may undergo a rigorous selection process, but as the dynamic of IS situations materialises what procedures and processes exist to allow for refinement and improvement? Theme four asked the following research questions:

- How can an IQ be improved for diverse IS situations?
- How can the necessary criteria for improvement be identified?
- What procedures can be put in place to implement new or refined criteria?

2.11 Chapter Two Summary

The central focus of our research is the challenge facing IQ as a result of the diverse nature of contemporary IS deployment. The literature review has revealed extensive studies and the steady development of IQ as a field of research. Many of the solutions that the literature proposes are domain specific, and do not adequately cater for the diverse nature of the IS situations. We have also discovered that there are a growing number of IQ frameworks that are employed to tackle IQ. Initially we found that these were directly related to a specific domain, with some of the frameworks over time being employed across a number of different domains.

The expansion of IQ frameworks, while initially addressing the specifics of new domains, does not fully cater for the new reality of diverse IS situations. The challenge of this diversity we believe demonstrates the necessity to formalise a method that caters for the adjustment and refinement of IQ definition, measurement, analysis and improvement. The software engineering approaches to the improvement of quality have focused on the refinement of development methodologies in conjunction with process improvement frameworks.

The multi-dimensional nature of IQ was also examined in the context of IQ frameworks and their measurement. The challenge of measurement of individual dimensions as they relate to IQ frameworks was also outlined. Our research endeavours to address these multidimensional challenges. We believe there is a clear need for a thorough analysis of IS environments, and IQ. Our research employs Madnick and Wangs [95] TDQM approach for classification of our research themes.

In chapter three we will outline and justify the principle design considerations of our chosen research methodology. We discuss the individual approaches to each part of our research and clearly indicate how this is completed. This includes an analysis of design science, experimental approaches, method engineering and action research. The engineering of a method to enhance the application of IQ frameworks is also a focus of chapter three. The approaches to its design and construction including situational method engineering, method fragment, roadmap and method chunks are explained. We also match the themes outlined in chapter two with the methods identified clearly indicating a systematic approach to addressing our research question.

3

Research Methodology

3.1 Introduction

Chapter Two presented a review of the literature of IQ and IS. This chapter outlines the approaches we employed to address the questions posed by this research. The discussion includes the rationale for the methodology chosen, a description of the methods implemented, the possible limitations of the methodology and individual methods, along with a description of our endeavours to overcome these limitations. In addressing the methodological approaches for this research we examined research methodologies in general, this was followed by an analysis of IS research methods that are appropriate to our research themes as identified in the literature review. This chapter concludes by presenting our research design.

We identified four research themes that provide us with a classification mechanism for answering our research question. Our principal research question asks: What is the relationship between diverse IS situations and IQ? Our literature review suggests there are four ancillary questions that stem from this and the TDQM approach [95] that allows for an examination of the relationship throughout the IQ life-cycle. The four ancillary questions pertinent to our principle research question are:

- How does IQ definition and classification cater for diverse IS situations?
- How can IQ measurement be enhanced in diverse IS situations?

- How can IQ be analysed for diverse IS situations?
- How can IQ be improved for diverse IS environments?

The IQ lifecycle incorporates a disparate range of characteristics that required examination of many aspects of IS in order to answer the above questions. No one approach provided us with all the necessary components to fully and comprehensively answer our research questions. The socio-technical nature of IS [133] challenged us to examine the research question from more than one perspective, primarily because of the diverse number of components that make up most IS.

3.2 Methodological Requirements

As is the case with any formal research activity, a methodology or approach is required that is suited to helping address the research questions. The answering of a research question must be addressed in a rigorous and consistent manner. It can be described as a process, must be careful, systematic, patient study and investigation in some field of knowledge taken to establish facts or principles [84]. We examined a number of fundamental approaches to research; and the following sections outline the essential processes we employed to choose our methods.

3.2.1 A Basis for Inquiry

A thorough understanding of phenomenon associated with the major concepts requires an examination from diverse angles. The socio technical nature of these systems places an onus on the researcher to examine thoroughly the environment that the IS operates in [68]. Researchers of IS face a more complex situation than that faced by the natural scientist, who, as Checkland [27] states: *"plays his game against natures unchanging phenomena"*.

One of the key requirements for this research pertains to the relationship between diverse IS situations and IQ in that the chosen methodology would have to be underpinned by an integrated philosophy of inquiry. At the initial phases of our research this required us to actively engage with IS environments and their participants. This placed an onus on the researchers to ascertain the opinions and attitudes of IS users to operation and application of IQ procedures and frameworks. The examination of the definition and application of these frameworks with respect to diverse IS situations can only be completed by interaction with the user. The subjective nature of quality was also a key consideration for this part of the methodology selection.

3.2.2 Inclusive of All Facets of the Research

The principal research questions and indeed the ancillary questions have an analytical element to them: the how can.. and what are.. questions. These are practical challenges that demand some concrete illustration of the possible outcomes. The research methods chosen for this study needed to be facilitating of this requirement to develop and deploy solutions i.e. (a method to measure the impact of diverse IS situations on IQ) to be iteratively tested and refined as necessary. This further influenced the researchers for the need to include design based research where iterative refinement of technology solutions is a key a methodological approach [10, 31, 70]. In order to further enhance our proposed solution we also conducted an experiment to examine the cause and effect relationship for diverse IS situations and IQ.

3.2.3 Employment of a Research Framework

The focus in the formal research question of this study are principally how and what.. how can.., what are.. The ability to answer these research questions required a detailed examination of the IS environment and its participants. The user involvement with respect to fitness for purpose of information as key indicator of quality is widely acknowledged in the literature [39, 144, 147]. Combined with the necessity to cater for the process of inquiry is the need for flexibility of the research framework to consider the technical nature of IS. The true nature of IQ requires a flexible research framework that is capable of answering the technically orientated research questions. This required us to examine the environment of IS deployment. The necessity of the research to cater for the process of inquiry with respect to the users of IS we believe is not sufficient for examination of the technical aspects of the research problem. These aspects required an environment that allowed for bespoke methods and processes that allowed for an assessment of the impact of diverse IS situations on IQ. This therefore required the application of more than one approach, in essence a mixed method approach.

3.2.4 High Quality Standards

If the outputs of the research are to be of lasting value, the methodologies followed have to have professional credibility [31], and in turn, the rigour of the methodological process would have to be adhered to fully. This would ensure that the research, within the parameters of the (accepted) methodology was valid and trustworthy. The above is not enough though: the issue of the possible limitations of the methodologies themselves (as opposed to specific limitations in applying methodologies in these particular instances) would also need to be adequately addressed, to ensure acceptance of the research among a wider community of peers. The issue of methodological limitations and our efforts to overcome them is dealt with in a later section of this chapter. General methodology considerations and the ultimate selection of specific methodologies are dealt with first.

3.3 Methodology Selection

Research questions can be approached either from a qualitative or quantitative perspective in the main; much of the literature breakdown the individual methods and approaches under this classification. Qualitative research aims to gain insight to peoples attitudes, behaviours, value systems, concerns, motivations, culture or lifestyles. It can be used to inform decision making and policy formation communication and research. Some of the individual methods associated with the qualitative paradigm include focus groups, in-depth interviews, content analysis, ethnography, evaluation and semiotics [31].

Quantitative research refers to the systematic empirical investigation of quantitative properties and phenomena and their relationships. This can involve the generation of models, theories and hypotheses or the development of instruments and methods for measurement. It can also include experimental control and manipulation of variables along with the collection of empirical data [31].

In summarising what methodology is, Manion et al [97] suggest that its aim is to help us understand, in the broadest possible term, not the products of scientific inquiry but the process itself [97]. Methodologies refer to more than a simple set of methods; rather it refers to the rationale and the philosophical assumptions that underline a particular study. Wilson describes a methodology as a set of guidelines which stimulate the intellectual process of analysis [152]. Methodology does not guarantee a solution but it is a structured approach to arriving at one. Any methodology will contain methods or techniques. Manion et al [97] also note that methodology aims to describe and analyse these methods to identify resources and limitations, as well as clarifying presuppositions and consequences.

Methods, as opposed to methodology refers to techniques and procedures used to gather data and include not just traditional positivistic or quantitative techniques and procedures such as eliciting and measuring responses to predetermined questions, but also methods associated with the interpretative or qualitative paradigm. Such interpretative methods include participant observation, non-directive interviewing, episodes and accounts [31]. Method then, refers to a range of approaches to gathering data to be used as a basis for inference, interpretation, and explanation. Importantly, there is a distinction between the tools for investigation (methods) and the principles that determine how such tools are deployed and interpreted (methodology).

3.3.1 IS and Methodology Selection

As an area of research IS has been described as unusual in that it deals with technological artefacts (computerised systems) in a non technological settings (human organisations) [4]. The technological perspective relies on research methods used in similar fields e.g. engineering or the hard sciences such as physics or chemistry, while non-technological aspects call upon methods found in the social sciences. IS research is also multidimensional in nature where approaches include theory building, system development, experiment and observation [99] . In essence IS researchers try to understand and explain what happens in organisational practice relating to IS and also aim to provide, through development a better practice. The relationship therefore between theory and practice is reciprocal in nature with occasionally a lag time between new theories and current practice, the reverse also being true. In both the physical and social sciences this degree and pace of change is not as apparent.

The examination of a particular technical or social aspect of research allows for the choice of a definitive research methodology from either the quantitative or qualtitative perspective. Our research questions required an analysis of existing theories (IQ frameworks) in practice which in turn presented the challenge of an appropriate research methodology that allowed for both interpretative and positivistic analysis. This presented us with many challenges when viewed through the lens of a distinct research methodology; the questions posed by our research required an adaptation and enhancement of existing artefacts. This challenge led us to examine the design science methodology in conjunction with behavioural science, this relationship is illustrated in figure 3.1 below.

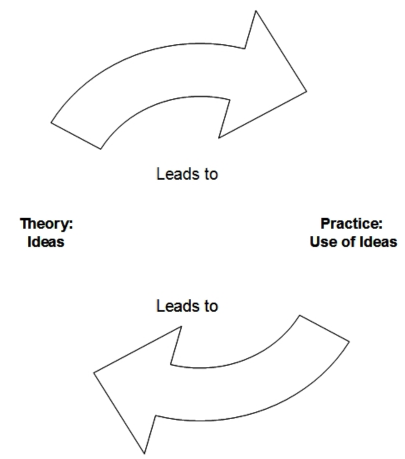


Figure 3.1: Design Science Research Cycle [68]

3.4 Design Science and Behavioural Science Research

Much of IS research can also be classified either as behavioural science or design science. Behavioural science attempts to comprehend reality, this is done by the development and verification of theories that enable an explanation or predict behaviour [68, 114]. Design science on the other hand is concerned with designing and /or changing reality. This can be achieved by the construction of artefacts. It is widely used in the field of engineering where it is an accepted methodology that places explicit value on the construction or design of artefacts to solve a specific problem or research question. A number of IS researchers in the last decade have successfully employed it as a methodology integrating design as part of the research solution [18, 47, 129].

Hevner et al. [68] believe that both paradigms are core to IS research as they address the socio-technical nature of systems namely the confluence of people, organisations and technology. It is possible argue Braun et al. [23] to employ both approaches to research by drawing on the outputs of the behavioural for the construction of artefacts in the design approach. This view is supported by Hevner et al [68] who argue that the two approaches are complementary but distinct in their own right. Behavioural science has its roots in the natural sciences where theories are developed and justified, while in design science an engineering approach is adopted. Problem solving is the very essence of its philosophy. Innovation of products in the broad sense that define ideas through which management of IS can be made more effective and ultimately improved.

Design research is endorsed in the literature as appropriate for the study of IS Benbast and Zmud [21] argue that the *"relevance of IS research is directly related to its applicability in design, the implications of empirical IS research should be implementable, synthesize an existing body of research, [or] stimulate critical thinking"*. The IT artefacts that are the product of design research can extend the ability of people and organisations in solving IS problems and thus add to the greater knowledge of IS as a field of research.

The complementary research cycle as illustrated in figure 3.2 offered an opportunity for us in our research to make a contribution by engaging in the cycle

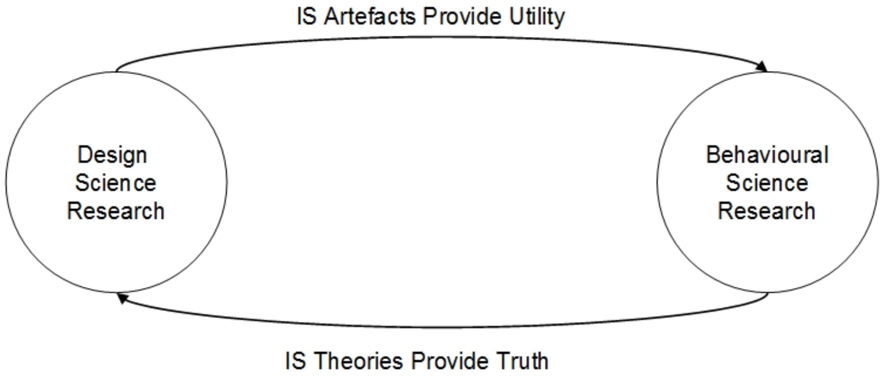


Figure 3.2: Research Relationship [68]

between design science and behavioural science. Our research simultaneously involved an inquiry into IS, and an enhancement of an artefact (IQ framework). This placed an onus on us to complete the enhancement in a methodical and structured manner. The IS examined are socio technical in nature and therefore do not operate in a vacuum, consequently we must examine them in such light and not in a detached manner.

The IS that are the subject of our research required enhancement and improvement of IQ throughout its lifecycle. Behavioural science methods offered us the opportunity to ascertain exactly the nature of the IQ problem with diverse IS situations, while the design science methods catered for the production of an artefact in our case a method and set of associated business processes that enabled application of an IQ frameworks in a diverse IS situations. Hevner et al [68] in simple terms describe the goal of behavioural science research is truth while that of design research is utility. IS research provides the full gambit of methods that can be employed when conducting research from both a behavioural science and design science perspectives which is illustrated in table 3.1.

The research questions and themes identified in our study require data that is both quantitative and qualitative in nature. Benbast [20] points out that no one single method can be considered superior to another. All methods have strengths and weaknesses the key imperative is the appropriate application of the method in order to answer the research question. It is also important that IS researchers understand the fundamental link between business strategy and IT

Table 3.1: Research Methods

Empirical Methods	**Constructive Methods**
Observation, Document Analysis, Ethnography, Exploration by means of case and field studies, Ex post descriptions and interpretations of real facts, Research through development, Reference Models, Surveys, Interviews	Action Research, Argumentative, Deduction, Development of Prototypes, Creativity Techniques, Modelling, Simulation, Futurology

strategy, this is becoming more and more important as more and more business processes require IT infrastructure for their successful completion [128].

3.5 Research Framework Selection

Peffers [114] have completed an extensive review of Design Science and its application in IS research; with a view to offering guidance on its application. They propose and develop a methodology for the production and presentation of Design Science research in IS. A key consideration of this methodology is an outline of the difference between it and other research methodologies. *"Where as natural sciences and social sciences try to understand reality, design science attempts to create things that serve human purposes"* [114]. Figure 3.3 illustrates possible entry points in the Design Science process. In our research we propose a method that enhances the application of IQ frameworks, following Peffer's model we enter the research process at the Design and Development stage. Prior to the design of our method we also demonstrate the phenomenon via an experiment outlined in Chapter Four.

Hevner et al. [68] present a conceptual framework as illustrated in figure 3.4 and set of practice rules for IS research combining behavioural science and design science paradigms. The complementary research cycle offered by this framework has at its core the confluence of systems, people and technology. This framework not only allowed us to position our research and identifies the appropriate methods

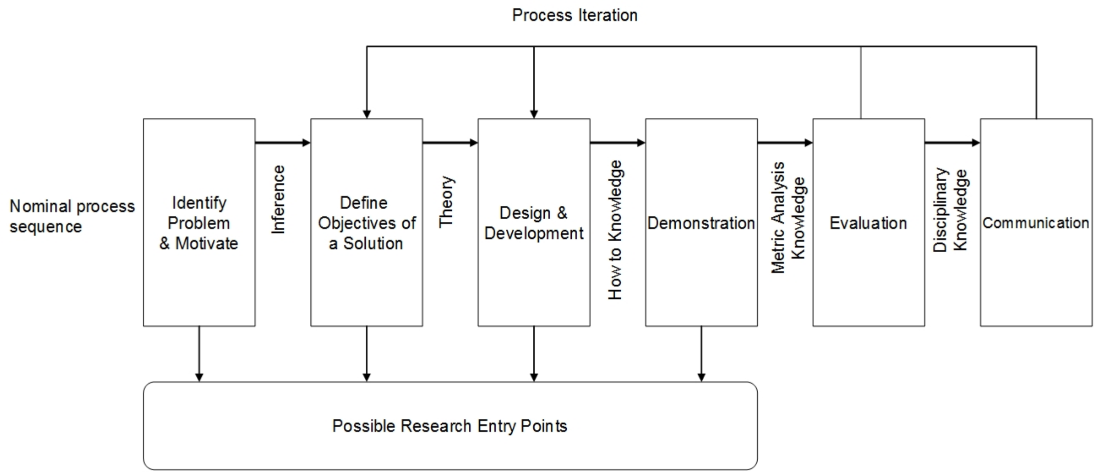


Figure 3.3: Design Science Entry Points - Adaptation of Peffers et al [114]

to address the research questions but also provided the necessary steps for their application.

The relationship between truth and utility provide the basis for the application of the framework. Hevner et al. and Peffers et al [68, 114] assert that truth informs design and utility in turn informs theory. Research activities in the justify / evaluate spheres can result in an identification of weaknesses in the theory along with a need to refine and reassess. The knowledge base of the framework provides the base for which IS research can be achieved. Prior IS research including frameworks, models and methods are the basis for foundational theories. Rigor is then achieved by applying existing foundations such as theories and frameworks along with data analysis and validation criteria.

Simon [132] suggests that a theory of design in IS research is a necessity, as IS are in a constant state of scientific flux and must be aligned to business needs and requirements and existing bodies of knowledge. Hevner et al. [68] indicate that innovations in database management systems, personal computers and the World Wide Web have had a dramatic effect on how IS are perceived by many. Therefore they further suggest that the manner in which IS researchers conduct their research in these environments must be adaptive and process-oriented. Accordingly we have applied these principles to our research and endeavoured to conform to best practice. Adopting Hevner et al. [68] research framework we

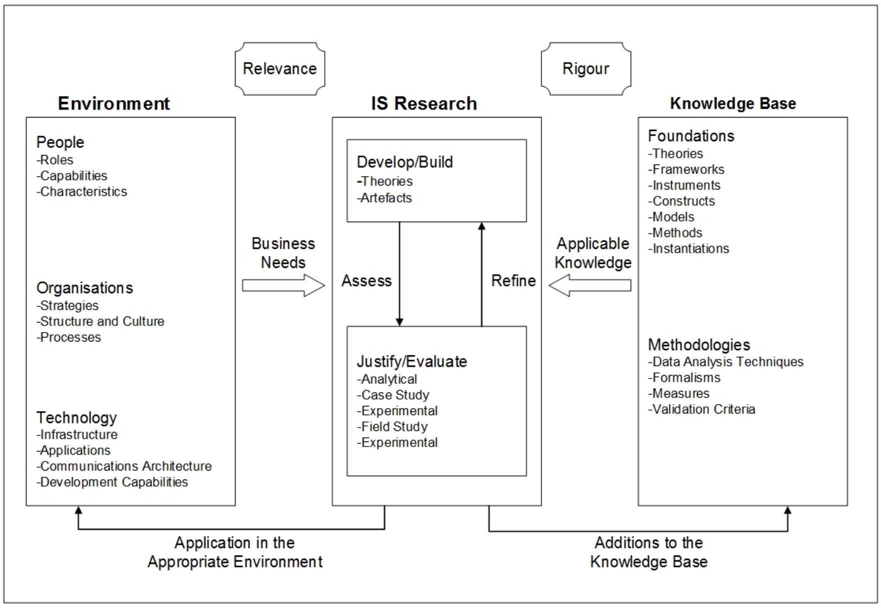


Figure 3.4: Information Systems Research Framework [68]

propose a research model for the construction of an artefact that enhances the application of an IQ framework for diverse IS environments. Figure 3.5 below illustrates the relationships between the environment and knowledge base inherent to our proposed research model.

3.6 Research Design Guidelines

Our research design required that the most appropriate methodology and methods be selected to address our four research themes as identified in Chapter Two. The literature review identified an ever increasing number of IQ frameworks that had been developed to cater for evolving IS. A number of frameworks are adaptations or enhancements of Wang and Strongs [147] seminal work. The key challenge facing many IS professionals are the adaptation or creation of new IQ frameworks that cater for diverse IS situations. The ever increasing number of frameworks we believe has the potential to present problems with selection of an appropriate framework and dimensions. A number of seminal frameworks have been widely applied in many situations (see citation map page 28). Our research contends that

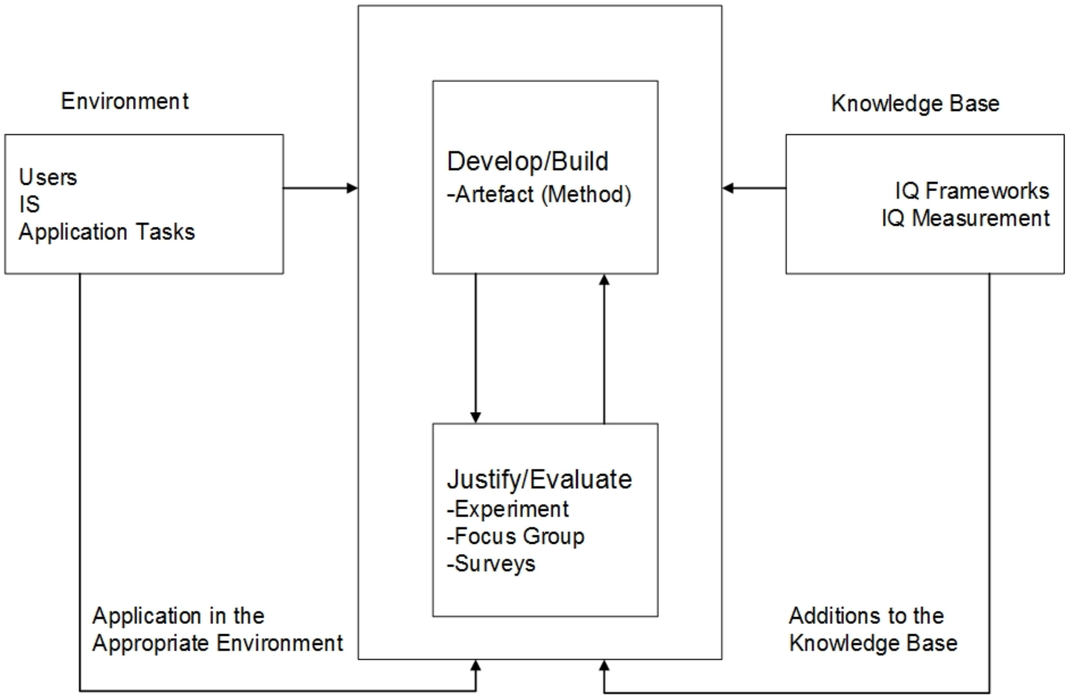


Figure 3.5: Research Model

guidelines for enhancements of these frameworks are more advantageous than the design and construction of new frameworks for new diverse situations.

Our research examined the application of Wang and Strongs [147] IQ framework for diverse IS situations. The research themes and individual questions imposed an obligation on us to employ a multiple of methods. In order to address the questions identified in the four themes we found it necessary to examine the complete IQ life cycle and as a result a holistic view of our main research question was adopted. This meant that the questions were not answered sequentially as we found it a requirement to build artefacts to elicit information for our answers.

The iterative nature of the framework application and the ability for the researcher to adopt refinements were considered critical for the successful exploration of our detailed research questions. Hevner [68] outlines seven guidelines, illustrated in table 3.2 that adhere to the principle that knowledge, understanding and solution are achieved in the building and application of an artefact.

Table 3.2: Design Science Research Guidelines [68]

Guideline	Description
Design as an Artefact	Design-science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation
Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems
Design Evaluation	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well executed evaluation methods
Research Contributions	Effective design science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies
Research Rigour	Design science relies upon the application of rigorous methods in both construction and evaluation of design artefact.
Design as a Search process	The search for an effective artefact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Communication of Research	Design Science research must be presented effectively both to technology-oriented and management oriented audiences.

3.6.1 Guideline 1: Design as an Artefact

The creation of an innovative artefact can include constructs, software, models and methods [19, 110, 114]. Benbasat [19] argues that theories are core to IS as a research discipline, he also contends that explanations must be proffered to how they can be amended, updated and refined to reflect the evolving environments. Our research examined IQ frameworks in this context. Much of the seminal work that is referenced extensively in the literature as outlined in chapter two dates from the 1990s (citation map). The theories of IQ as a research discipline formed a central part of our opinion with respect to the construction of an artefact.

We also examined the people, organisation and technology applicable to the research space. The novel artefact instantiation takes the form of a method and associated business processes that allow for a refinement of existing IS theories with respect to IQ frameworks. The construction of the artefact employed method engineering and Business Process Modelling Notation (BPMN). Method engineering provided us with a goal focused, systematic approach where many of the principles are related to design principles. It also allowed for repetition with in the method application. BPMN provided us with a notation that caters for the design and development of processes that can be interpreted by business analysts and technical developers. We expand further on both method engineering and BPMN in Chapter Five.

3.6.2 Guideline 2: Problem Relevance

The objective of IS research is to solve problems that are relevant to the business context in which IS are deployed. These systems are not deployed in a vacuum and any solutions proffered by researchers must take this into account [34]. Research can approach these problems from behavioural science and design science perspectives. There is much debate on the merits of either approach [19, 68, 114] we contend that Hevner′s et al. [68] complementary approach offered by their IS framework provides for a holistic and complete view. The relevance of the IQ problem to the IS domain is well documented in the literature (citation map page 28), the ever more ubiquitous nature of IS will ensure that this is to the forefront of IS research. The problem of IQ and diverse IS situations was highlighted, classified and refined by means of interviews, surveys, focus groups and workshops. This provided us with the components and boundaries for the construction of our artefact, thus drawing on the behavioural science and allowing us to make the artefact relevant to the IS practitioners.

3.6.3 Guideline 3: Design Evaluation

The design of any artefact must be of high quality. This in essence requires a high degree of rigour and must involve the application in a business environment. The application of the design includes the IS environment and may also consist of the technical infrastructure. It also requires the definition of appropriate metrics, gathering of and analysis of data [68]. The artefact may in its initial stages be simple in nature, but the iterative nature of the IS research framework allows and in fact encourages refinement of the artefact. The evaluation of the artefact uses methodologies from the knowledge base that are appropriately applied to the designed artefacts. These include observational, analytical, experimental, testing and descriptive techniques [68].

Our research employed observational, experimental and descriptive methods to evaluate the effectiveness of our methodology. This involved field experiments, with a Library IS where the users are familiar with the functionality but the diverse situations are assigned randomly. It also involved an in-depth analysis of the business environment and discussion of results obtained from its deployment. Detailed scenarios employed in the application of the method, and associated business processes, also provided us with an opportunity to demonstrate its effectiveness. The detailed construction, analysis and testing of the method along with a practical application are outlined in Chapters Five and Six.

3.6.4 Guideline 4: Research Contributions

The artefact in design research must make a contribution to the field of study. Hevner et al state that this can be summed up by the researcher asking *"What are the new and interesting contributions?"*[68]. This they argue can with the use of the IS research framework be evaluated from three perspectives the design, artefact, foundations and methodologies. The research contribution can then be classified under any or all of the three perspectives. Our main contributions were from the design artefact perspective but we also made contributions with respect to the foundations and methodologies. These are expanded upon in Chapter Six.

3.6.4.1 The Design Artefact

In design science research the artefact itself is considered a major contribution [59]. We believe that, in the case of our research that, it extends the existing knowledge base and enhances the field of IQ research by providing a method and guidelines for the application of IQ frameworks. It also is of significant value to the IS community and in particular those charged with ascertaining IQ.

3.6.4.2 Foundations

The extension of existing foundations in the design science knowledge base is also of importance. Our research employs a method engineering approach to construct our novel method; this extends the knowledge with respect to research problems in the IQ field. Storey et [134] cite the presentation of novel problem and solution representations as a contributions in this area.

3.6.4.3 Methodologies

The creative use of evaluation methods can provide design-science research with contributions. In our research we have creatively combined a number of evaluation methods: experimental, observational and descriptive. We believe that this novel application of methods contributes to the knowledge base in terms of application in the field of IQ research, where hitherto the majority of research has been conducted using traditional behavioural science methods [15].

3.6.5 Guideline 5: Research Rigour

The manner in which research is conducted must be rigorous for both the construction of the artefact and its subsequent evaluation. In order for the process of construction to attain this rigour appropriate methods and approaches must be employed. We adopted a method engineering approach for the construction of our design artefact (outlined in more detail in Chapter Five). This offered a goal oriented and systematic approach to construction and also catered for principles of design that conform to general construction guidelines [103]. The repetition of the use of the various constructs was also important.

3.6.6 Guideline 6: Design as a Search Process

The process of design is an iterative one with the ultimate goal of discovering a solution to a research problem [108]. The dynamic of the business environment must be acknowledged in this respect. The ability to refine the artefact to reflect a new environment and search for an optimal solution must be considered. Our research caters for this by allowing for a refinement of our research design and application. We provide for the generate test cycle as provided for in Hevner et al. [68] IS research framework and illustrated in figure 3.6. This allows for refinement in the practical application of our method and also provides flexibility in the adaptation of our method for future research.

3.6.7 Guideline 7: Communications of Research

The results of the research must be presented in a manner allowing for their technical and management application. This requires sufficient detail that allows for the technical implementation of the artefact and also a description to cater for implementation of the artefact from an organisational perspective. We have provided for detailed method design and description both in technical and organisational terms. A metal-model and the associated detailed business processes for the implementation of the method are provided, including the refinement of the method to a changing IS environment and situation. Our work has been presented to the IS and IQ community [48, 49, 50, 51, 52, 53, 54, 55, 56].

3.7 Research Approaches and Methods Adopted

This section outlines the approaches employed in the demonstration of research problem, design of the artefact (method), construction of the method, and in

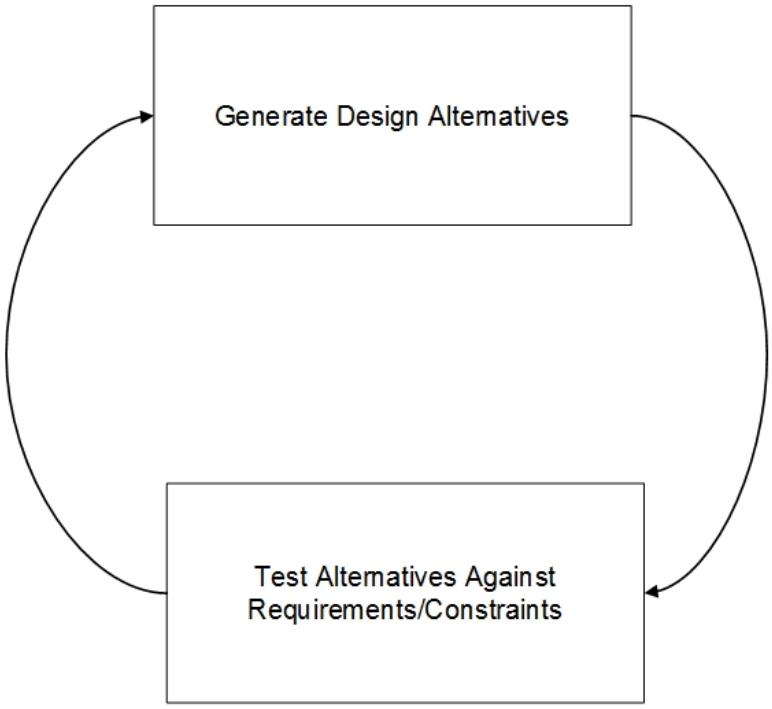


Figure 3.6: Test Generate Cycle [68]

conclusion evaluation of the artefact. We employed experimental, method engineering and action research approaches. The rationale for their employment, with more details of the experiment in Chapter Four and the method in Chapter Five. Figure 3.7 illustrates where we employed each of the methods.

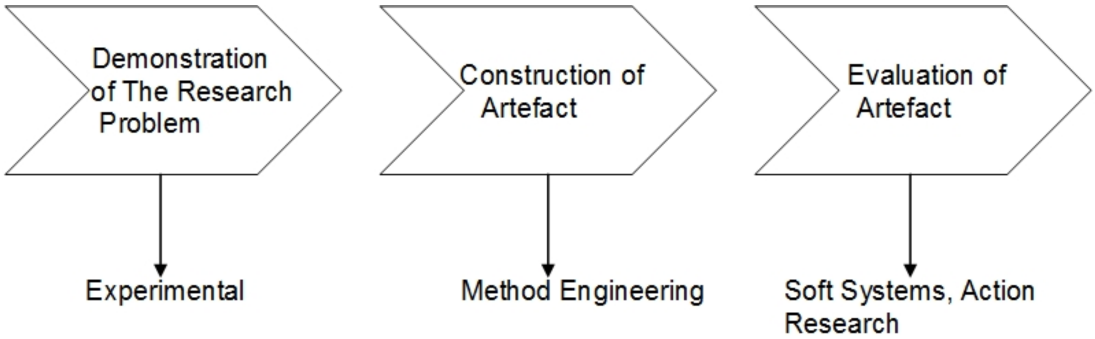


Figure 3.7: Individual Research Methods

3.7.1 Experimental Approach

We conducted an experiment in order to test our research hypothesis. The experimental research approach is used to investigate the relationship between IS environment and IQ dimension satisfaction as perceived by the user. The experiment comprised thee components; a model an experiment and analysis of results. Data can be collected in a number of ways in order to answer research questions. It can be gathered by direct observation or reported by the individual. Fisher [46] indicate that systematically collecting data to measure and analyze the variation of one or more processes forms the foundation of statistical process control. In the case of an experiment a variable is manipulated and the corresponding effect on the other variables is noted. Fisher [46] also point out that a statistical experiment is a planned activity where variables that have the potential to affect response variables are under the control of the researcher [45]. We expand on this in Chapter Four.

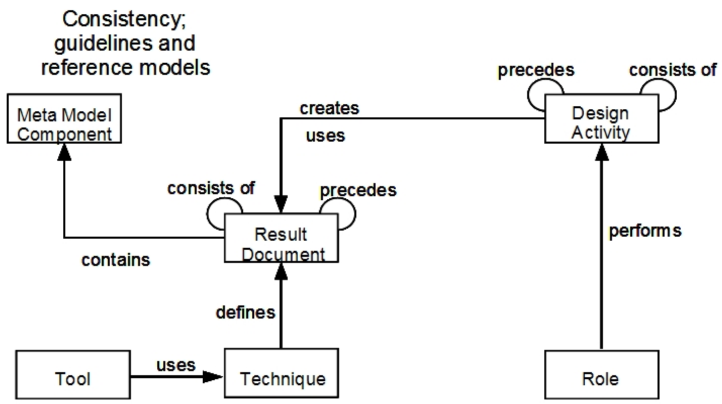
3.7.2 Method Engineering

The testing of our hypothesis in Chapter Four demonstrates that the perception of IQ is affected by the IS, we employed a method engineering approach to construct our artefact. Method engineering is concerned with the construction of methods. They can be described in terms of their constituent elements, namely: activity, role, specification document, meta-model and technique. Activities are described as construction tasks that create results, which in-turn lead to the creation of specification documents. Activities are performed in a specific order and completed by roles. Tools can be used to support the application of techniques. [23]. The meta-model specifies the conceptual model of the results. The complete application and evaluation of the approach is outlined in Chapters Five and Six.

Method engineering, as a discipline has been recognised over the last fifteen years. It is concerned with the process of designing, constructing and adapting generic artefacts such as models, methods, techniques and tools aimed at the development of IS [25]. Punter [118] describes the discipline from a process perspective where methods are comprised of phases, phases are comprised of design steps, and design steps are method-oriented constituents (e.g. techniques, procedures) can be assigned.

In order to describe methods, a meta-model for methods that includes activities, roles, specifications, documents and techniques is presented. Figure 3.8 below illustrates the relationship between these elements. The meta-model facilitates a consistent and concise method, which allows for their application in a goal oriented, systematic and repeatable fashion. According to Gutzwiller [62] activities are the construction of tasks which create certain results. These activities are assigned to roles and the results are recorded in previously defined and structured specification documents. The techniques comprise the detailed instructions for the production of the specification documents. Tools can be associated with this process. The meta-model describes the information model of the results. The detailed application of individual method fragments to our research problem is outlined in Chapter Five, including the process followed for their construction.

The evaluation of our artefact was conducted by application of our method. Our primary research question was concerned with the impact of diverse IS situ-



Role	Design Activity	Result Document	Technique	Tool
Who performs?	What?	With the result?	Applying technique?	Using tool?

Figure 3.8: Method Engineering Approach [62]

ations on IQ. Our method provided the mechanism for assessing this impact. In order to evaluate its utility we employed an action research approach, where we engaged with the stakeholders of the airline IS.

3.7.3 Action Research

Action research is the study of a social situation with a view to improving the quality of action within it. Because the researcher is also the practitioner, action research is often referred to as practitioner based research; and because it involves thinking about and reflecting on ones own work, it can also be called a form of self-reflective practice [100]. It can be said to have two pursuits; action (i.e. change) and research (i.e. understanding), at the same time. As noted by Lewin [90] and later proponents, this is achieved through a cyclic or spiral process, which alternates between action and critical reflection, and in the later cycles, continuously refining methods, data and interpretation in the light of the understanding developed in the earlier cycles. Action research is thus an emergent process, taking shape as understanding increases. It is an iterative process, which converges towards a better understanding of what happens [13].

McNiff [100] suggests that action research is, by necessity, open-ended: *"It does not begin with a fixed hypothesis. It begins with an idea that you develop. The research process is the developmental process of following through the idea, seeing how it goes, and continually checking whether it is in line with what you wish to happen"* . Action research is frequently, although not necessarily, participative two key assumptions of the action researcher are, firstly, that settings cannot be reduced for study, and that secondly, action brings understanding.

A variety of techniques and methods can be used within an action research framework including: researcher observation, interviews, surveys, solicited dialogue and feedback. As a class of research, various forms of action research approaches exist, and each share some common characteristics, which serve to distinguish action research from other approaches to enquiry. Baskerville [12] summarises what he describes as the most prevalent action research description; a journal paper from Susman and Evered [138] which looks at the scientific merits of action research. They describe action research as a five-phase iterative (and oftentimes collaborative) approach as follows:

1 Diagnosing the Problem 2 Action Planning 3 Action Taking 4 Evaluating 5 Specifying Learning

The application of these steps is outlined in detail in Chapter Six where we outline the evaluation of our method. We found that the action research represents a form of *"learning by doing"*, interested and affected parties identify a problem, take action to resolve it, evaluate how successful their actions were, and, if not satisfied, try again. Our method facilitates this iterative approach.

Participatory action research embraces participatory methods in a defined cycle of research consisting of four steps: plan, act, observe and reflect. It extends the traditional action research approach, realigning the role of researcher and subject along more collaborative lines. The approach is also described as emancipatory action research; the (entire) cycles are carried out by the participants, under the guiding philosophy that action research is something that clients do, not something that is done to them by a researcher [12]. The focus on dialogue as a key methodological requirement is one distinguishing feature of participatory action research, as is the move away from description and toward trial (and perhaps error) to achieve change.

3.8 Research Questions and Research Methods

We have identified four research themes that conform to the IQ lifecycle, and the application of individual research methods to each of the research themes allows for a comprehensive examination of the main research question. *"What is the impact of diverse IS situations on the user perception IQ?"* This alignment was completed in conjunction with the application of Hevner′s [68] IS research framework. Table 3.3 outlines each theme and its questions along with the appropriate methods.

In the alignment of our research methods and research themes we examined the broad spectrum of research approaches, not only to ascertain the impact of diverse IS situations on IQ, but also to provide a solution space to cater for an artefact that can be implemented with IS. Design Science offers an over arching approach allowing for this, and consequently we are not restricted to research methods of either the quantitative or qualitative paradigms.

Table 3.3: Research Questions and Methods

Research Question	Method
How does IQ framework definition cater for diverse IS situations?	Document Analysis and Literature Review (Chapters Two and Five)
How do IQ frameworks consider user perception for diverse IS situations?	Document Analysis and Literature Review (Chapters Two and Five)
How flexible are IQ frameworks enhancements?	Document Analysis and Literature Review (Chapters Two and Five)
How can IQ measurement be enhanced for diverse IS situations?	Method Engineering (Chapter Five)
What diverse situational factors need to be considered for IQ measurement ?	Method Engineering (Chapter Five)
What IQ dimensions are affected by diverse IS situations?	Experiment (Chapter Four)
Do weightings need to be assigned to IQ dimensions for different IS situations?	Experiment (Chapter Four)
How can IQ be improved for diverse IS situations?	Action Research (Chapter Six)
How can the necessary criteria for improvement be identified ?	Action Research (Chapter Six)
What procedures can be put in place to implement new / refined criteria?	Action Research (Chapter Six)

3.9 Chapter Three Summary

This chapter set out the research methodology selected including rationale and justification. It describes in detail the research framework we employed to conduct our research The individual methods selected for each of the sub questions identified were also put forward. The design of our research was also discussed. Finally we mapped our research questions to our chosen research methods. In chapter four we will describe the experiment we conducted to test our hypothesis that the perception of IQ by user is affected by the IS environment.

4

Experiment - Diverse IS Situations and IQ Perceptions

4.1 Introduction

Chapter Three outlined our research methodology and approach for each of our research questions identified in Chapter Two. In this chapter we further build on these by means of an experiment. The genesis for our research is based upon the hypothesis that the same information viewed from diverse situations provides for different levels of IQ as perceived by the stakeholders. This presented the challenge of obtaining a true or normalised measure of IQ for an entire IS that have diverse situations with respect to the access of information. Many contemporary IS have multiple accesses by the same users to the IS.

In addressing this challenge we conducted an experiment that caters for each of the IQ dimensions outlined in Wang and Strongs [147] framework with a view to ascertaining the impact if any of diverse situations on these individual dimensions. These experiments were conducted in conjunction with the Library IS. Because IQ is a multidimensional concept we are concerned with the impact at a dimension level.

4.2 Hypotheses and Experiment Research Model

The dimensions identified in Wang and Strongs [147] framework categorise information as Intrinsic, Contextual, Representational and Accessibility. From our research question we define hypotheses that examine each of the individual IQ dimensions as outlined below in table 4.1

Table 4.1: Research Hypotheses

No	Hypothesis
1	Diverse IS Situations impacts the user perception of Believability
2	Diverse IS Situations impacts the user perception of Accuracy
3	Diverse IS Situations impacts the user perception of Objectivity
4	Diverse IS Situations impacts the user perception of Value Added
5	Diverse IS Situations impacts the user perception of Relevancy
6	Diverse IS Situations impacts the user perception of Timeliness
7	Diverse IS Situations impacts the user perception of Completeness
8	Diverse IS Situations impacts the user perception of Appropriate Amount of Data
9	Diverse IS Situations impacts the user perception of Interpretability
10	Diverse IS Situations impacts the user perception of Ease of Understanding
11	Diverse IS Situations impacts the user perception of Representational Consistency
12	Diverse IS Situations impacts the user perception of Concise Representation
13	Diverse IS Situations impacts the user perception of Accessibility
14	Diverse IS Situations impacts the user perception of Access Security

In summary we proposed a total of 14 hypotheses (with their corresponding Null hypothesis) that examined the impact of diverse IS situations on IQ. The data gathered from these tests allowed us to investigate further the extent of this impact with a view to providing input for our meta-model and rule base. Figure 4.1 illustrates the relationships between the different components of our experimental model. The application tasks are specified with their completion from the diverse IS situations. The IQ assessment is then completed, using the same survey instrument. The diverse situation is the only factor that is different; i.e. the independent variable. In testing our hypothesis we had users conduct a limited set of tasks appropriate to their user group, ideally a more complex set of diverse tasks over a longer time period would have been conducted, however this was beyond the scope of our research.

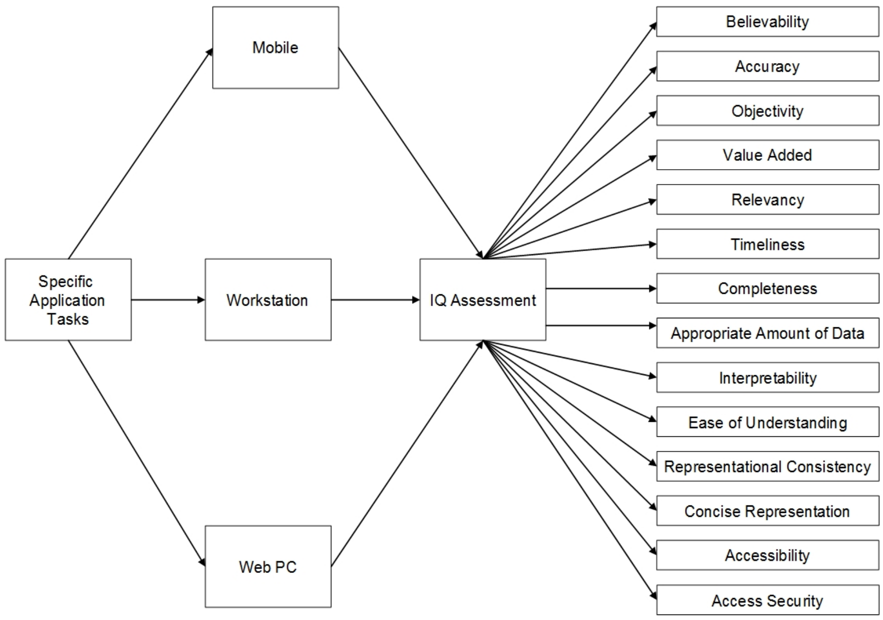


Figure 4.1: Research Model - Experiment

4.3 Experiment Design

To test our hypotheses we designed and constructed a field experiment with a Library IS. The operational nature of the Airline IS was not suitable for experiments. The experiment focused on the perception by users of the same information from diverse situations. The Library IS users were assigned a number of tasks appropriate to their user group. These tasks were then measured for three diverse situations. We then analysed and compared the scores from the diverse situations.

The total number of users surveyed was 105 (56 male, 49 female). The user analysis identified 3 stakeholder groups broken down between librarians (12), library users (90) and technicians (3). Our experiment involved the users completing a number of tasks with respect to information retrieval as they pertained to each stakeholder group. The selected dimensions of the framework for the particular situation can then be identified. The objective measures are further subdivided into two categories data base integrity analysers and software service analysers. The results from application of the measures can be compared upon completion. The tasks for each user group were specific to that group. Members of the groups were randomly allocated to each of the diverse situations. The experiment involved control of one independent variable the diverse situation (access device).

4.3.1 Assessment Technique

The assessment of the dimensions was completed using both experimental and survey measures. The dimensions surveyed were those associated with Wang and Strongs framework [147] and the AIMQ [88] survey instrument. The experimental assessments were nonparametric statistical techniques. The AIMQ is outlined in Appendix (A).

4.3.1.1 Nonparametric Techniques - Employed (Rationale)

These tests are sometimes referred to as assumption-free tests because they allow for less strict assumption about the distribution of the data being analysed [26]. Non-parametric methods are widely used for studying populations that take on a ranked order (such as satisfaction with IQ). The use of non-parametric methods may be necessary when data have a ranking but lack numerical interpretation, such as when assessing preferences in terms of level of satisfaction for data on an ordinal scale [45]. Although one-way analysis of variance (ANOVA) is the method of choice when testing for differences between multiple groups, it assumes that the mean is a valid estimate of centre and that the distribution of the test variable is reasonably normal and similar in all groups. However, when the test variable is ordinal, the mean is not a valid estimate because the distances between the values are arbitrary.

4.3.1.2 AIMQ Survey Instrument (Rationale)

The argument for an empirical approach is well documented in the literature. As Strong et al. [136] summarise: *"It is well accepted in quality literature that quality cannot be assessed independently of the consumers who choose and use products. Similarly, the quality of data cannot be assessed independent of the people who use data data consumers."*

Within the marketing discipline approaches for assessing product quality attributes that are important to consumers are well established [147]. Methods have been developed in the discipline of marketing research, such as questionnaire development, for determining the quality characteristics important to consumers of products. These same methods were adapted in studies, such as Wang and Strong [147], Lee et al. [88] and Pipino et al. [116], to highlight how information can be treated as a product. Furthermore, these methods were employed to identify information consumer needs, the hierarchy of these needs and to measure the importance of these needs. Further details about IQ questionnaire development are outlined in Huang et al. [72].

In choosing to apply the AIMQ instrument we reviewed research of Madnick et al. [96] who recognise it as the key research to date in their overview of the current landscape of IQ research. It is the most established instrument to both measure and analyse IQ and is the culmination of many years of IQ research.

Lee et al. [88] present a comprehensive IQ assessment instrument developed for use in research as well as in practice to measure IQ in organisations. The instrument addresses each dimension with four to five measurable items in a questionnaire. The appropriate functional forms are then applied to these items to score each dimension [116]. Moreover the IQ measures assessed in this questionnaire have been well tested in previous research [88, 145].

4.3.2 Survey Instrument Validation

The complete AIMQ questionnaire was supplied to the library manager, library user group and chief technical officer, for stakeholder validation. The questionnaire was reviewed and feedback was received. A decision was made to include definitions at the beginning of each dimension being assessed. Comment fields were also included to provide space for participants to add any further information. Finally a glossary of terminology (an explanation of the 14 IQ dimensions) was also included at the back of each questionnaire.

4.3.2.1 Assessment Procedure - Survey Instrument

All participants were gathered for an overview session where the broad aims of the research and questionnaire were presented. This session served to motivate the participants to complete the questionnaire carefully and thoroughly while also ensuring a full understanding of the contents of the questionnaire. Previous research has indicated that such a session is necessary to ensure the questionnaire was completed fully with quality responses [88]. To avoid any bias the subjects were requested to fill out the questionnaires on their own without supervision. Analysis of the results was then performed, initially examining the individual dimensions for each of the IS under experiment. Statistical Analysis of the variance in situation is applied to the results of each IS separately.

4.4 Experiment Analysis

The experiments analysed via our hypotheses were tested by employing The Kruskal-Wallis Test, Mann Whitney statistical tests and Cohens benchmark [45]. These were employed in conjunction with the AIMQ survey instrument. The Kruskal-Wallis Test was applied for testing differences between groups of users from diverse situations. One of the main focuses of our research was the impact of diverse situations on users perception of IQ. The use of The Kruskal-Wallis Test overcame the problem of ordinal data by not using raw scores, instead the data was ranked. The ranking of the data is a work round and in doing so some data about the magnitude of the difference between scores is lost [45]. However this has to be considered and balanced in the context of the empirical approach and the sometimes inexact nature of IQ as postulated by Kahn [77] *"Information quality is an inexact science in terms of assessment and benchmarks"*.

The Library IS experiment primarily afforded our research the opportunity to measure IQ for diverse situations. The experiment with the library IS involved library users completing tasks from three different situations as outlined earlier. We analysed the results with respect to the perception of IQ of the same information from three diverse situations. Library users for each of the diverse situations were required to complete routine tasks. The tasks and user ability were the same; the only difference was the diverse situation with respect to access of the IS. Group one accessed the IS from workstations, group two from the web PC and group three from a mobile device. We present an analysis of the results. There were 90 participants, male (48) and (42) female. Thirty participants were allocated to each group. The complete process of analysis is presented for the believability dimension the same steps were followed for all dimensions. Subsequent dimension results are summarised in table 4.2. The Statistical Package for the Social Sciences (SPSS) was employed for data analysis.

Believability is the extent to which data is regarded as true or credible [147]. An interesting analysis from our workshops indicated that this dimension was considered the most important dimension by all stakeholders across both IS. Initial IQ problems with the airline IS were identified through dissatisfaction with this dimension.

4.4.1 Ranked Data Analysis

Figure 4.2 illustrates a summary of the ranked data for the believability dimension. The output shows the mean rank in each diverse situation (condition). These mean ranks are important for interpreting any effects which will be elaborated upon subsequently.

4.4.2 Test Statistics and Box Plots

Figure 4.3 shows the test statistic (H) which is a function of the total ranks and the sample size on which they are based. The test statistic has a Chi-Squared dis-

Ranks

	Situation	N	Mean Rank
Believability	Workstation	30	61.23
	Web PC	30	50.00
	Mobile Device	30	25.27
	Total	90	

Figure 4.2: Summary of Ranks SPSS

tribution and its associated degrees of freedom is two, along with the significance of less than .01. We therefore conclude that the situation of IS access affected the users rating of the believability dimension, whilst this informed us that a difference exists, it does not indicate where the difference lies. Consequently we examined box tests of each of the groups.

Test Statistics[a,b]

	Believability
Chi-Square	32.272
df	2
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Situation

Figure 4.3: Test Statistic SPSS

As our tests are nonparametric in nature we examined the difference in medians as distinct from means. The median measure is not as influenced by outlier values [45]. The box-whisker plot in figure 4.4 illustrates that the median for both the workstation and web pc situation were the same at seven but that the mobile situation was lower at five. However these conclusions are based on a subjective view of the chart.

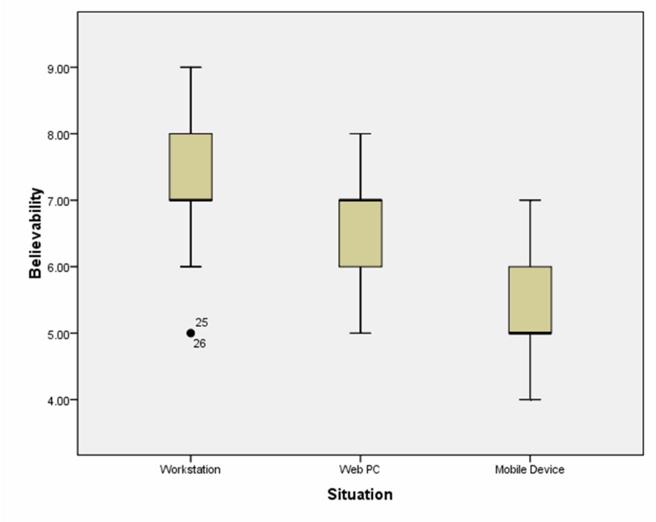


Figure 4.4: Box Plot SPSS

4.4.3 Mann-Whitney Tests

Field [45] states hypotheses can be tested by employing Mann-Whitney tests noting that it is advisable that some adjustment be made for the increased potential of type 1 experiment errors. To avoid this we applied a Bonferroni correction where instead of using 0.5 as the critical value of significance, it is divided by the number of comparisons of groups in our case 0.5/3=0.167. Figures 4.3 illustrate the tests statistics from doing the Mann-Whitney tests on the three situations. The critical value of 0.167, when analysed for the three comparisons produces significant results for the workstation mobile comparison and the web PC mobile comparison. However there was no significance for the comparison between workstation and web pc environment. Figures 4.5 and 4.6 illustrates the Mann Whitney tests for the Workstation V Mobile access situation, group comparisons. These were also completed for web PC situation versus mobile devices and web PC situation versus workstation situation.

4.4.4 Calculating Effect Size

The effect size provides an objective measure of the importance of experimental effect. A correlation coefficient of zero means that the experiment had no effect

Ranks

	Situation	N	Mean Rank	Sum of Ranks
Believability	Workstation	30	41.45	1243.50
	Mobile Device	30	19.55	586.50
	Total	60		

Figure 4.5: Mann- Whitney Test Workstation V Mobile Device Part A

Test Statistics[a]

	Believability
Mann-Whitney U	121.500
Wilcoxon W	586.500
Z	-4.990
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Situation

Figure 4.6: Mann- Whitney Test Workstation V Mobile Device Part B

and a value of one means that the experiment completely explains the variance in the data. Cohen's benchmark [44, 45] provides widely accepted values that indicate what a large and a small effect are:

- r=0.10 (small effect): in this case the effect explains 1% of total variance
- r=0.30 (medium effect): in this case the effect explains 9% of total variance
- r=0.50 (large effect): in this case the effect explains 25% of total variance

The effect size for our research is calculated with respect to the Mann-Whitney test. This provided us with adequate data for writing and interpreting our results. Field [44] indicates that converting a chi-square statistic that has more than one degree of freedom can also be done in conjunction with Kruskal-Wallis test statistic. The effect size for each of the groups is outlined below.

$$r_{workstaion-mobile} = \frac{-4.990}{\sqrt{60}} \qquad = -0.644 \tag{4.1}$$

$$r_{webpc-mobile} = \frac{-4.309}{\sqrt{60}} \qquad = -0.556 \tag{4.2}$$

$$r_{workstaion-mobile} = \frac{-2.273}{\sqrt{60}} \qquad = -0.293 \tag{4.3}$$

4.4.5 Interpreting the Results

Users perception of the Believability dimension was significantly affected by the IS situation. ($H(2)=32.27$, $p < 0.1$). Mann-Whitney tests were used to follow up this finding. A Bonferroni correction was applied and so all effects are reported at a.0167 level of significance. It appeared that the perceptions of the Believability dimension were significantly higher from workstation situation compared to the mobile situation U=121.5, r=-.64. It also appears that the perceptions of the Believability dimensions were significantly higher from web PC situation compared to the mobile situation. U=171.5 r=-0.556. However the perception of the Believability dimension from the workstation situation compared to the web PC was not significantly different U=306.5 r=-.293. We can conclude that the perception of believability from the mobile situation was poorer than both the workstation and web PC where there was no significant difference in perception of the Believability dimension.

The statistical tests outlined for the Believability dimension were completed for all dimensions in the framework. Table 4.2 summarises the results with an indication of the significance of each diverse IS situation. We illustrate the level of effect based on the criteria outlined by Cohen [44] small (S), median (M) and large (L). Figure 4.7 illustrates a graph of the significance for the IS situation.

The results of our experiment with the Library IS indicate that there are varying levels of significance for each of the diverse situations that the users rated their perception of IQ from. There is a significant difference in variance for those users of the IS from the mobile environment in comparison with both workstation and web PC. These users are completing the same tasks, viewing the same underlying information and consequently this variation should be addressed by those with responsibility for measuring IQ.

4.4.6 Experiment Findings in the Wider Context of E-Commerce

Our experiment examined users perception of IQ of diverse situations for a single IS within an organisation, however despite this limitation we contend that our findings have relevance to the wider context of E-Commerce. The perception of IQ can be viewed from the perspective of the users trust or belief in the IS. Our experiment findings demonstrate that the perceptions of IQ vary depending on the IS situation. This is greater for some dimensions than others (table 4.2).

The trust that users place in a web-site is essential for success. Maximising trust and minimizing risk are the critical factors that dictate the long-term success of a web application. In essence trust encourages relationships and consequently economic activity through cooperative transactions that may be at an individual or corporation level [81]. It has been identified as a key factor in many studies and has been examined from a range of perspectives including technical, social, psychological, economic and behavioural [105]. Trust as a phenomenon can be difficult to observe and similar to IQ it is multi-dimensional in nature. Frameworks and models have evolved [113] in attempt to classify, measure and improve trust and although accuracy, believability and other dimensions of trust are examined in the literature their relationship with diverse IS situations remains an open research question.

The results of our experiment demonstrate that the IS situation is a factor that must be considered when measuring user perception and trust and though objective measures of IQ may return values for intrinsic dimensions such as accuracy or completeness, the same outcome may not be perceived by the user of a particular IS situation. Objective measures we argue should therefore be used in conjunction with subjective measures for each diverse IS situations.

*WS = Workstation *MOB = Mobile *WEB PC = Browser launched application on Personal Computer

Table 4.2: Significance IS Situation

Dimension	WS V MOB	WEB PC V MOB	WS V WEB PC
Believability	r=-0.64(L)	r=-0.55(L)	r=-0.29(S)
Accuracy	r=-0.28(S)	r=-0.21(S)	r=-0.19(S)
Objectivity	r=-0.61(L)	r=-0.49(M)	r=-0.09(S)
Value-Added	r=-0.31(M)	r=-0.28(S)	r=-0.23(S)
Relevancy	r=-0.27(S)	r=-0.22(S)	r=-0.14(S)
Timeliness	r=-0.67(L)	r=-0.58(L)	r=-0.24(S)
Completeness	r=-0.59(L)	r=-0.48(M)	r=-0.08(S)
Appropriate Amount of Data	r=-0.31(M)	r=-0.28(S)	r=-0.29(S)
Interpretability	r=-0.67(L)	r=-0.52(L)	r=-0.28(S)
Ease-of-Understanding	r=-0.71(L)	r=-0.66(L)	r=-0.21(S)
Representational Consistency	r=-0.64(L)	r=-0.48(M)	r=-0.12(S)
Concise Representation	r=-0.52(L)	r=-0.54(L)	r=-0.17(S)
Accessibility	r=-0.68(L)	r=-0.61(L)	r=-0.31(M)
Access Security	r=-0.60(L)	r=-0.48(M)	r=-0.28(S)

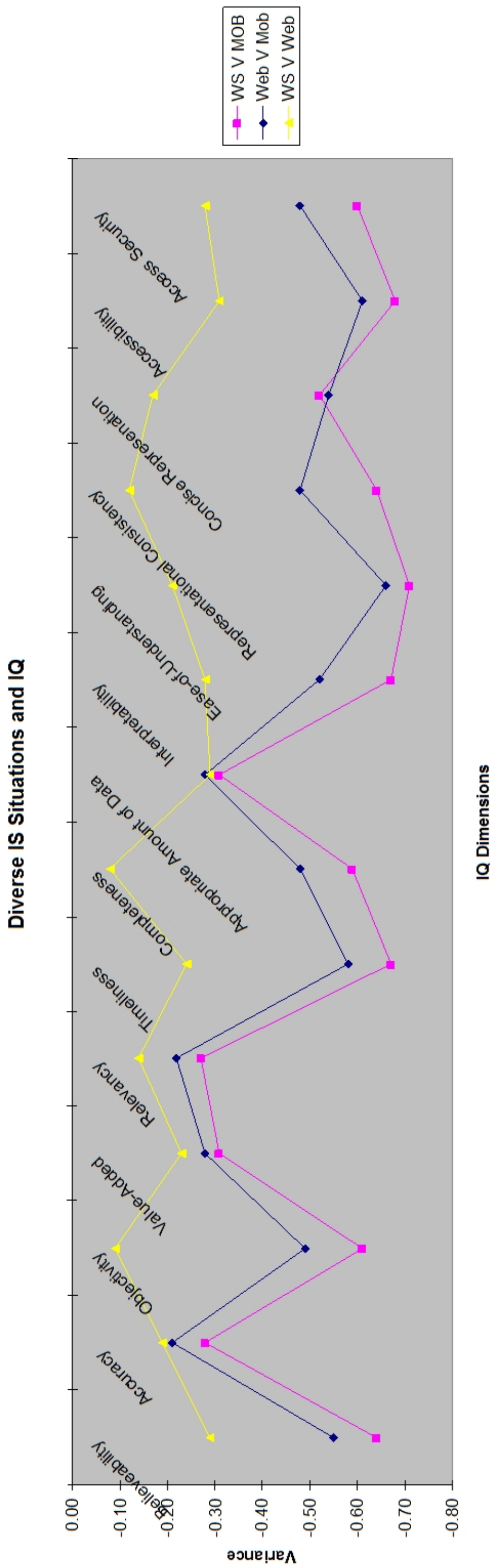


Figure 4.7: Significance of IS Situation

4.5 Diverse IS Situations and IQ Dimensions

The variance between IS situations requires that those charged with ensuring IQ for the IS take it into consideration when calculating the overall level of IQ. There are a number of ways that this variance can be achieved depending on the IS. We demonstrated that it is possible to measure empirically the perception of IQ and calculate the variance Cohens [44] value and situation analysis.

In order to aggregate single IQ measures, researchers have proposed a number of options; often underlying a weighted aggregate of single values for IQ dimensions [147]. Although, some researchers have attempted to identify IQ value curves and trade-offs by analyzing the potential impacts of IQ [137], much research still measure the overall impact of IQ as a weighted aggregate. For example, a principle measure of the weighed sum of all the criteria (IQC_i) is illustrated in equation 4.4 as

$$IQ = \sum_{i-1}^{n} \alpha_i IQC_i \qquad \text{where} \quad \forall \alpha_i : 0 \leq \alpha_i \leq 1 \quad \sum_{i-1}^{n} \alpha_i = 1 \tag{4.4}$$

The weight, or priority of each IQ criteria (IQC_i) is represented by $\alpha\ _i$. However, most frameworks provide limited assistance to define the weights for IQ dimensions. Furthermore, most frameworks do not provide any guidelines on how to apply the framework and the IQ aggregation to diverse IS situations. In order to provide indications for aggregating IQ measures, weightings need to be assigned to reflect the perception of the same information from diverse situations or at the very least the bias should be recorded. We address this, proposing that the *IS situation factor* be represented when aggregating IQ measurement by for example the weighted sum measure [54]. Indeed each weight used for aggregating IQ measures needs to be IS situation dependent. This is reflected in revising the traditional weighted sum aggregation, by including IS situational factors c as illustrated in equation 4.5.

$$IQ^c = \sum_{i-1}^{n} \alpha_i^c IQC_i \qquad \text{where} \quad \forall \alpha_i : 0 \leq \alpha_i \leq 1 \quad \sum_{i-1}^{n} \alpha_i = 1 \tag{4.5}$$

The weight or priority of each IQ criteria (IQC_i) is represented by α_i^c which considers the IS situational adjustment for this IQ criterion. This allows for aggregation and comparison of various results of IQ assessments within different IS environments.

In traditional IQ approaches and frameworks, priorities and weights for IQ dimensions, where assigned are completed without considering fully the impact of diverse IS situations. However, as our experiment demonstrates that there is a relationship between the IS situation and the corresponding satisfaction with IQ dimensions. Although an organisation may consider individual dimensions to be particularly important and consequently assign an individual weighting to their significance, generally completed by means of survey instrument among managers and users this alone we argue is not sufficient. The IS situation and in particular the manner by which it is accessed it has been demonstrated to be a significant factor. The ranking or weighting of IQ needs to take this into consideration. The traditional method of applying a weighted sum measure irrespective of IS situation requires refinement in order to achieve a normalized IQ score.

Figure 4.7 illustrates the need to consider the concept of normalizing IQ for a situational factors on IQ assessment. Our experiment demonstrates that the satisfaction with the IQ dimensions is dependent on the IS situation from which the IS is accessed. The accessing of the same information from diverse IS situations produces different results with respect to the level of IQ. This presents us with the challenge of obtaining an accurate reflection IQ for IS with diverse access, which we address in Chapter Five by the construction of our method.

4.6 Chapter Four Summary

In this chapter we proposed a number of hypotheses with a view ascertaining the impact of diverse situations on IQ. We also outlined the format of an experiment we conducted to test our hypotheses. Our experiment clearly demonstrates that diverse situations affect the users perceptions of IQ to varying degrees. In chapter five we outline the construction of a method to enhance the application of IQ frameworks for these diverse IS situations. We will outline the design, construction of the method along with the processes and procedures for implementation.

5

A Method for Information Quality and Diverse IS Situations

5.1 Introduction

The aim of this chapter is to describe in detail the construction and configuration of our novel method and repository for diverse IS situations. The adoption of method engineering principles and practices are aligned to our research aim of enhancing guidelines for the implementation of IQ frameworks and measurement for diverse IS. This is further deconstructed into two areas: method design and method implementation. An explanation of the constructs that were employed along with their detailed processes for both construction and application are outlined. We used TDQM [95] as an over arching approach or philosophy, thus ensuring that we examined each phase of the IQ lifecycle. A novel method that considers each phase of the lifecycle is thus proposed. We also demonstrate how to iteratively apply the method with additional information being propagated to the rule base. This iterative approach allowed us to enhance the method by the subsequent addition of more detailed knowledge and guidelines for IQ dimension measurement to the rule base.

Foremost in our approach to construction and configuration of our method, is the importance of the stakeholders in the IQ process; namely the collectors, the custodians and the consumers of information. Specifically addressing the challenge of how we can encode our understanding of an organisation and its measurement of IQ in a consistent way addresses the different needs of the stakeholders with respect to IQ frameworks and diverse IS situations.

We build on our research methods chapter with a more detailed analysis of both the design science artefact and the method engineering approach that we have adopted to answer our research question. Initially we outline the steps involved in the construction of our method, followed by an outline of its configuration and implementation. Figure 5.1 illustrates the components and order of events for method construction, where initially we have the IQ framework with no guidelines for diverse IS situations. The procedural and product model of our method are described followed by an explanation of the method implementation where we outline the relationship between method fragments, a rule base, experimental data and domain experts. This combination allows for implementation of an IQ framework and diverse IS environment.

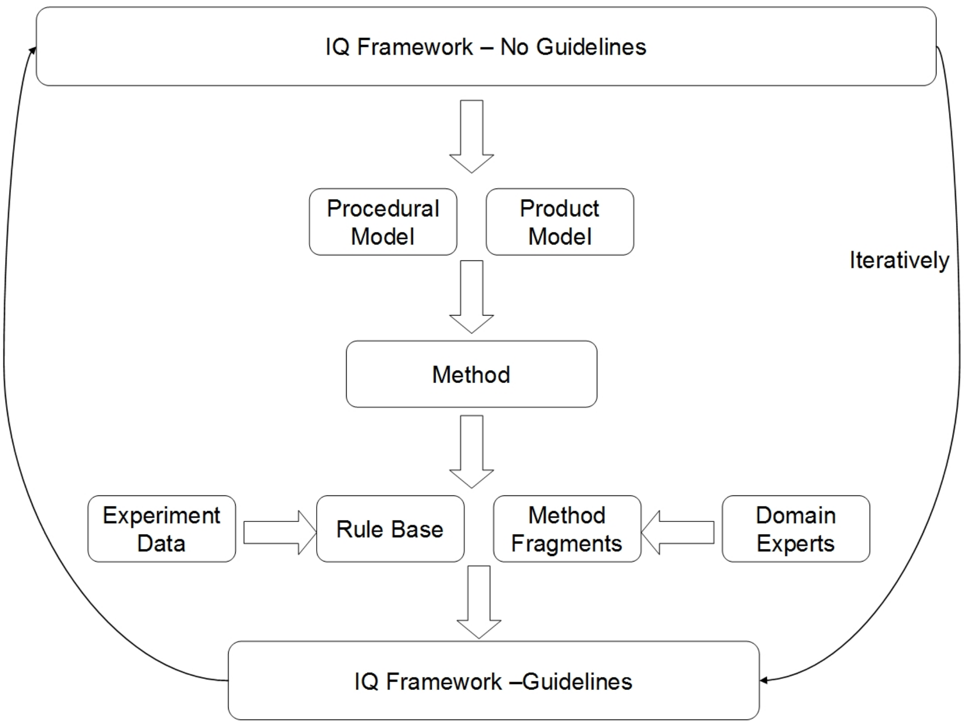


Figure 5.1: Method Design and Construction -Our Approach

5.2 An Overview of Method Construction

Engineering a solution that allows us to measure IQ for diverse IS situations required us to initially construct a new method suitable for the IQ context where none previously existed. This necessitated the building of both a procedural model and a product model for our planned method. The initial output of this process provided us with a method and rule base that allowed us to commence the iterative process of refinement with each of the IS and associated situations. The resultant method post initial application was comprised of a comprehensive set of fragments (individual element of a method) and a rule base for implementation in conjunction with Wang and Strongs [147] IQ framework. The method fragments describe both processes and associated outputs. This not only produced the guidelines but also provided for a systematic approach for further refinement and enhancement as IS evolve. This also allows for a recording of new knowledge.

The construction of the method must according to Bucher et al [59] fulfil three criteria:

- The method construction process must result in a method that is suitable or fit for purpose.
- Contain a validation of the constructed method (Chapter 6).
- The method construction process is iterative.

To design and build our method we follow the systematic approach outlined by Bucher et al [59] . This approach to engineering a method is compatible with the assembly based and road map approach for method construction for individual fragments in a method repository [103]. An initial setting for analysis leading to more refined solution with the employment of iterative techniques such as prototyping was employed. This allowed us to refine a finer level of granularity to our knowledge that can be added to the repository and used in subsequent implementations.

We then employ our method with the Airline IS. This allows for the refinement of the artefact construction within a design science approach. The need also to cater for adaptability is an important component of our research as IS are constantly evolving. This dynamic presented challenges with respect to method refinement. Enhancements to IQ framework implementation, such as our method can cater for evolving IS situations and in particular the new access modes. Many IQ requirements have resulted in the design and implementation of domain specific IQ frameworks to overcome the problem of IS situation dynamic [83].

There is no one fixed approach to constructing a method, a number of approaches can be adopted including action research, case study, deduction and ethnographic research [23]. Our research involved working in conjunction with stakeholders of Library and Airline IS. The stakeholders were an integral part of the research and as such action research method was considered an appropriate approach for this part of our research. IQ literature also formed an important part of our work in the construction of our method.

Initially our method considers an analysis of IQ problems across a number of domains as outlined by the literature (citation map page 28). The sequence of steps as illustrated in figure 5.2 provided the basis for our overall approach to method construction. This required not only method design but also corresponding artefacts for implementation including a rule and knowledge base.

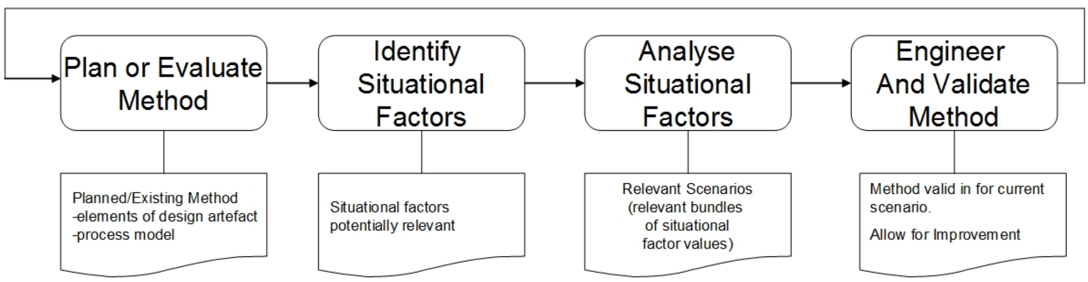


Figure 5.2: Sequence of Tasks Method Construction -Our Approach

5.2.0.1 Business Process Modelling Notation

The construction of the procedural model is a critical element of the method engineering approach and it is necessary to model in a consistent manner the elements that make up our method. The necessity for all stakeholders to fully understand the mapping of the system is critical for successful implementation. Engagement from the stakeholders is essential as selection and prioritisation of

IQ dimensions is a core component of our method. These stakeholders include business and non technical users therefore any modelling notation employed must be widely understood by each of the communities. It is also important that the modelling of the processes allows for a high degree of flexibility for amendment because of the iterative nature of our method combined with the dynamic of the IS and business environment.

There are a number of well established modelling techniques that can be employed to model business processes. Examples include Use Case Diagram, Activity Diagrams in UML and Business Process Modelling Notation (BPMN). The Business Process Management Initiative (BPMI) has developed a standard Business Process Modelling Notation [151]. The motivation for the development of BPMN was to create a bridge for the gap between the business process design and the process implementation. BPMN is based on a combination of flowcharting techniques and graphical models for business operations. An examination of the BPMN core concepts suggest that it is intuitive and easy to understand. One of the advantages according to the BPMI is the simplicity of its mechanisms for creating business process models while also capturing the complexity of business processes. The main components of this model were introduced to the stakeholders of both the Library and Airline IS.

5.2.0.2 BPMN - Flow Objects

BPMN classifies three elements which are flow objects.

- Event: describes something that occurs or happens. They affect the flow of process. Represented by a circle. Three types of event start intermediate and end.

- Activity: a generic term for work that is performed. Activities can be atomic or compound. There are two types task and sub-process.

- Gateway: Represented by a diamond shape, determines decisions, forking, merging and joining of paths.

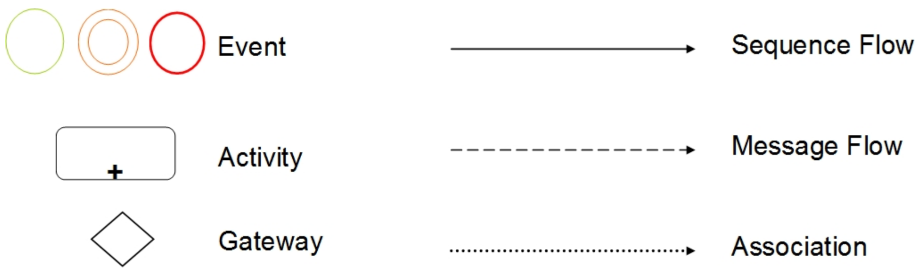


Figure 5.3: BPMN Flow and Connection Objects

5.2.0.3 Connecting Objects

The flow objects are connected to each other by connecting objects outlining the basic structure of the business processes. There are three connecting objects that provide this function.

- Sequence Flow: Used to show the order or sequence that activities are performed in.
- Message Flow: Show the flow of messages between two process participants.
- Association: Used to associate data, text and artefacts with flow objects.

5.2.0.4 Artefacts

BPMN allows artefacts to be added to as appropriate for the context of the business processes being modelled. We added three such artefacts for our process model.

- Data Object: Mechanism to show how data is required or produced by activities.
- Group: A group is represented by a rounded corner rectangle. This can used for documentation or analysis purposes.
- Annotation: Mechanism to provide additional text information.

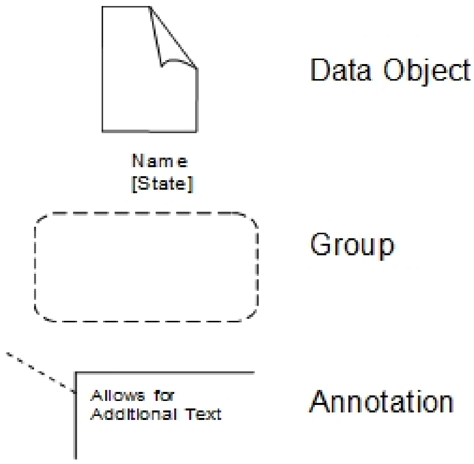


Figure 5.4: BPMN Artefacts

5.3 Step 1 - Plan or Evaluate Method

This is the original situation where no method exists. The concept of the method and the various components had to be identified. The procedure model and the product perspective of the method were then outlined in detail. Gutwillers [62] product perspective is utilized by our research. A review of the method engineering literature conducted by Braun et al. [23] validated these constituent factors.

The process model for our research involved the stakeholders of our IS, the IQ research group and IQ literature. Three workshops were conducted along with a thorough review of the literature as outlined in Chapter Two. The workshops initially acted as an education forum on IQ for the IS stakeholders. This was conducted as the literature indicated that IQ knowledge among many IS stakeholders was at best sporadic [42]. In common with what the literature revealed no formal IQ role existed for the IS. At an IQ workshop (Appendix B) of IS managers, IQ while acknowledged as important had no dedicated resource in terms of personnel, planning or training. Resource allocation was on ad-hoc case by case basis. The majority of this was reactive rather than proactive.

The identification of the order of IQ activities and the sequence in which they are carried out, followed TDQM approach [95] where the philosophy espouses a critical evaluation of IQ through out the lifecycle of the IS. Our procedural model can be described as a set of generic activities. We used requirement maps as a tool in the elicitation of the requirements for our methods. This provided us with a systematic approach to elicit our requirements. A distinct advantage of this approach and the primary reason for its selection was the ease of understanding of the by mixed ability user groups. We identified the sequence of tasks accompanied by the appropriate tools and techniques. This was completed in conjunction with survey instruments, focus groups, literature review and IQ research group. This allows for an initial conceptual model.

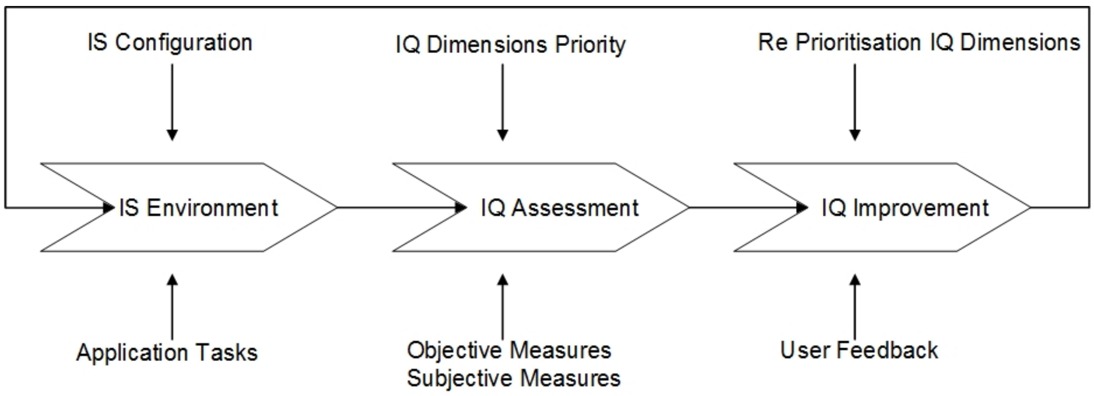
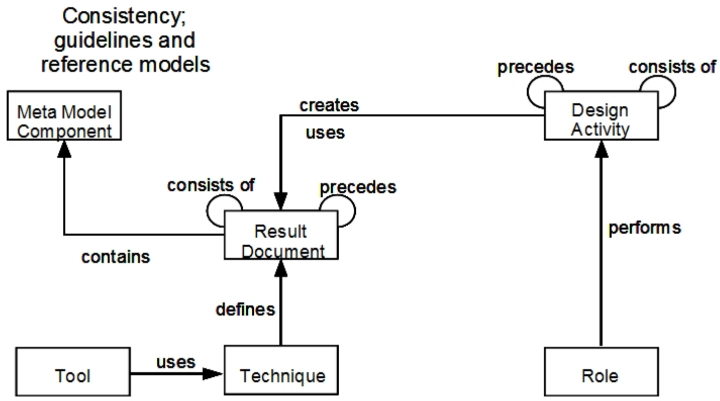


Figure 5.5: Conceptual Model

5.3.1 Conceptual Model

In order to construct the conceptual model of our novel method we were required to integrate a number of key components. These comprised of IS stakeholder knowledge, IQ expertise and IT technical know how. This compelled us to conceptualise our requirements into an initial model reflecting the relationships between the various components. The combination of the method engineering approach and requirement gathering encompasses the activities, roles, specifications, techniques and meta- model which are considered necessary for generic IQ measurement. This was accompanied by a set of business processes outlining the necessary tasks that must be completed to fully implement the method. Finally we present a meta-model of our information, thus ensuring the consistency of our guidelines. Figure 5.5 outlines a conceptual model of the various components that make up our method. These concepts are subsequently transformed into our initial procedural model as a set of sequenced activities (business processes).



Role	Design Activity	Result Document	Technique	Tool
Who performs?	What?	With the result?	Applying technique?	Using tool?

Figure 5.6: Method Engineering Approach

5.3.2 Procedural Model

The procedure model builds on the constituents of a method as outlined above in figure 5.6. We take the conceptual model and identify the design activity and the order they are to be completed. The stakeholders, roles, techniques and tools are also identified. The steps for completion of each task are outlined via a set of business processes.

The components referenced and information stored with respect to each of the business processes is outlined in the sections that follow. The adoption of this approach allowed for the detailing of tasks in a systematic manner, the details of each activity are laid out in order of necessary completion. This in turn allows for the design of specific business processes. Table 5.1 illustrates our procedural model with the techniques, tools, activities, resultant documents and those responsible outlined. The individual elements and associated business processes outlined are illustrated in detail in Figures 5.7 to 5.11.

Table 5.1: Procedure Model

Order	Role	Design Activity	Result Document	Technique	Tool
When?	Who Performs?	What?	With the result?	Applying Technique?	Using Tool?
1	Business Analyst	Select Appropriate Situational Factors	Situational Factors	Domain Experts	Survey Instrument and or Interview
2	IS and IQ Mgmt	Select IQ Priorities	IQ Dimensions and Metrics	Review IQ Lit Workshop	Internet Digital Lib
3	IS and IQ Mgmt	Implement Selected IQ Measure	Service Analyser, Integrity Checker, IQ Survey	Script and Survey Instructions	Scripts and Modules
4	IS Mgr, IT Mgr, Business Analyst	Improve	Revised IQ Dimensions	Workshops with Users	Diaries, Case Studies

Activity (1) is carried out by the Business Analyst, involves interviews and surveys with domain experts. This activity completes and measures situational factors including IS device, user competencies and the currency of IS infrastructure. Activity (2) identifies and prioritises IQ metrics and requirements and this is carried out by business analysts. Activity (3) is completed by the information technology manager, and software developers who implements the IQ measures, such as in the form of Service Analysers, Integrity Checker and IQ surveys. Activity (4) is undertaken by IS managers, information technology managers and business analyst who review and then revise the situational factors as well as IQ measures, thus initiating a continuous improvement process. Figure 5.7 illustrates an overview of the method fragments which are outlined in detail in the subsequent sections.

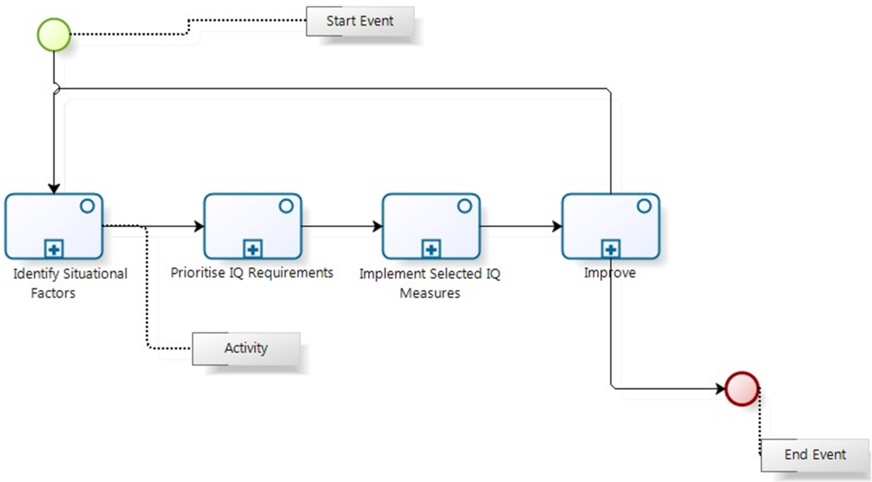


Figure 5.7: Method Implementation

5.3.2.1 Selection of Situational Factors

The selection of appropriate situational factors as illustrated in figure 5.8 includes analysis of the role groups of the IS, tasks, associated IS service and access devices employed. This assessment is done in conjunction with the domain users and IS experts. The situational factor and situational factor measurement tables are populated with the appropriate values.

5.3.2.2 Identify Stakeholders IQ Priorities

The prioritisation of IQ requirements necessitates domain experts, IS and IT managers to prioritise and rank dimensions. This may involve the application of domain metrics or survey instruments to ascertain the most important dimen-

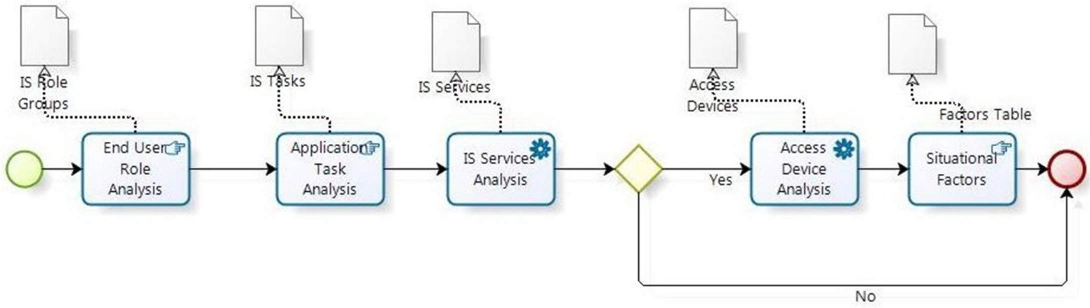


Figure 5.8: Selection of Appropriate Situational Factors

sions and may impact on the choice of measurement instrument chosen. Once completed the appropriate dimension tables are updated.

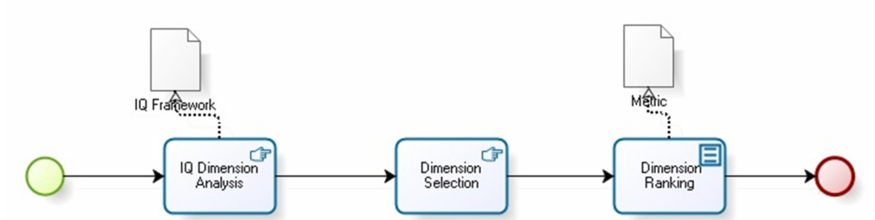


Figure 5.9: Prioritise IQ Requirements

5.3.2.3 Measure IQ Dimensions

Identification of situational factors directly affects the selection of the appropriate IQ dimensions. In certain instances binary measurement of IQ dimensions affected by internet services is required, prior to measurement of subsequent dimensions. For example, the measurement of the accessibility dimension is completed prior to subjective survey instruments. A requirement for subjective and objective classification of metrics is also necessary. Combined, these tasks provide the process to implement selected IQ measures.

5.3.2.4 Identify Improvement

The necessity for the method to be of an iterative nature, along with the TDQM approach, prompted us to include an improvement process. The process of im-

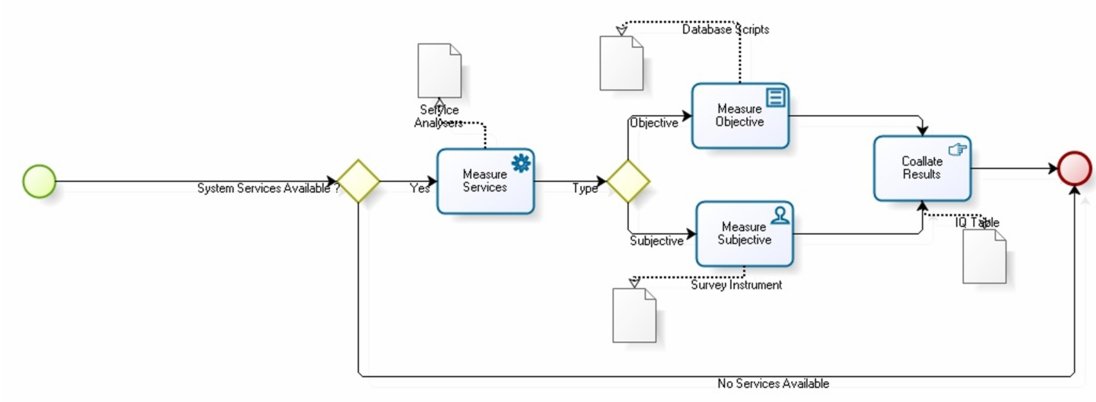


Figure 5.10: Implement Selected IQ Measures

provement involves revised situational factor analysis by means of user work and measures. Revised factors are updated in the situational factors table. The addition of finer levels of granularity to our base method is facilitated by the completion of a number of experiments. The experiments allow us to expand the rules and guidelines thus: enabling improvement.

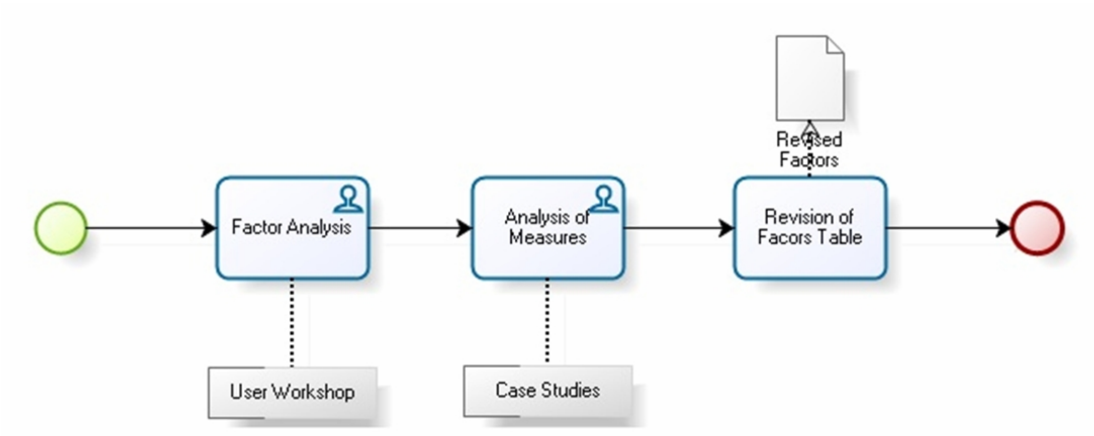


Figure 5.11: Improve

5.4 Step 2 - Identify Situational Factors

The identification of situational factors required their systematic collection and recording. The product and procedural model approach of method engineering allowed us to outline the steps involved. There was also a requirement for the storage of the information in a consistent manner, which was achieved by the implementation of a meta model. Figure 5.12 describes the meta model for recording the information gathered by our the method which comprises the situational factors, IQ dimensions and IQ measurement types. These factors are dynamic and consist of the end user role, the application task, the necessary services to access the IS and the access device as outlined in method fragment one (Figure 5.18).

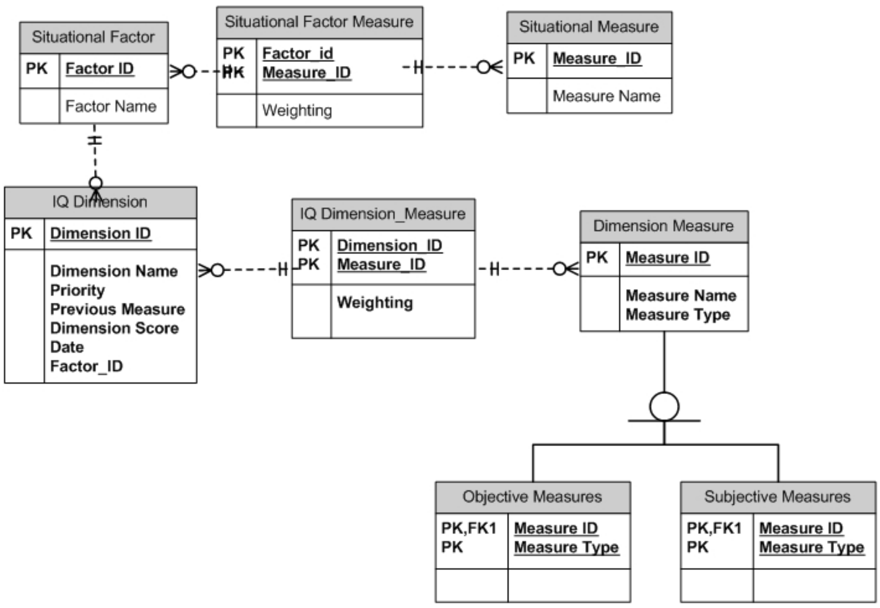


Figure 5.12: Meta Model

The employment of situational method engineering techniques allowed for the construction of appropriate method fragments and rules for each component of our procedural model. The results of each activity required systematic storage and retrieval, this also facilitated the provision of a repository.

Most method construction approaches combine inductive elements (case studies, field studies, surveys) with deductive elements (theory driven) [23]. Our research followed this pattern where we worked in conjunction with two IS (Library and Airline IS), and also examined cases from the IQ literature. The IS we examined throughout our research have identified IQ as important for their operation. In particular, the Airline IS formally measure IQ using survey instruments. However none of the IS have organisational or formal methods or guidelines for the application and measurement of IQ. Both the Library and Airline IS dealt with IQ problems as they arose on a case by case basis. A review of the IQ literature as outlined in Chapter Two has revealed that many organisations have adopted existing IQ frameworks or developed their own. However reference to adaptation of these IQ frameworks for evolving IS situations especially access modes is not evident. The review of IQ frameworks table 2.3 and the initial focus group discussions with the stakeholders of the IS identified the key dimensions of IQ.

To identify specific IQ dimension priorities we interviewed the stakeholders of both the IS and while some differences were evident in emphasis on each of the individual dimensions, there was agreement that the dimensions outlined in Wang and Strong's [147] framework offered a comprehensive view of IQ for their IS. The relative importance of some dimensions was also emphasised by the stakeholders of each of the IS. Presently this is not adequately addressed by any of the IS under study.

The situational factors that IS administrators encounter with respect to IQ require mapping to individual dimensions. The dimensions identified by Wang and Strong [147] and subsequently applied in much IQ research cater for this. Workshops conducted with stakeholders the three IS also confirmed these dimensions.

The evolution of the IS in our research included many changes since initially deployed; the number of users, the tasks and the access modes are described in terms of constant change. This presented us with a major challenge: the need to have a flexible approach to IQ measurement. The method engineering approach facilitated this by allowing for configurable methods fragments.

The planning of our method along with the identification of situational factors allows for individual configurations depending on the IS and particular stakeholders requirements. This ability to reconfigure our methods also allows for evolving situations, and the ability to apply to different IS. We identify this as a major contribution as it negates the requirement to design and build a new IQ framework as the IS evolve. The iterative approach adopted by our novel method allowed for the most appropriate dimensions, measures and weightings to be selected and adjusted appropriately to the new situation.

The procedure and product model identified in Step 1 are generic and are as result of research conducted with our IS. This provided a basis for individual IS to analyse their individual IS domains and in particular specific IQ requirements that are not of a generic nature. This also involved systematically working in conjunction with the stakeholders in each of the domains. The knowledge gained from our literature review provided us with the necessary expertise to analyse the IS from an IQ perspective. We then analysed the individual domains with respect to the following factors:

- Existing models and methods
- Existing generic knowledge about the individual domains and IQ
- Experiences from previous projects gained formally or informally

Mirbel et al. [103] support the view that lists of items (with respect to previous experiences) need not be restrictive and are also of the belief that projects staffed by very experienced personnel have a tendency to gradually build in more efficiencies. The factors identified then required them to be stored in a repository for access and amendment as the method and IS evolved.

5.5 Step 3 - Analyse Situational Factors

Familiarity with the IS environment, and knowledge of the needs of the stakeholders is crucial if the important situational factors are to be analysed correctly. The reality of our experience and that supported the literature [15, 42] is that it was impossible to analyse all situational factors in existence, but only those above a certain occurrence. These can be obtained by observation, or by empirical investigation. The focus groups and interviews with the stakeholders of the three IS involved an analysis of IQ frameworks and dimensions. The capturing and analysis of situational factors particular to each IS required systematic and in-depth discussion with the stakeholders. These workshops focused on the appropriateness of individual dimensions with respect to situational factors and requirements maps were also used for this process.

5.6 Step 4 - Engineer Method

Following on from the design of our procedural and product models along with business processes and meta-model for the implementation of our method we also propose an approach for engineering the method. The practical implementation of our method required us to engineer a solution that would apply to the principles of method engineering and the philosophy of TDQM. The adaptation of our method is critical because it must be capable of reflecting new situations as they are presented for IQ assessment. The three main scenarios as recommended by Mirbel et al. [103].

- Method configurable for scenario
- Method scenario specific
- Method scenario independent

Method engineering acknowledges that the-one-size-fits-all-approach is not applicable to many problem domains including many of those identified in the field of IS research. Consequently the need to cater for individual situations has been the focus of much research in the method engineering discipline [23, 25, 129]. The requirements of individual IS necessitate a tailoring of the method to allow for guideline selection that reflects a new situation. For example, all dimensions may not be relevant to an IS, only a subset may be required by the stakeholders. This adaptation is possible by the use of situational methods.

5.6.1 Situational Methods

Situational methods incorporate distinct configurations allowing for individual situations, and users and roles can be altered for different situations. The adaptation of a method against the particulars of a specific problem domain offers our research an appropriate approach to catering for the diverse access modes to IS.

The methods constructed can be considered as artefacts as outlined in our discussion of Design Science Research. Gericke et al. [59] state that *"they describe viable ways of performing goal-oriented activities in order to solve a real world problem"*.

Method fragments are initially identified and associated with a method, thus allowing for reuse and consistency. Rules can then be derived for individual scenarios. The provision of a rule set and order within the method ensure that the methods are unique and that rules are not duplicated. The rules can be amended, enhanced or dropped as situations evolve. This approach offers a higher degree of flexibility to the users ensuring that its application is not overly rigid yet simultaneously possess enough structure for its application. Our research involved diverse access modes and consequencently this proved appropriate; facilitating dynamic and diverse access modes to IS by the combination of appropriate method fragments and rules.

The construction of the method commences with an examination of the method containing the individual method fragments and associated rules. The rules and fragments when obtained combine to give appropriate method for a particular situation. Mirbel et al. [103] indicate the process is comprised of four steps:

- Characterisation of the situation
- Identification of method fragments
- Development of method configurations
- Assembly of fragments

Applying Mirbel et al. [103] method engineering approach to our method design offers the ability to provide adaptation as the IS situation evolves. Following the four steps outlined, provided us with a structured approach for method, chunk (process and product of method fragment combined) and fragment construction along with rule selection. This approach places a heavy emphasis on flexibility for configuration of individual situations. The applications of TDQM approach have presented us with many diverse access modes thus challenging us to cater for IQ measurement in a very diverse number of situations.

Situational Method Engineering (SME) allows for both project specific method construction along with customization for each participant group. We initially identify roles (types of users) that conduct individual parts of the situational method. This allowed us to select the particular fragments that support the different tasks of the roles identified.

Figure 5.13 illustrates the overall approach to engineering our novel method design along with the steps and stages involved in the adaptation and employment of it to a particular situation. Our approach, as illustrated is composed of two stages combining both assembly based and roadmap driven method engineering approaches. The aim of the initial step is to build our method in a systematic and structured manner where we interface with the reuse frame and method fragment repository while the second step involves an optimization of configuration. In essence, the constituent stakeholders validating the appropriate method fragments and rules as proposed by our method design.

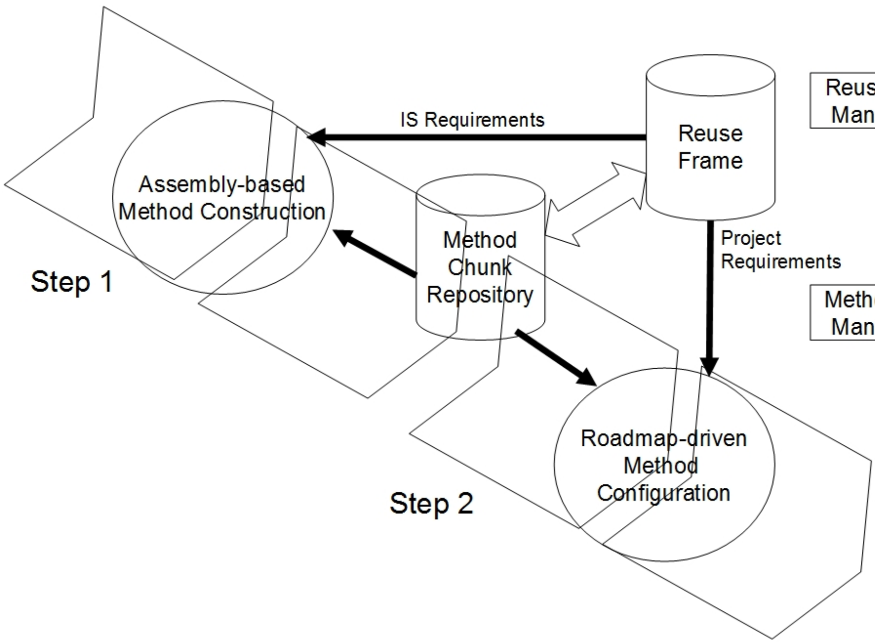


Figure 5.13: Method Construction and Implementation Adaptation of Mirbel et al. [103]

Foremost method engineering research [25, 59, 129] attaches importance to both the method engineer and the domain specific expert to ensure successful implementation. In our research it is imperative that IQ and IS proficient personnel drive the roadmap configuration. The meta-model outlined in our design caters for the consistent storage of information. This required us to construct a method chunk repository, roadmap and reuse frame.

5.6.2 Method Chunk and Repository

An essential element of our approach was the need for encoded guidelines enabling stakeholders to access knowledge with respect to IQ measurement. The method chunk collection provides this in the form of a repository, which holds reusable method fragments, and its maintenance and currency is central to the successful implementation of our novel method. The combination of process and product fragments is often referred to as a method chunk in an integrated approach [25]. Rolland [125] refers to this concept as a method block where process and product components are combined into the same modelling component.

The method chunk as illustrated in figure 5.14 is made up of two interrelated models namely the product and process model. The product model defines concepts, constraints and relationships while the process model describes how to construct the corresponding product model. In the case of our method the method chunk providing guidelines (process part) for the use of the IQ framework in a diverse IS situation is complemented by definitions of concepts such as IQ dimension, IS environment and principle actors (IQ and IS) that are necessary for the construction and instantiation of the method.

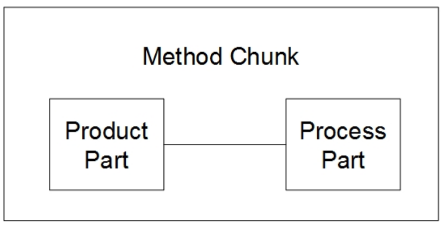


Figure 5.14: Method Chunk

5.6.3 Roadmap for IQ

The roadmap provides a guide for one, or many, of the relevant method chunks taken from the situational method repository for use by an IQ manager in measuring IQ for an individual situation. The roadmap provides the IQ manager with guidelines, and experiences, about similar situations accumulated in the repository. The implementation of the roadmap can be done from three perspectives.

- A member of the IQ management group requests the method chunks appropriate to a particular situation for IQ measurement; that has occurred in the past. For example, the method chunks appropriate to IQ measurement for an IS that is exclusively accessed by PC desktop application.
- The IQ management group looks for assistance on a particular point of an IQ method. For example, he / she may look for the guidelines or rules on how to implement IQ measurement instruments for new IS situation.
- The IQ management group wishes the situational method to be presented from a particular perspective. For instance, assistance may be requested for the implementation of IQ measurement with a novice user group. In this case, an appropriate set of guidelines, with regards to novice users are chosen.

The roadmap objective is not to provide IQ management with a full and detailed outline of all tasks they need to fulfil during the IQ measurement process, but to offer assistance and / or guidelines about similar situations that have been accumulated in the repository.

5.6.4 Reuse Frame

The practical use of methods and models suggests, that adaptation is always critical to their successful implementation. Project related factors, the unique configuration and implementation of technology, user experience, technical know-how and many others, necessitate flexibility. The tailoring of methods is supported by the assembly of predefined chunks. The classification and retrieval techniques implemented in our method are based upon structural relationships among chunks and reuse intention.

When constructing methods information about organisational, technical and human factors should be taken into account in addition to IS structural knowledge [125]. This caters for both quality method chunks when entering them into the repository and also allows for a better matching and higher potential of reuse. Our research therefore implements a reuse frame that aggregated different IQ critical aspects necessary to tailor our methods with regard to the organisational, technical and human aspects of IS deployment. The elicitation of these aspects also provides the basis for the rule base in our repository.

Building on previous research by Mirbel et al. [103] we implement a polymorphic structure facilitating the construction and classification of reusable assets dedicated to method engineering, describing IQ critical knowledge in terms of aspect belonging to aspect families, these aspect families are refinements of the four main factors of consideration for IQ frameworks and measurement.

Relevant knowledge with respect to the IQ methods for the particular IS are included in the reuse frame, and it is represented in the form of a tree where leaf nodes are aspects and intermediary nodes are families. Nodes close to the root node can be viewed as general aspect while those close to the leaf or the leaf node themselves can be viewed as precise aspects. The top of the reuse frame in figure 5.15 represents the generic position at the commencement of a typical IS and IQ development project. The TDQM approach throughout the lifecycle of the IS allows for further refinement and further additions of leaf nodes as more and more detail with respect to the IS, the user profile IQ assessment and IS access mode become available.

A leaf node is defined by a name and completed by information about relationships among the different aspects or sub-families belonging to it. This additional information provides further refinement, specifying more clearly the exact manner in using and implementing the individual aspect. This also allows for an exact specification of their application particular to a given situation, for example the selection of appropriate aspects for the measurement of IQ and diverse IS access modes. Two kinds of information are provided:

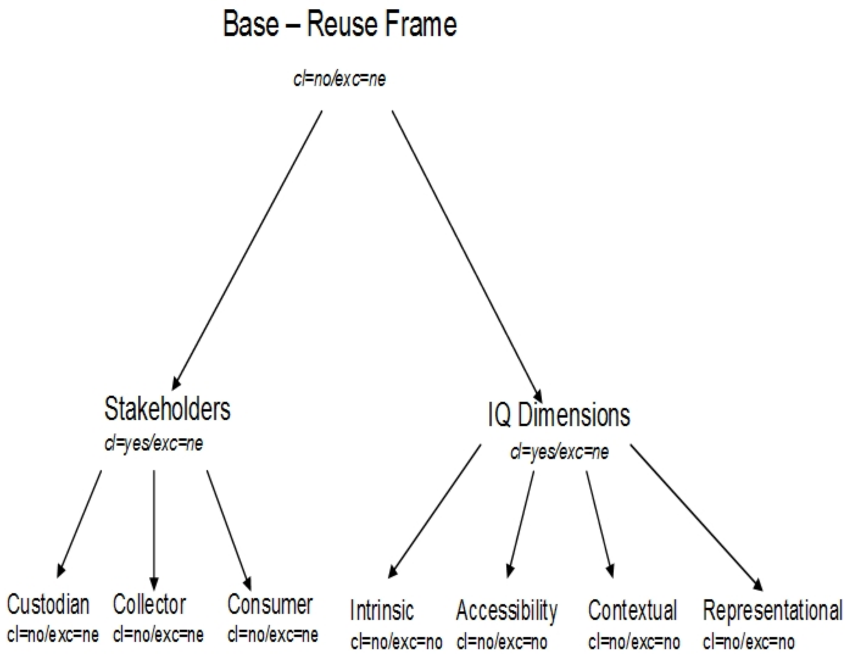


Figure 5.15: Reuse Frame

- Classified field: indicate if direct aspect or sub-families are classified (cl=yes) or not (cl=no). For example, in the Accessibility family, Access Security can be classified initially as weak, medium or strong. The initial information for this and other aspects was obtained by interviewing domain experts. Indicating this information assisted us when retrieving chunks associated with the measurement of IQ from diverse IS situations. The application of the TDQM philosophy allows the repository to be appended as more information is gathered with respect to the individual aspect.

- Exclusion field: indicates whether direct aspects are exclusive. For example guidelines may be given for an IS where timeliness is a family with real time and delayed as aspects. These can be specified as exclusive as the guidelines for each are different and consequently any weighting allocated would be different.

Capturing all relevant aspects with respect to an IS, is by its nature, dynamic and continuous. Our conceptual model in figure 5.6 illustrates the various components of the environment. We designed a base reuse frame to capture its various elements, so the reuse frames are in essence a mapping of the environment that the IS operates in to a set of generic base guidelines for method construction. Consequently to represent this fully we follow best practice from the IQ literature [42, 147] which advocates that a successful IQ strategy must revolve around the key stakeholders; namely the collector, custodian and consumer.

5.6.4.1 Reuse Family for IQ Dimensions

The four themes characterising IQ as outlined by Wang and Strong [147] were repeated or adapted across a wide number of frameworks as detailed in our citation map (page 28). These four themes and associated IQ dimensions were also to the fore with the stakeholders of the IS that we conducted our research on. As many of these frameworks referenced this seminal work, and many of the individual dimensions were repeatedly mentioned by the IS stakeholders, we decided to represent the four aspects for our IQ reuse frame accordingly. This is the critical knowledge that a project must capture with respect to the importance of IQ to individual stakeholders. The relevance of each dimension was classified as low (L), medium (M) or high (H).

We proposed a generic initial state for each of the IQ families identified. Wang and Strongs [147] framework and dimensions were then discussed in detail with the key stakeholders of the IS for our research. The relevance of the individual IQ dimensions to particular stakeholders is critical and will evolve with the use of the IS, both the reuse frame and repository reflect this. These allow the IQ manager in consultation with the stakeholders to prioritise IQ dimension selection.

5.6.4.2 Reuse Family for IQ Stakeholders

The key stakeholders of information are the creators, custodians and consumers of information [58]. Their perspectives with respect to IQ vary and it is incumbent on the IQ management team to ascertain this with respect to individual dimensions. The level of expertise of the stakeholder is of course also a critical factor, and the IQ management team must review this on a regular basis as the user population of an IS generally is dynamic.

The rules for initial repository are populated following in-depth discussions with domain users they provide an initial roadmap for method construction and the detailed trees and tables for the thesis are those conducted for the Library and Airline IS. In essence the roadmap provides a set of guidelines for the application of the IQ framework. Over time the application of the frameworks will mature via the method chunks, producing guidelines for each phase of the IQ life-cycle: thus mapping to the TDQM.

5.7 IQ Method Construction - An Assembly Based Approach

Next having outlined the various components involved in our method, we outline the manner of its construction. The use of assembly based method construction is suited to our research as it allows for the construction of a method as the situations of a particular project dictates. It involves the selection of method components (chunks) from the method chunk repository and assembling them. This approach to method engineering can be broken down into three distinct areas: methods requirements engineering, method design and finally method construction and implementation. Drawing on the TDQM philosophy [95] the involvement of the stakeholder is critical throughout the IQ lifecycle, it is crucial therefore that the stakeholders are central to the entire process.

5.7.1 Method Requirements Specifications

The specification of method requirement for a particular IS depends on the initial method situation and the IQ goal of the particular stakeholder. Our research identified two fundamental situations:

- The IS and IT Manager along with the IQ management implement the method as outlined by our design.
- The IS and IT Manager along with the IQ management team deem that no suitable method chunk exists in the repository.

In the first instance the method is applied with the results being recorded in the appropriate tables outlined in the data model. Prioritised functionality particular to the IS may also be added. In the case of diverse IS situations this may entail the method facilitating the introduction of new access modes. Where the need to adapt the method chunk exists in order to facilitate this, a requirements elicitation process is key and must be driven by the identification of the new IQ intentions. In the case of new functionality the full set of requirements must be elicited. It is important that IS, IT and IQ stakeholders thoroughly examine the existing method base prior to embarking on the amendment of the method chunk.

Both approaches lead to requirements specification expressed by the IS, IT and IQ managers in the form of a guideline map [124]. The example of guideline map in figure 5.16 illustrates how we conducted the elicitation of requirements. This was followed by their conceptualisation, either by scenario or use cases, and their validation by prototyping. This enabled us to adapt the application of our method as the project situations evolved, and particularly as the diversification of IS situations changed.

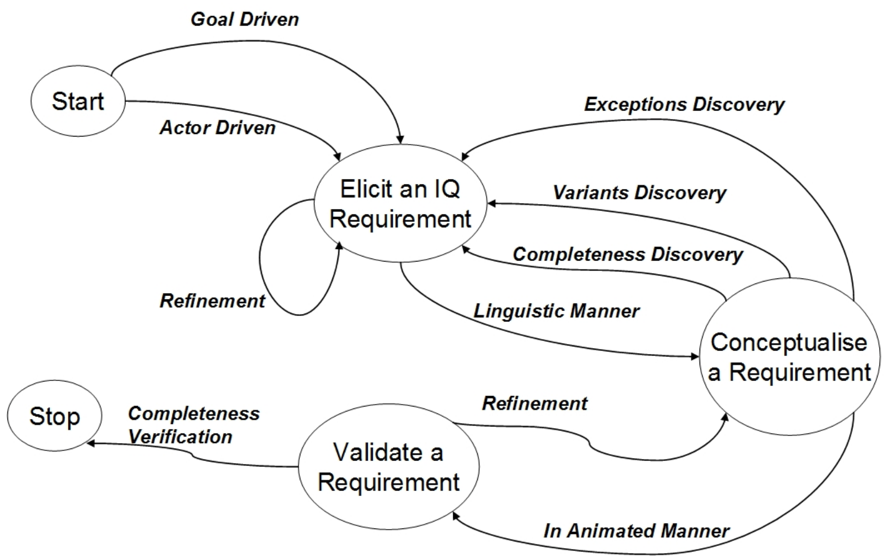


Figure 5.16: Requirements Map

5.7.2 Method Chunk Selection

Specification of the method requirements is followed by the identification and selection of chunks. Their selection is based on the requirements map defined in the requirements engineering step. The IQ management team, IS manager and IT manager must satisfy themselves to the appropriateness of the particular chunks. The product and process description of the chunks are initially examined, and the reuse frame where the initial details with respect to the IQ dimension aspect and the IQ stakeholder aspect is then interrogated. The assembly of the chunk with respect to its rules and processes is then initiated. Initial application of our research describes a generic reuse base, but as we apply our method this base can be appended to with new rules and aspects generated throughout the application of our method.

5.7.3 Method Chunk Assembly

Assembly then follows the selection of the appropriate method chunks. Two approaches for method chunk assembly can be adopted; assembly by association and assembly by integration [125]. Assembly by association is most useful when one chunk is used as a source product for the second chunk [103]. The products of the individual chunks must be connected by defining links between their different concepts and rules while the connection of the processes is dependent on their order of execution. For example, method chunks providing guidelines for IQ dimension measurement requires that a chunk with respect to users of the IS have been already specified two chunks may have complementary objectives but their assembly is limited to the identification of the order in which they must be executed.

Assembly by integration is applicable to chunks having similar goals but provide different ways to achieve it. Initially, in our research, this is limited as the method repository contains only the base generic method chunks, but throughout both the IQ and IS lifecycle this will expand as the experiences and needs of the key stakeholders evolve. The conceptual view of our solution based on the TDQM philosophy provides for constant feedback and consultation with each of the stakeholders. For example it could be useful to integrate a chunk for IQ requirements gathering for two very similar user groups, or to reflect the restructuring of a business group. In our research with the Airline IS we initially defined a number of technician user groups, but the assembly integration process of IQ requirements conducted by the IS manager, the IT manager, the IQ management team and the stakeholders integrated these individual method chunks.

5.8 Method Configuration - Roadmap Approach

The roadmap driven method configuration aims at customizing the IQ project specific method in order to match the possible profile of the IS stakeholder. This allows for a specific set of guidelines, or a roadmap for specific groups. Stakeholders add to the repository by providing feedback that allows for the adaptation of mechanisms based on experiences from previous stages of the IQ lifecycle. This provides more detail to the IT, IS and IQ management group. Through these different means a roadmap is produced that is most appropriate for the needs of the individual stakeholders.

Roadmap building completes the process of method chunk selection and assembly and there are a number of ways the roadmap can be constructed. The stakeholders must consider this when implementing the situational method approach. Factors such as user experience, IS, IT and IQ management know how and familiarity with the IS, IQ frameworks and method engineering techniques must be considered. The implementation of the roadmap can be completed in a number of ways depending on the IS capabilities of the organisation [103] as illustrated in figure 5.17:

- Guided roadmap building consists of manually selecting method chunks from the project specific method as outlined. Interrogation of the reuse frame with the various families and aspects assist in this. The IQ management team in conjunction with the stakeholders are central to this approach in constructing a project specific method map.
- Balanced roadmap building allows for a more formal specification of rules for a particular intention and context. The selection of the chunks appropriate to a given context is based on these rules. The method chunks are proposed

to the IQ management team for selection. As an IS matures and more knowledge is added to the repository the approach may become more viable.

- Free roadmap building is direct selection of the method chunk from the repository without the help of the reuse frame or project specific method. This approach maybe suitable for an organisation with a very mature IS and IQ requirements.

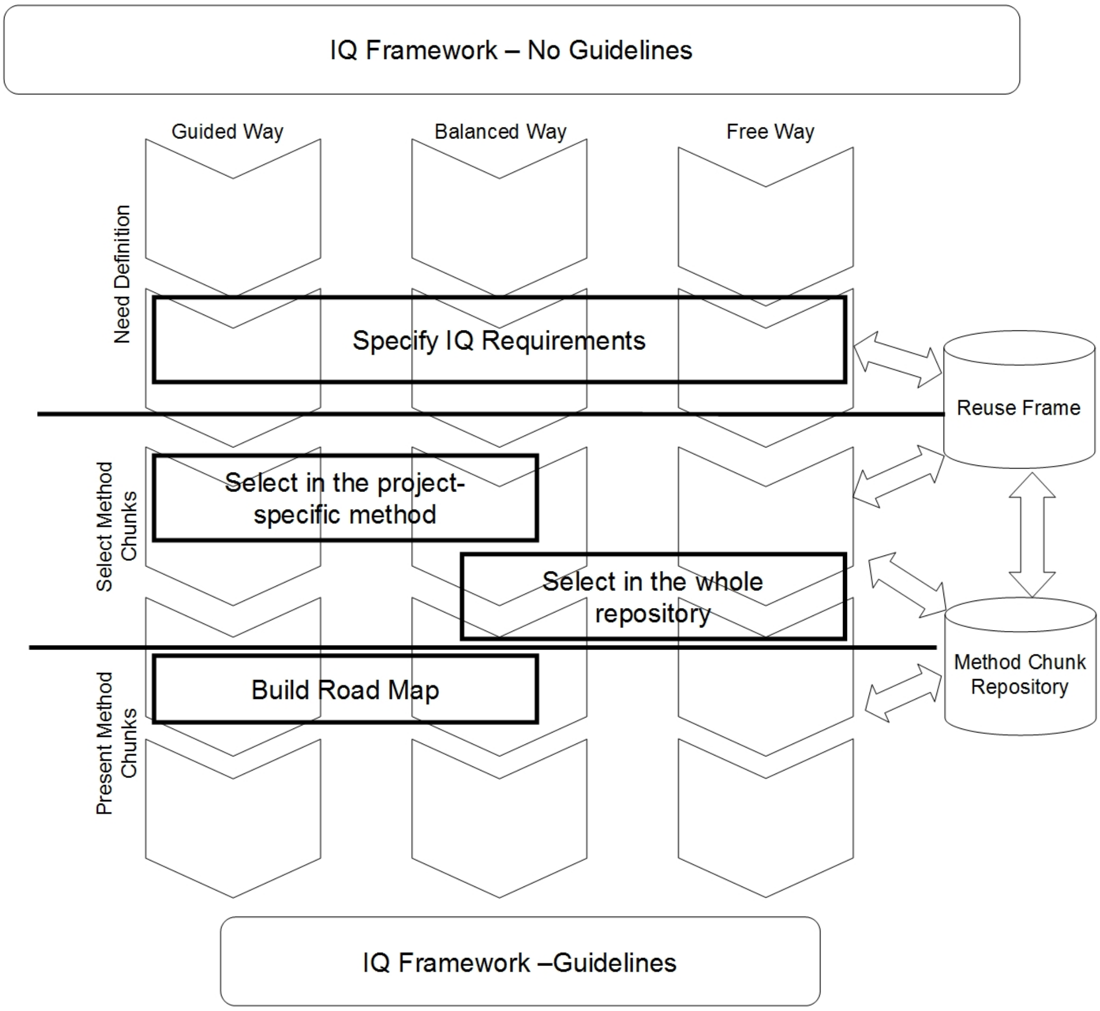


Figure 5.17: Method Assembly Approaches

As our approach is novel we decided to initially implement our roadmap in a guided manner. We contend the cooperation of the various stakeholders and the continued implementation of our method over time will allow for the evolution of the approach to a Balanced Way followed by progression to a Free Way implementation.

5.9 Method - Controlled Application

Our novel method is initially applied in a controlled fashion in conjunction with the IQ dimensions outlined in Wang and Strongs [147] framework. This application of the method does not involve the roadmap and repository as they are only populated post collection of data from its application. The Library IS provided us with the initial environment for deployment and application. Our research approach involves us working in conjunction with the stakeholders of the IS. Initial application of the method, allowed us to populate the rulebase for each of the IQ dimensions in the framework. Adopting the assembly and roadmap based configuration approach in conjunction with the IQ method definitions, outlined above, our research gathers the necessary information for our meta-model. Consequently this allows the IQ manager to apply the measurement instrument (AIMQ) with the knowledge base and the appropriate method fragments providing for a more comprehensive IQ measurement. Figure 5.18 illustrates the sequence of events, we outline the tasks and their order of completion. The various objects (meta model, reuse frame and method chunk repository) that require amendment are illustrated, and the application of the method fragments to the library IS domain are outlined in detail.

5.9.1 Identify Situational Factors Fragment

The application of our method to the Library IS commenced with a workshop on IQ, to inform the stakeholders of the principle concepts of IQ with an emphasis on IQ dimensions. The user groups and task associated with them and the Library IS were then identified by means of interview and database scripts. The services necessary for IS access were also identified. Because the potential number of tasks completed by any particular user group could in theory be exhaustive; consequently we prioritised these. Also as this was the first iteration of application

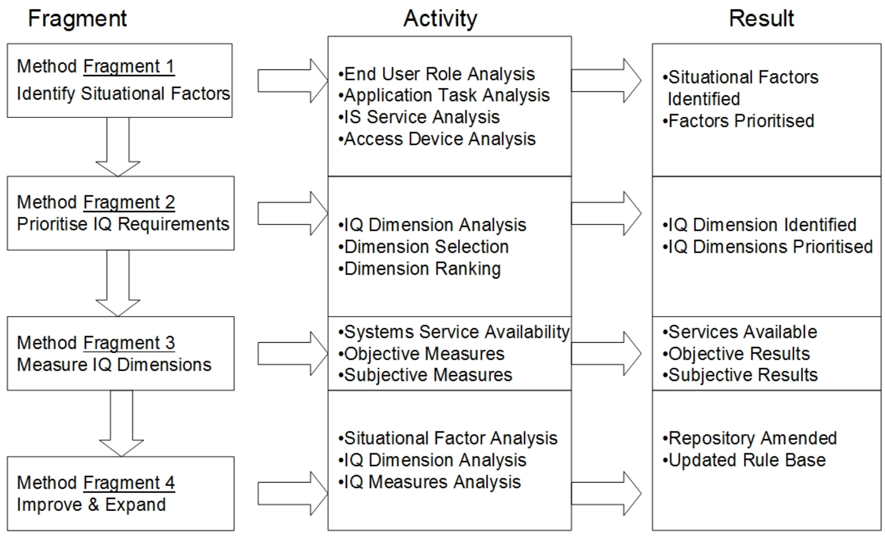


Figure 5.18: Method Fragment Sequence

of the method we confined the tasks to the top three tasks for each of the user groups identified. This was done by database transaction log analysis and focus group discussion with the users of the Library IS. Table 5.2 outlines the results of the application of the fragment.

5.9.2 Identify IQ Dimensions and Measurement Instruments

Identification of the main IS tasks is followed by the selection of appropriate IQ dimensions and accompanying measurement, or survey instrument. The subjective nature of IQ and the requirement to ensure that information is fit for purpose were discussed with the Library IS workshops. The most complete view of IQ is only possible if this is discussed. Our research identified the heterogeneous nature of IS access, not only is the selection of appropriate survey instruments important but an analysis of the IS environments and selection of appropriate measures, to ensure a minimum level of service quality is also necessary. These services have been identified in the IS Situational Factors Fragment. The sequence of execution of measurement instruments was also deemed important.

In discussion with both Library IS and IT managers the necessity to check IS

Table 5.2: Output IS Situational Factors Fragment

User Group	Application Task	Services	Access Device
Library Staff	Catalogue Search, Update, Delete	Database Listener, Web Services	PC, Notebook, PDA
Systems Admin	Add Users, Change Permissions, Add Role Groups	Database Listener, Web Services	PC, Notebook, PDA
Library Users	Catalogue Search, Book Retrieval, Book Return	Database Listener, Web Services	PC, Notebook, PDA

services for the environment prior to subjective views of users is required. Only when an appropriate level of service is in place should subjective views be sought. This is presently not the case with the application of survey instruments examined in the literature review as the advent of many of these services is post development of the IQ framework [147]. The workshop also discussed the use of objective IQ measures. The employment of objective measures for intrinsic dimensions was identified as a complimentary approach to the subjective measures. The initial application of the fragment only identifies the IQ dimension, but in further iterations .more detailed information for the individual IQ dimensions is catered for. Table 5.3 illustrates the output from the application of the IQ dimensions fragment.

5.9.3 Measure IQ - Fragment

The identification of services, dimensions and measurement instruments both objective and subjective is then followed by their application. The sequence of their application ensures that the meta-model is updated in a consistent manner. The objective and subjective measures are only applied if the adequate level of services are a available. The services identified in the library IS were classified

Table 5.3: Output IQ Dimensions Fragment

Service Measures	IQ Dimensions	IQ Measures - Subjective	IQ Measures - Objective
Port Check Database Listener, Port Check Web Services	Believability, Accuracy, Objectivity, Reputation, Value-added, Relevancy, Timeliness, Completeness, Appropriate Amount of Data, Interpretability, Ease of Understanding, Representational Consistency, Concise Representation, Accessibility, Access Security	AIMQ Survey Instrument	Database Scripts

by us as binary services i.e. either available or unavailable.

Essentially this means that their unavailability prevents the unnecessary collection of objective or subjective results. This is important as this provision is not adequately catered for with existing IQ measurement. Web and mobile services are integral constituents of contemporary IS deployment. Table 5.4 illustrates the output of the IQ Measurement Fragment.

Table 5.4: Output IQ Measures Fragment

Service Measures Result	IQ Results Subjective	IQ Results - Objective
Port Check Database Listener, Port Check Web Services	AIMQ Survey Appendix A	Database Scripts

5.9.4 Improve IQ

The final fragment of the initial application of our method involved an analysis of the results of the IQ measurements; the approach adopted, the services analysed along with the dimensions selected. The population of the rule base along with the necessity to amend or outline, in more detail, the method fragments was also examined. This was conducted via a review of work diaries from each of the stakeholder groups and a workshop. These workshops identified and reprioritised the IQ dimensions that the stakeholders agreed were most relevant. Associated service measures, objective measures and subjective measures were also outlined. The main output of this workshop was to outline in more detail the applications of each the IQ dimensions, which was then populated into the rule base and acts as a commencement point for the next iteration of the method.

Table 5.5: Output IQ Improve Fragment

Situational Factors	**IQ Dimensions**	**IQ Measures**
Updated Situational Factors	Updated IQ Dimension	Updated Measures

5.10 Population of the Reuse Frame

The second component of the application of the method is the population of the rule base for the reuse frame. The aim of the reuse frame is to gather knowledge relating to the application of each of the method fragments. This facilitates a more informed application of the method in subsequent iterations. Prior to subsequent applications the reuse frame can be accessed to obtain the most current guidance for each method fragment. The initial capturing of this information is in narrative form, allowing for manual application in a guided way, whilst keyword analysis could facilitate the automation of this process, and allow for its application in a balanced (semi automatic) or free way (automatic). This is outside the scope of our research. As previously stated the context of the IS must be considered when evaluating IQ, however the number of factors for any given context could be exhaustive. The reuse frame, families and aspects allow for the recording of non structured information that is of particular relevance to a given situations. The reuse frame application will be expanded upon in Chapter Six with the Airline IS.

5.11 Chapter Five Summary

In this chapter we outlined the components and sequence of events for the design and construction of our method. Adopting a method engineering approach we initially outlined a meta model, comprising of process and product parts that combined made up a number of method fragments. We also introduced the concept of a reuse frame, which allows for the systematic recording of IQ data. The method and reuse frame were built in an iterative manner in conjunction with the stake holders of the Library IS. In Chapter Six we build on this will evaluating a complete application of the method and reuse frame in conjunction with the Airline IS.

6

Method Evaluation

6.1 Introduction

In Chapter Five we outlined the design and construction of our method, in conjunction with the Library IS where we employed an iterative process with the stakeholders, experiment, and the method design and construction. The genesis of our research is the poor perception of IQ from diverse IS situations. In the Airline IS, the operational nature of this IS did not facilitate experimental intervention necessary for construction of our method. However it was possible to evaluate the utility of our proposed method by its application to the Airline IS. This comprised of two parts; an initial evaluation of the application of our method along with population of our rule base repository, where we employed workshops and gap analysis techniques.

Our experiment with the Library IS demonstrates that the diverse IS situations have an impact on user perception of IQ. Although there are certain limitations with respect to a single domain, the evidence proffered by the airline IS is worthy of evaluation as increased problems of IQ have come about with diversification of IS situations in terms of access. Our method provides a mechanism for conducting IQ analysis and measurement allowing for the application of variance weightings that may be applicable to diverse IS situations. As outlined in the problem statement for our research IQ problems were becoming more prevalent for the IS and more resource intensive for the MIS department. The day to day running of the Airline involves routine rating of quality across many areas of its operations, not just IT and IS. Our analysis of IT helpdesk logs with respect to the IS over a three month period indicates that the majority of the logs are concerned with some aspect of IQ. Other requests relate to routine administration of the IS such as requests for new users, password change and role group analysis or updating.

6.2 Overview of Airline IS

The Airline IS is a bespoke system with a relational database management system (RDBMS) built to capture the necessary details for operation and maintenance of aircraft and associated tasks. The users access the IS through a number of IS situations; workstation, personal computer and mobile devices. The original interface was command line driven but this has evolved to graphical user interface (GUI). Data input was initially completed by the MIS department but this has evolved over time with all users now entering their own data via a number of IS situations. The IS has a four distinct stakeholder groups:

- Pilots: The pilot modules of the application allows for the filing of flight plans, including features such as route management, load management, fuel requirements, etc. The pilots interface with the application before and after flights. No specific IS situation is laid down, access to the IS is via a mixture of mobile devices and desktop PCs.

- Engineers: The engineering modules application facilitates the procurement and inventory management of parts required for the ongoing maintenance of aircraft. Again no specific IS situation is laid down, access to IS is via a mixture of devices including desktop PCs and more recently tablet devices.

- Administration: The administrative modules cater for time and attendance and provide data for a separate pay database. This section of the application is predominantly accessed from desktop PCs.

The business rules of the IS have evolved over its lifetime, these changes have been incorporated in amendments to the application and its database schema and are well documented. A help desk is in place that facilitates concise recording of user issues concerning the IS and IT in general. User training is also provided at intervals through out the year. A combination of in-house and external consultants support and maintain the IS. The ORACLE DBMS (Enterprise Edition 10g) is hosted on a UNIX server, an ORACLE forms server is employed for the application. User authentication is via the network operating system and separate individual user login for Airline IS application. The role groups, correspond to the stakeholders outlined in section 6.2. Access to the IS is via database software on the DBMS server (MIS stakeholders) web client on the desktop PC and mobile devices (PDAs and Smartphones).

6.3 Evaluation Approach - Method Application

After the build phase of our proposed method it is necessary to evaluate the constructed artefact. Data from the experiments conducted with the Library IS assisted in this process, as it identified suggested variances in IQ depending on IS situation. This information was used in conjunction with our method and in particular with respect to the road map for method implementation. Pfeiffer and Niehaves [114], evaluation of conceptual models adopt a holistic approach to the evaluation of the artefact, consisting of an analysis of artefacts for evaluation and criteria for their evaluation. The holistic approach adopted by the conceptual model is suited to our research as it facilitates a comprehensive evaluation of our method, which is similar in philosophy to the TDQM approach that we adopted throughout our research.

The first component of the model addresses the IT artefacts, including constructs, methods, models and instantiations. The conceptual model requires that methods explain in detail the process of problem solving, in conjunction with guidelines to provide for a solution. The second component of the model details the structure, evaluation criteria and evaluation approach that collectively provide for a holistic approach to evaluating the IT artefact [114].

- Structure of the Artefact: Determines the configurational characteristics necessary to enable the evaluation of the IT artefact. Based on this structure, all required information about the artefact can be deduced. The structure represents the information space the artefact spans.

- Evaluation Criteria: Specifies the dimensions of the information space which are relevant for determining utility of the artefact. These criteria may differ on the purpose of the evaluation.

- Evaluation Approach: Defines all roles concerned with the assessment and the manner of handling the evaluation. The result is a decision on whether or not the artefact meets the evaluation criteria based on the available information.

The conceptual model also outlines examples of corresponding research results for each of the constructs. Table 6.1 describes those that are appropriate to the method artefact. We employed these to inform our approach to evaluation of our method for diverse IS situations and IQ.

Table 6.1: Conceptual Model to Evaluate IT Artefacts (Methods)

Artefacts	**Structure**	**Evaluation - Criteria**	**Evaluation - Approaches**
Method	Process Based Meta Model, Intended Applications, Conditions of Applicability, Products and Results of the Application	Appropriateness, Completeness, Consistency	Lab Research, Field Enquiries, Surveys, Case Studies, Action Research, Practice, Descriptions, Interpretative Research

Pfeiffer et al. [114] state that a core constituent of a method is given by a process model, which must describe how to reach the objective of the method.

Becker et al. [17] ascertain that the model has to explicitly state the product and results of its application as well as constructs used in the context. In the case of our method this is systematically mapped using Business Process Modelling.

Critically Greiffenberg [61] points out that in order to appraise the applicability of the method it must describe its conditions and intended scope of application. Greiffenberg [61] also outlined the criteria to evaluate methods, and three criteria are recommended to evaluate the artefact:

- Appropriateness: Verifies whether the method is efficient, well structured and easy to apply.
- Complete: Describes the methods inputs and outputs as well as its processes and relations.
- Consistency: Satisfied if all the method elements are mutually compatible.

The evaluation of methods can be completed by employing field surveys, case studies and action research.

Gericke et al. [59] believe that the validation should be realised within different steps. Initially, the utility of the identified method fragments should be proven. Next the identified roles of possible method users and the developed method configuration should be evaluated regarding their appropriateness. Finally Gericke et al. [59] suggests that the interplay of the different method fragments, i.e. the whole method should be evaluated by applying it in real implementation projects.

Design Science research [68, 110] requires that upon construction of the artefact evaluation must be clearly demonstrated. The validation of our method is performed through a verification of its implementation. We examined the impact that diverse IS situations had on the perception of IQ. We initially examined the field of IQ and associated frameworks and dimensions. In order to address and overcome the problem we constructed a method to aid in the implementation of an IQ framework. Experiments further enhanced this, by demonstrating that perceptions of IQ are affected by the diverse situation of access.

The Library IS experiment provided us with an excellent opportunity to test our hypotheses with respect to the individual IQ dimensions. It also acted as our development ground for the method fragments, business processes and models.

This involved prototyping, workshops, interviews and focus groups, and was iterative in nature with many of the participants being central to the process. This allowed us to apply and revisit method fragments regularly until we refined the individual fragments. This involved a major rework of many elements along with much discussion and suggestion from stakeholders and IS professionals. We decided to conduct the assessment of our method with the airline IS because there was a greater ability to assess the method independent of a specific domain that it was developed in.

An action research approach is adopted for this portion of our research, as we are active participants in the intervention or action studied. There is a requirement to heavily interact with the stakeholders of airline IS; therefore an organisational rather than a machine solution is deemed appropriate. This lent itself towards a methodology where the affect on the stakeholders is a central tenet of the philosophy. Checkland [28] describes it as holistic rather than reductionist. Baskerville and Harper [14] describe the ideal domain of the action research method is characterised by a social setting where:

- The researcher is actively involved, with expected benefit for both researcher and organisation.
- The knowledge obtained can be immediately applied, there is not the sense of the detached observer, but that of an active participant wishing to utilize any new knowledge based on an explicit, clear conceptual framework.
- The research is a (typically cyclical) process linking theory and practice.

Susman and Evered [138], as described in Chapter Three detail a five phase, cyclical research process. The approach first requires the establishment of a client-system infrastructure or research environment. Then, five identifiable phases are iterated:

- Diagnosing
- Action Planning
- Action Taking

- Evaluating
- Specifying learning

6.4 Method Evaluation The Airline IS

Adopting Susman and Edwards [138] overall action research approach in conjunction with Pfeiffer and Niehaves [114] conceptual model facilitated an evaluation of our method, which involved its implementation with the Airline IS . The various elements of our method were applied appropriately throughout the Action Research Lifecycle. The effectiveness of our method is measured with respect to the appropriateness of the solution proffered. The client system infrastructure as illustrated in figure 6.1 specifies and lays the agreement for the boundaries of the research. In some instances this may be a formal agreement while in others the boundaries are agreed upon. At a minimum the responsibilities of the client and the researcher need to be agreed upon.

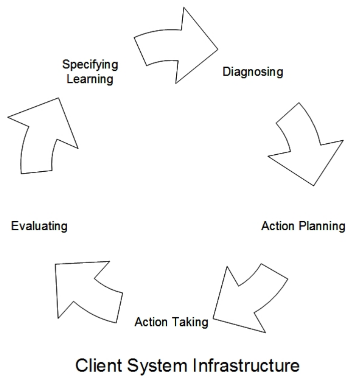


Figure 6.1: Action Research Cycle

As researchers we provided assistance and know how for the implementation of our method to tackle the problem as laid down by the client, namely the problem of poor IQ from diverse IS situations. The importance of client cooperation is fundamental to the successful implementation of our method, without this the results of the method application may be of limited use.

The key stakeholders of the airline IS were identified along with the main functionality for each of the groups. The roles and responsibilities of the MIS team were outlined while a reporting structure for the research was also established. Clarke [30] summarizes the role of the participants in action research, emphasising the importance of successful application where solutions to practical problems are the measure of success. *"For convenience it is useful to think of the practitioner as part of a set of actors who are oriented to solution of practical problems, who are essentially organizational scientists rather than academic scientists."*

The life cycle is iterative in nature with the client system architecture at its centre of the process. The subsequent subsections outline how we implemented each phase of the action research cycle including the method fragment, process model and resultant method chunk. The method fragments were individually evaluated in conjunction with the stakeholders for their appropriateness, completeness and consistency. A complete evaluation of the entire method (combined fragments) was also undertaken.

6.4.1 Diagnosing (Method Fragment One)

This is the first phase of the action research cycle, it is essential that the problems that are motivating the organisation's need for change are clearly laid out. The initial meeting was with the MIS department comprising of nine staff, where the airline maintenance and logistics IS purpose and functionality were outlined. This meeting was then broadened to include all stakeholders that used the IS, where we outlined the nature of the research placing an emphasis on its collaborative nature and overall goal of improved perception of IQ with respect to the IS, this holistic approach is in keeping with best practice [95, 138]. The TDQM philosophy and an overview of IQ and its importance were also discussed with the stakeholders, including the the application of a reuse frame and roadmap.

The first method fragment identifying situational factors was outlined to the stakeholders, this involved selecting the appropriate situational factors (diverse IS situations and user profiles) and was completed by means of survey and IS analysis of user profiles. The stakeholder groups were broken down between pilots (34), engineering (23), administration (17) and MIS (9). The diverse situations for access to the IS were classified as server (7), PC (31), Notebook (15) and mobile device (30). The situational factors and users profiled identified were then propagated to our meta model, a data schema and prototype application were built to capture data for the situational factors and the meta model. The evaluation of the method fragment was completed by the researcher and the stakeholders employing Pfeiffer and Niehaves [114] criteria:

- Appropriateness: The method fragment was considered by stakeholders groups to be relevant and easily understood. The MIS stakeholders described it as intuitive, easy to understand and apply. The MIS stakeholders also suggested that the feasibility of propagating questionnaire data directly to the meta model should be examined for subsequent applications. The initial data gathered with respect to the stakeholder family was populated to our reuse frame, namely the custodian, collector and consumers of the information. The possibility of expanding the reuse frame was enquired to by the MIS stakeholders, the approach to its expansion was outlined, again this was considered to be straight forward with an appropriate set of guidelines put forward.

- Completeness: All of the inputs and outputs of the method fragment are as illustrated in figure 5.6 and the necessary data for the reuse frame are as illustrated in figure 5.13. The stakeholders and researcher were of the belief that both the process model and the reuse frame ensured that the data gathered from the stakeholders was done so in its entirety.

- Consistency: The use of the method engineering approach in conjunction with the meta model ensured that all the data with respect to the situational factors were recorded in a consistent manner. The employment of the reuse frame ensured that data with respect to the stakeholders was collected in a consistent manner.

6.4.2 Action Planning (Method Fragment Two)

Identification of the situational factors by the researchers and stakeholders along, with their assignment to the data model ensured a consistent view of the problem domain was jointly understood. The stakeholders commented that the placement of structure around the problem specification and domain lead to a more focused approach for a plan of action. Previously, IQ problems were not characterised with respect to the individual situations but instead the central focus was on the correction of a data value. The identification of planned actions must indicate some desired state for the organisation and the changes that would achieve such a state [138]. This involved an analysis of the IQ requirements for the stakeholders. The stakeholders examined the Intrinsic, contextual, representational and accessibility classifications of Wang and Strongs [147] (table 1.2 page 10). The discussion focused on the classification most relevant to the stakeholders, the majority (66) deemed the Intrinsic group to be most important followed by the contextual group (17). Although none of the stakeholders believed the representational or accessibility group to be most significance all stakeholders deemed them relevant. The necessity to have the user at the centre of the process was deemed critical by all the stakeholders, and this should be reflected in the measurement of IQ. The emphasis to the stakeholders was that planning for IQ was not merely an IS or IT responsibility but an issue that affected all groups.

- Appropriateness: The appropriate IQ dimensions relevant to each of the stakeholder groups were completed in conjunction with the IQ education workshop. The stakeholders emphasised the importance of the explanations of IQ dimensions prior to selection and prioritisation, including the need to review and update IQ policies, practices and procedures. The stakeholders were of the opinion that this responsibility should be shared between the MIS stakeholders and user groups.

- Completeness: The inputs and outputs with respect to the IQ dimensions that were selected and prioritised, these were recorded in the process model and rule base.

- Consistency: The use of the method engineering approach in conjunction with the meta model ensured that all the data with respect to the situational factors were recorded in a consistent manner. The employment of the reuse frame ensured that data with respect to the stakeholders was collected in a consistent manner.

Prior to the action taking phase the importance of building up knowledge with respect to the IS from an IQ perspective was discussed with stakeholders. All the stakeholders outlined the reactive nature of currently dealing with IQ problems. It was felt that a knowledge base could overtime enhance the measurement of IQ by not only recording formal data with respect to IQ dimensions but also experiences associated with dimensions by stakeholders of the IS, for example the experiences of various user groups. MIS stakeholders were also of the opinion for example that such information could be used to assess the level of effectiveness of an IQ training programme.

6.4.3 Action Taking (Method Fragment Three)

Implementation of the plan involves considerable commitment from both the stakeholders and researcher. A heavy emphasis is placed on collaboration in order for the stakeholders to gain knowledge for future application of the artefact but also for the researcher to build refinements in the various elements of the artefact. The workshops proved an invaluable forum for discussion and clarification prior to action taking. The literature suggests that intervention can be made in many ways; the role of the researcher is pivotal but should not be authoritative in nature [27].

Stakeholders and researchers rely on each other for successful implementation of the plan. In our research the stakeholders were the domain experts while the researcher had extensive knowledge with respect to the method. Optimum execution of the plan allows for both roles to complement each other and engagement and learning are critical factors for this to be a success [114].

- Appropriateness: Our third method fragment built on the identification of the factors and dimensions. The situational factors and dimensions along with the importance of user opinion were central to the application of the measurement techniques. The sequence of the measurement was critical for the correct analysis of IQ to be collected. Intervention from the researcher to emphasise this point to the stakeholders was significant, as the MIS stakeholders had previously not considered these services with respect to the assessment of IQ. The diverse situations identified in method fragment one (PC, server and mobile) all require web and database services in order to ensure IS access. Although the necessity to capture data with respect to services was agreed in the planning phase the full impact of this was only realised during this phase. The availability of key web services ensured that the IS was accessible for the assessment of the IQ dimensions not associated with accessibility. The MIS stakeholders were of the opinion that many problems classified as general IQ problems could, under this method fragment, be more refined to reflect the exact nature of the IQ problem. This in turn would allow for a more targeted use of resource. IS service analysis availability, objective IQ scores and subjective scores are all recorded.

- Completeness: The method fragment outlines the order for the execution of IQ measures and its implementation, along with the recorded scores for each of the identified dimensions, provides a thorough view of IQ for the IS.

- Consistency: The importance placed upon IS service analysis prior to measuring user perception of IQ ensured that survey results were recorded in a consistent manner, for example the users only rated information on the completeness if the IS was accessible, thus ensuring a more accurate reflection of IQ for the IS.

6.4.4 Evaluate (Method Fragment Four)

The completion of the actions phase required an evaluation of the tasks undertaken by both the researcher and stakeholders a determination as to whether the proposed effects of the artefact achieved the desired outcome. The application of the improve fragment of our proposed method facilitated this evaluation, involving a reflective process to analyse the data recorded from the action phase. It is a crucial fragment of our method as it facilitates improvement recommendations from the stakeholders and the researchers and also adheres to best practice [27, 114, 138] . The necessity to improve the artefact and its application is a key part of any method or model that claims to cater for the dynamic of an IS. The iterative nature of the method is particularly useful for the update of the rule base for subsequent IQ measurement and improvement.

- Appropriateness: The improvement method fragment facilitated a review of the operation of the three proceeding fragments, along with the assignment of information to the rule base for subsequent applications.
- Complete: The improvement method fragment allows for the dynamic of the IS and the environment it operates in, facilitating the enhancement of guidelines for its subsequent application. The importance of the stakeholders engaging with the application of the method fragments at regular intervals, as agreed between the stakeholders of the IS was emphasised as this ensures that the rule base, situational factors and prioritised dimensions are current.
- Consistency: Throughout the application of our method stakeholders and the researcher maintained a diary of events in order to facilitate the updating of the rule base and meta-model where appropriate.

6.4.5 Specifying Learning

Susman and Evered [138] formally specify in their action research model that learning takes place at the end of the implementation of the artefact. However in reality the entire process is a constant learning experience as we gained invaluable insight with the design of our method and initial application to the Library IS even if this was in somewhat of a staged environment. It allowed us to outline in more detail the steps involved in method application An important aspect of the application of our method with the Airline IS was the necessity to have guidelines for its implementation broken down into very fine levels of granularity.

The learning activity also allowed the stakeholders gain knowledge allowing them to refine processes and procedures with respect to their organisation. The Airline IS stakeholders for example, examined and reconfigured the process of creating users and recording details with respect to the diverse situations from which they accessed the IS.

The application of our method demonstrated to both practitioners and researchers the importance of collaboration at all phases of its implementation. The formal reviews by both interest groups at critical milestones of the implementation although important were not enough. The rationale for particular design decisions must not only be well modelled and documented but also thoroughly explained to the practitioners. This proved very beneficial for the researcher as it provided very informed feedback outside the formal reporting mechanisms. We contend that all forms of feedback should be encouraged both formal and informal as it leads to a greater understanding of the critical needs of both practitioners and researchers.

6.5 Analysis of Complete Method

The individual method fragments were initially evaluated, this was then followed by an analysis of the complete method. The primary focus of this was an analysis of the link up and interaction between the individual method fragments. This was completed by means of a workshop with all stakeholders, where participants were encouraged by the researcher to focus on information that they deemed important which emanated from a method fragment that did not directly interact with. This intervention was commented upon by the MIS stakeholders as significant as it emphasised that high quality information was the responsibility of all stakeholders and not just a MIS responsibility.

- Appropriateness: The stakeholders reviewed the sequence of the method fragments MIS stakeholders were of the opinion that it flowed in a logical manner. The importance of the user at the centre of the process was illustrated by the fact end user role analysis was the first event to be conducted. The stakeholders were also of the opinion that the appropriate type and amount of data was being collected in order to enhance the IQ of the IS.

- Completeness: The stakeholders were asked to examine the inputs and outputs from each of the method fragments with a view to ascertaining if they were complete. The stakeholders in conjunction with the researcher examined the prerequisites for each fragment by reference to the product and process model along with the individual experiences of the appropriate stakeholders. The stakeholders engagement in this demonstrated the importance of engagement with the improvement method fragment. The most appropriate way to measure IQ also formed part of this discussion. Three options emerged automatically (12), survey (42) and combination of both (29). This confirms the importance of the stakeholders in the IQ process.

- Consistency: We examined the method fragments to ensure that information gathered was done so in a consistent manner, this was achieved by the employment of our meta-model. The stakeholders were also asked to examine the information gathered for consistency and contradictions. Some minor modifications to data structure and format were adopted as a result.

6.6 Populating the Rule Base - Gap Analysis

The successful application of our method to the Airline IS was enhanced by the application of Gap Analysis Techniques. These techniques allow for assessment of IQ at dimension level and provide information for the rule base. The AIMQ employs them as an analysis technique, thus enabling organisations to identify IQ problem areas. Lee et al. [88] aggregated the dimensions into the quadrants of the PSP/IQ model. These quadrants can be compared for trends and resources can then be focused accordingly.

We build on the gap analysis techniques for our analysis of the airline IS. Our workshops focused on an explanation of IQ at a dimension level therefore we presented our results to the stakeholders at that level. Benchmark gap analysis was outlined to the stakeholders. Role group analysis was completed along with an analysis of IQ for each of the diverse situations.

6.6.1 Benchmarking Gap Analysis

Lee [88] describes benchmarking as *"a continuous, systematic process for evaluating the products, services, and work processes of an organization that are recognized as representing best practice for the purpose of organizational improvement"* The constant striving for improvement by organisation requires a best practice to aim for. This presented a number of problems for our research with respect to adequate data about comparable IS being freely and openly available. However the researcher and stakeholders agree that the technique be a component of future IQ policies for the airline IS and the acquisition of data about comparable IS is a priority.

6.6.2 Role Gap Analysis

IQ Role Gaps examine the differentiation in IQ assessments from the each of the user role groups associated with the IS. The results of this analysis can form the basis for allocation of resources with respect to IQ investment, or training, and provide information for the rule base stakeholder family. Figure 6.2 outlines the role gap analysis completed for the user groups of the Airline IS Pilots, Administrators and Technicians. A preliminary analysis indicates that the pilot users group have the worst perception of IQ for nearly all dimensions. This information can be applied to the repository and will inform subsequent analysis and measurement of IQ.

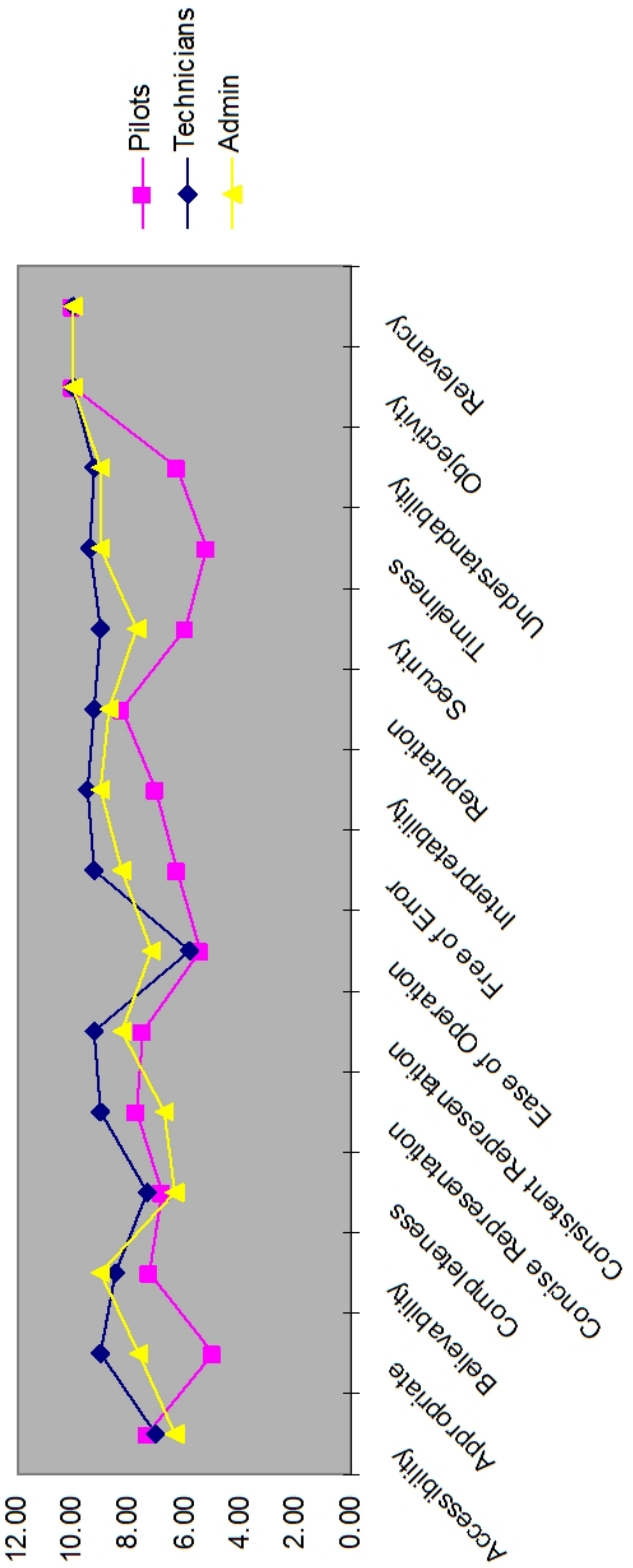


Figure 6.2: Role Gap Analysis Airline IS

6.6.3 Diverse IS Situation Gap Analysis

The Library IS afforded us the opportunity of conducting an experiment where we were in a position to ascertain the effect of diverse situations, drawing upon this and Lee et al. [88] role gap analysis we conducted a gap analysis of the users' perceptions of IQ from diverse situations. This provided the MIS stakeholders with data for the rule base and roadmap.

Figure 6.3 illustrates the analysis that was completed across the pilot role group for the mobile device, PC and server situations. The perception of IQ was the least satisfactory from the mobile situation. This finding formed the basis for our final workshop discussion with airline IS. The expectation of the technology was mentioned by many users. They satisfactorily use these devices for other routine tasks at work and consequently were of the belief that the same level of quality should be available from the IS. The IS stakeholders commented upon the pervasiveness of mobile devices and the lack of methodology for their implementation and integration with an IS that was introduced to the organisation twenty years previously. The information gathered allowed further data to be added to the rule base for subsequent applications of the method where an allowance for variance based on IS situation can be allowed for.

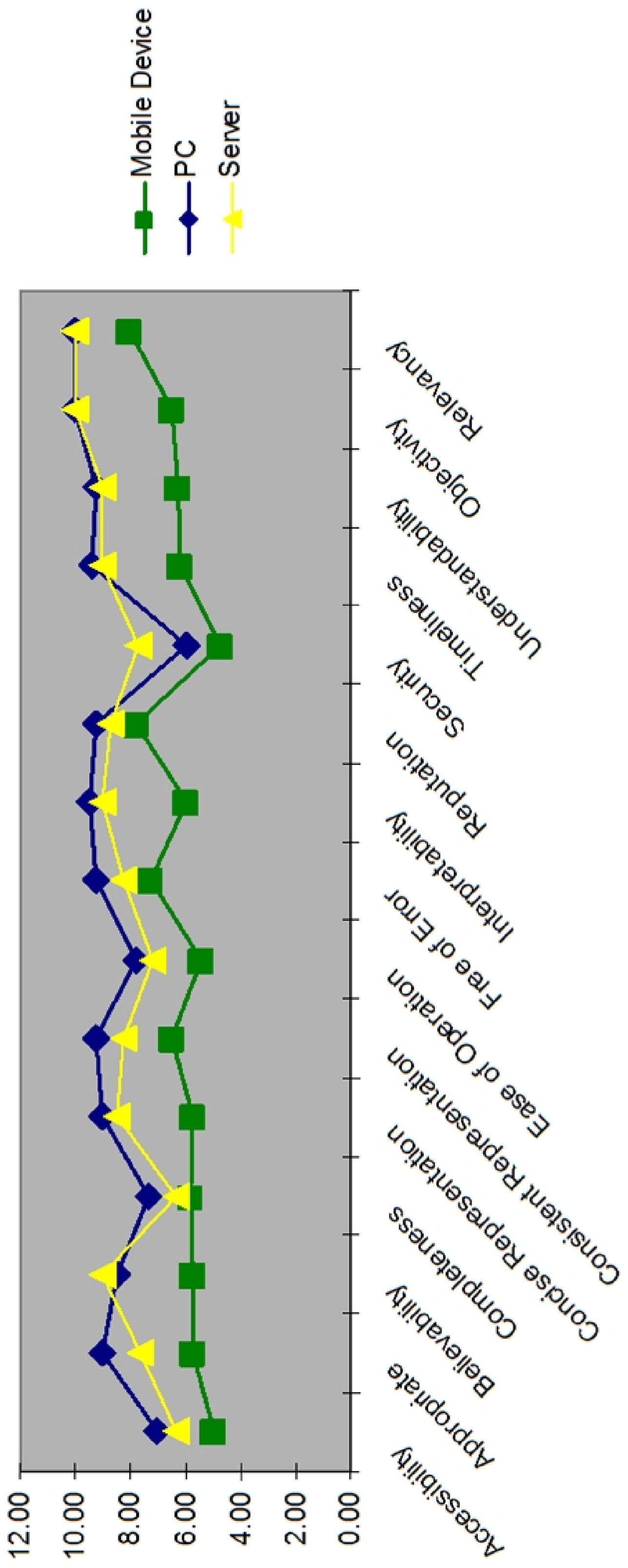


Figure 6.3: Diverse Situation Gap Analysis Airline IS

6.7 Chapter Six Summary

In this chapter we evaluated the utility of our method by means of application to the Airline IS. This involved an action research approach where we collaborated with the stakeholders of the Airline IS. The practicality of the application of each method fragment, business process and rule base were evaluated via a set of workshops. In some instances they were refined. We also introduced the road map and rule base as a means of capturing relevant information for both the IQ dimensions and stakeholders of the IS. We furthermore conducted role gap analysis and proposed situation gap analysis, as a means by which information can also be gathered. The stakeholders of the Airline IS have positively adopted the method for implementation of IQ. There is a clear indication from situation analysis that IS situation impacts on the perception of IQ.

In chapter seven we will outline a review of of our research, including a discussion of the contribution of our work along with some of its limitations. We revisit each our research themes and questions and also outline some possibilities for future research.

7

Summary and Conclusions

7.1 Introduction

This chapter presents the conclusions of our research. We initially summarise the main contributions of work, followed by a discussion of its significance within the context of our four IQ research themes; definition, measurement, analysis and improvement. A critical review of the limitations of our experiment and method are then outlined. Finally we examine the possibilities for future research, including the potential for commercial application of our method.

Our research involved a number of approaches to the problem of IQ and diverse IS situations; experiments, surveys and method. A considerable body of work [15, 83, 147] with respect to the definition of frameworks and dimensions has identified the key characteristics of quality and its relationship with information. Concurrent with this has been the revolution in IS situations, especially in terms of access devices. It is within this context that we conducted our research. Building on the seminal work of Wang and Strong [147] we evaluated the impact that these new situations have upon IQ and its assessment. The use of multiple research methods enabled us to test our hypothesis both experimentally and by practical application thus improving its rigour.

Critical to our research was the use of existing frameworks and measurement instruments, previously tested for rigour and validation [88]. The proliferation of an ever increasing number of IQ frameworks to cater for these new situations and evolving domains presents practitioners and researchers with the challenge of selecting the most appropriate one. Our motivation to overcome this challenge resulted in the construction, application and validation of our method. The approaches we adopted both in the experiment and method construction have the potential to be applied in a wider context to concepts where definitions are complex and multidimensional in nature, such as trust in E-Commerce.

7.2 Summary of Contribution

The main contributions of our research focus on three areas: testing our hypotheses that diverse IS situations impact IQ, our method and thirdly our research approach. These contributions add to the knowledge and implementation of IQ policies, frameworks and assessments. While our research examined two IS in detail, the adoption of our findings and the implementation of our method is not confined to these IS. Summarising our research contributions below we outline the four main areas:

- Diverse IS Situations Impact IQ: Testing our hypotheses via an experiment we found that diverse IS situations impact IQ. The results of our experiment with the Library IS demonstrate variance for individual IQ dimensions from diverse IS situations. The proof of our hypotheses, coupled with our evaluation of the situational gap analysis conducted with the Airline IS clearly identifies the necessity to consider the situation of the IS when conducting IQ assessment.

- Method: Having identified the necessity to facilitate diverse IS situations when assessing IQ we constructed a method for the improved application of IQ frameworks for these diverse IS situations. This is our major contribution and constitutes our addition to the knowledge base as recommended by best practice [68]. The construction of our method, employing situational method engineering techniques, facilitates its application at a finer level of granularity and in a flexible manner. We also constructed a meta-model and rule base which allows for the application of IQ frameworks over time, thus catering for the dynamic needs of both IS and IQ.

- Approach: IQ research provides numerous frameworks, criteria and methodologies to guide enterprises in the assessment, analysis, and improvement of IQ [15, 42, 83]. Our approach focused on the application of these validated frameworks and assessment techniques for emerging diverse IS situations. We contend that our approach provides for the assessment of diverse IS situations and IQ requirements as they evolve, enhancing their application over time by adding to the knowledge and rule base. Consequently the requirement to design, build and validate new IQ frameworks for diverse IS situations as they evolve is minimised.

- Evolution: Enterprises are also developing their own approaches to address IQ issues, [15, 57] although several algorithms have been developed for a subset of dimensions, such as accuracy, completeness, consistency, and timeliness. In fact the practical relevancy and generalization of some frameworks can be argued. Most common approaches used to obtain an IQ assessment is to consider domain specific measures associated with the different quality dimensions. Our work caters for the diversity of the IS situation and the IQ dynamic by facilitating their evolution. We contend that the need to design, construct and validate new IQ frameworks is much reduced by our method. We believe over time that this has the potential to lead to an evolution in the maturity of IQ frameworks and dimensions.

In the subsequent sections we revisit our work in the context of the IQ lifecycle [95] analysing our research questions from the IQ perspectives of definition, measurement, analysis and improvement. Our literature review, experiment and method facilitate the analysis of the significance of our work, where we compare results form our experiment with the evaluation of the utility of our method.

The adoption of the TDQM cycle is recursive in nature, where lessons are learned at each stage. The knowledge gained at each stage provides the basis and many of the inputs for the subsequent stage, thus ensuring that the dynamic of the environment is catered for through out the life cycle. The individual method fragments provide the necessary process and product models that capture the information associated with each of the stages. The definitions of the IQ framework selected by the users directly impact on the measurement instrument selected. This in turn in conjunction with the data collected dictates the analysis conducted. The resultant data forms the basis for necessary improvements for subsequent applications of our method.

7.3 Research Theme One - IQ Definition

This theme was concerned with an examination of the IS literature, with a view to ascertaining how IQ is defined. The evolution of IQ as a distinct field of research within IS, and also separate from software quality (in the sphere of software engineering) emerged as the main area of focus. This narrowed our focus and presented us with three questions:

- How does IQ framework definition cater for diverse IS situations?
- What consideration do IQ frameworks give to user perception in evolving IS situations?
- How flexible are IQ frameworks for enhancements?

The many frameworks that we reviewed (Chapter Two) placed much emphasis on the definitions and classifications of IQ with much research focusing on refining these definitions and their attributes. Wang and Strongs [147] seminal work confirmed the most pertinent dimensions that were of concern to IS users. We examined these dimensions in other frameworks with a view to ascertaining how their definition catered for diverse situations. Many were domain specific with little or no account of diverse situations, and we deduced that research pertaining to the definitions of IQ dimensions has matured with, if not a consensus, certainly a convergence towards agreement on what constitutes IQ. However these frameworks do not specifically cater for diverse situations, consequently there is a requirement for guidelines or methods to address this deficit.

Aligned to our initial examination of IQ frameworks is the consideration given to the users when measuring IQ. Our analysis found that research [42, 57, 147] placed a heavy emphasis on the fitness for purpose of information which very much depended on the context of its use. Our analysis also highlighted the various stakeholder perspectives that information are viewed from, and that these stakeholders perceptions are critical. The divergent views of creators, custodians and end users of data also require consideration. We also noted that different approaches to the measurement of IQ have emerged: namely intuitive, theoretical and empirical [58].

Examining these considerations we felt that while frameworks were in the main very comprehensive in nature they did not cater specifically for user knowledge where diverse situations of access exist to the same underlying information. New frameworks have emerged for some of these diverse situations such as web access [83], however diverse IS situations will continue to evolve. Rather than develop new frameworks to cater for these evolving and diverse situations we argue that guidelines and methods to cater for these are more appropriate. Such methods and guidelines have the potential to enhance the knowledge base of existing frameworks encouraging a more widespread application. This in turn, we believe, has the potential to lead to a wider acceptance of their importance across the wider IS field amongst both practitioners and researchers.

We examined the definitions of IQ frameworks across a number of domains. Upon preliminary examination, the growth in the number of frameworks suggested that there was little if any flexibility in this regard. However a thorough examination of these frameworks revealed a heavy reliance on much of Wang and Strongs work [147], tailored for a particular domain. This therefore suggests that Wang and Strongs work can form a basis for assessing IQ in many diverse situations. However the construction of new frameworks for specific domains can be restrictive in nature thus limiting their relevance to the broader field of IQ. Our analysis suggested that the existing approaches to measuring IQ for new domains and situations does not allow for enhancements. Therefore instead of constructing new frameworks we developed a method to adapt and enhance the application of Wang and Strongs [147] framework in a more practical and sustained manner. The IQ dimensions identified as most relevant form the basis for identifying associated tools and instruments for the measurement phase.

7.4 Research Theme Two - IQ Measurement

We examined the measurement of IQ from a literature perspective, by practical application, through our experiment and method. This presented us with two questions:

- How can IQ measurement be enhanced for a diverse IS situation?
- What diverse situational factors need to be considered for IQ Measurement?

An emphasis on the empirical approach is prevalent in the literature [58, 145, 147]. Objective and subjective measurements approaches are also prevalent across many frameworks and domains [15, 58]. Best practice suggests a combination of both approaches. We examined the diverse situations that contemporary IS deployment presents. Many of these situations required IS or web services to be available in order to critically measure the correct nature of IQ. A number of frameworks have been developed for the assessment of IQ and websites [83]; however these mainly concentrate on design and HCI (Human Computer Interface) issues as distinct from the access devices or situations. We identified that service availability is critical for IS access and should be measured prior to subjective survey instruments being conducted. We therefore contend that IQ managers must consider the sequence of application of both objective and subjective measures, and we propose a method fragment that caters for the sequencing of services along with both objective and subjective measures.

Our research involved an examination of the perception of IQ from diverse situations. Our experiments and practical application of our method demonstrated that there is a variance between these situations in the perception of IQ. We contend that the enhancement of IQ measurement for diverse situations can be achieved by making allowance for both the variance itself and a mechanism to cater for its recording. In our research we demonstrate the possibility of applying Cohens variance [46] effect for each of the diverse situations in our experiment. We also demonstrate that it is possible to use a variation of role gap analysis by measuring the variance in the perception of IQ between each of the diverse situations. Allowances can then be made for the overall IQ of an IS with a weighting being allocated for individual dimensions based on situation, and we provide for the recording of this variance in our meta-data model. Our road map approach for implementation also allows for input from the stakeholders prior to the any variance application. Subsequent dynamic in the variance can also be applied over time as the IS evolves.

Contemporary IS are complex in nature, and the environments in which many are designed, tested and deployed into, soon evolve. We acknowledge this complexity with our method fragment and rule base. Our analysis revealed the importance of user experience, IS services and device. The inexact nature of IQ and the dynamic in the factors restricted our selection to those of user, services and device. The measurement phase maps a consistent view of the diverse situations of the IS and the associated variance in IQ perception, allowing for an informed analysis in the subsequent phase of TDQM.

7.5 Research Theme Three - IQ Analysis

The analysis of IQ from our experiment and method application focused on the impact of diverse situations. The impact was examined at dimension level. Our results demonstrate that the situation of access to the IS impacts on the perception of IQ by the user. Those interested in obtaining valid IQ scores must not only recognise this but also record it in ascertaining situational impacts over time. Our meta-model allows this information to be stored at dimension level. The rule base and reuse frame allow for a systematic approach to the analysis of the IS environment and IQ by all the stakeholders. The provision of the artefact (our method) also enhances the IQ process.

The initial analysis of our work identified the core concepts of IQ frameworks and dimensions. Measurement and analysis of IQ were completed initially at dimension level. The users perception of IQ for diverse situations required an empirical approach to measurement. Both our experiment with the Library IS and the application of our method to the Airline IS demonstrated that the situation from which the IS is accessed affects users' perceptions. The Library IS experiment allowed us to control the diverse situations and examine the corresponding affect on each of the dimensions. The significance of the users completing the same tasks from diverse situations clearly indicates that situation affects perception.

The variation in perception was evident across all dimensions, to different levels. The varying perception from a mobile environment of Ease of Understanding, Believability and Interpretability were the dimensions most affected.

The practicality of conducting experiments with the Airline IS did not allow for controlled experiments. However a variation on role gap analysis allowed for a comparison between diverse situations. Again the perception of IQ varied depending on the situation. We found the perception of IQ for mobile devices was poorer than that of the PC. Both the experiment and the situation gap analysis demonstrate that the situation of access for the IS impacts on the users perception of IQ.

This variance between situations requires that those charged with ensuring IQ for the IS take it into consideration when calculating the overall level. We demonstrated that it is possible to measure empirically the perception of IQ and calculate the variance by employment of Cohens [45] value and situation analysis. The analysis phase provides for an accurate reflection of the impact of diverse IS situations on IQ, that can be used in the improvement phase of TDQM.

7.6 Research Theme Four - IQ Improvement

The ultimate aim of organisations that implement an IQ policy is an improvement in the overall quality of the information that the IS generates. The improvement involves a range of areas across the IS. Key to improvement is knowledge about the IS and its dynamic, and IQ policies, procedures and practices must reflect this. Our research indicates the need to consider the IS situation. However in order to implement this philosophy there must be a structure with respect to both processes and procedures and our work provides for this through the method that we have constructed. This facilitates an ongoing analysis of IQ, with the potential to improve the knowledge and level of IQ.

Stakeholders knowledge of the IS is critical for IQ improvement. Our research puts forward a clear and concise method for analysis of the IS environment. Users, tasks and situations are considered, and recorded in a repository and rule base accessible by stakeholders. The variance for each of the diverse situations can be accessed from the repository or, if none is available, situation gap analysis can be conducted. We also outline the order in which analysis and measurement should be conducted. Consequently our approach to the improvement of IQ is transparent to the users of the IS. The administration of the IS is streamlined by the application of our method as it presents an accurate reflection of the diverse situations that may exist.

The successful application of our method to an IS requires an ongoing commitment to IQ as a fundamental policy, with interaction and feedback from stakeholders throughout the IQ lifecycle deemed critical. The evolution of diverse IS situations and the dynamic that business face must also be considered.

Addressing this requirement we constructed an improvement method fragment. This allows for a review of the IQ factors by the stakeholders. The application of the method to the airline IS involved all stakeholders keeping a diary of their experiences. This proved invaluable when setting the priorities for subsequent applications of the framework.

In order for an IQ policy to be effective the new priorities as identified by the stakeholders of the IS must be recorded. We implemented this via our rule base where the dimensions of most importance were noted. The diverse situations for IS access were also recorded. This, we contend, provides for a comprehensive approach as the changes in the IS and IQ priorities are thereafter maintained in a repository. This information is semi-structured in nature and relies on the engagement of the stakeholders in the process. The more involved the stakeholders, the more comprehensive the knowledge base, and consequently a more accurate reflection of the IQ needs of the IS.

7.7 Our Approach

In this research we set out to examine if the IS situation impacted on the perception of IQ. Our motivation stemmed from the evolution, if not indeed, revolution with respect to the diversification of IS access. Critical to this is the access to the same information from these diverse situations. IQ policies and procedures need to take this into account. Our approach was not to build a new IQ framework to overcome a specific domain problem but instead to analyse existing IQ frameworks and artefacts with a view to enhancing their application in these new situations.

We tested our hypotheses that diverse IS situations impact IQ by means of an experiment with the Library IS; upon finding that the hypothesis was correct we embarked upon providing an artefact as a solution. The traditional qualitative and quantitative research methodologies did not lend themselves to the construction of an artefact. Design science however allowed for a systematic approach to the construction of our method. The approach we adopted endeavours to improve the application of existing artefacts in the IQ domain. We believe this to be a novel development as the literature clearly indicates an expansion in the number of frameworks as IS situations evolve [15, 42, 96].

Consolidating seminal work, rather than the design and implementation of new frameworks, we argue has the potential to enhance IQ as a field of research. The method provided by our work includes a rule base and repository that caters for the dynamic presented by new IS situations rather than creating new artefacts for new situations. This we believe is essential as the dynamics of IS situation continue to evolve. The necessity of new methods and rules that can be amended, or appended to, rather than new frameworks is critical for widespread adoption of IQ. The data gathered in the definition, measurement and analysis phases culminate in a re-commencement of the TDQM life-cycle that facilitates IQ best practice.

7.8 Critical Evaluation of Our Research

Our research investigated the impact of diverse IS situations on the perception of IQ. In testing our hypothesis we conducted an experiment with a Library IS where we had users conduct a limited set of tasks appropriate to their user group. The feasibility of conducting experiments on larger IS with a more complex set of tasks was beyond the scope of this research. A longitudinal study of the IS would allow for a more in-depth analysis of user profiles including such factors as demographics and technology exposure, education level and a multiple IS. However the experiment did demonstrate that the diverse situations tested had an impact on the perception of IQ by the users.

IQ resources were not directly provided for in either the Library or Airline IS; the intervention was facilitated by the stakeholders of both IS. Because the level of knowledge of IQ was scant we consequently conducted a number of workshops that involved IQ education. In the case of the Airline IS where we tested the utility of our method cooperation from a disparate group of employees was required. The facilitation of both IQ resources and employee cooperation should be considered prior to the application of our method as they are critical for the successful adoption of our method. This may not be feasible in all organisations.

The nature of the airline IS did not lend itself to conducting experiments. However it was possible to carry out gap analysis which again indicated that there was a difference in the perception of IQ by the users from diverse situations. The importance of the user at the centre of the IQ measurement and the necessity to ascertain the fitness for purpose of information required that user opinion be obtained via survey instrument. This information was ordinal in type and consequently we were unable to conduct our analysis using parametric statistical methods, whilst actually not as powerful, we employed nonparametric techniques in conjunction with our experiment.

The challenge of diverse situations is also significant, given especially their dynamism. We were limited to three situations; however for most IS these will expand over time. Even within the timeframe of our research new situations were evolving for both IS, however the iterative nature of our method provides the processes and procedures to cater for this dynamic; engagement by the stakeholders is essential for successful application.

7.9 Future Work

The importance of IQ has become well established over the last number of years. The pervasiveness of IS continues apace with more and more business processes reliant on information that is fit for purpose. Our work builds on the seminal work [147] in the area with our results demonstrating that diverse situations affect the perception of IQ. An analysis of emerging IS situations is worthy of further examination, as presently many are evolving in an unstructured manner. The impact of the traditional approaches and attitudes to IQ could inform the research community about IQ expectations in these new situations. An extension of our rule base and repository could also form the basis for artefacts that map these evolving situations.

IQ software that is *"situation aware"* is also worthy of exploration and could prove to be research rich. The widespread use of mobile devices and deployment of small scale applications with a very specific purpose is a significant development that offers potential for IQ assessment. Our work demonstrates the variance of perception of IQ based on the situation. The development of applications for individual situations has we believe the potential to make IQ more pervasive. Figure 7.1 illustrates a possible configuration for an IQ situation aware application, that incorporates rule base, method chunk selection and configuration. The possibility of a device being *"situationally aware"* could allow for the appropriate variance to be applied when IQ is measured. Our research examined distinct situations, and could be expanded by refining the number of situations and dynamically building a rule base to reflect this.

The dynamic of business situations and their associated IS in conjunction with the increasing number of business process that directly rely on them push the commercial requirement for IQ inclusion in IS to the fore. The need to capture IQ information separate from the application we contend is now a very real imperative that has the potential to give significant commercial advantage. It is envisaged that such an application could cater for diverse situations and dynamic IQ by providing the ability to append rules as situations diversify. The IQ software has the potential to cater for the dynamic as distinct from the application software, thus acknowledging and catering for the variance of IS situations without altering the business rules of the application.

The critical commercial advantage of this approach to the user is the focus placed on IQ. Even if the business application is significantly amended or replaced in its entirety the information gathered for the IQ requirements of the business processes remain. The impact of changes to the core business application on the perception of IQ can be set in the context of previous data gathered. Over time we argue that a more comprehensive analysis of diverse IS situations along with the relationships between IQ dimensions can be established. Future IS policy formulation it is argued can be formulated with a greater emphasis placed on IQ.

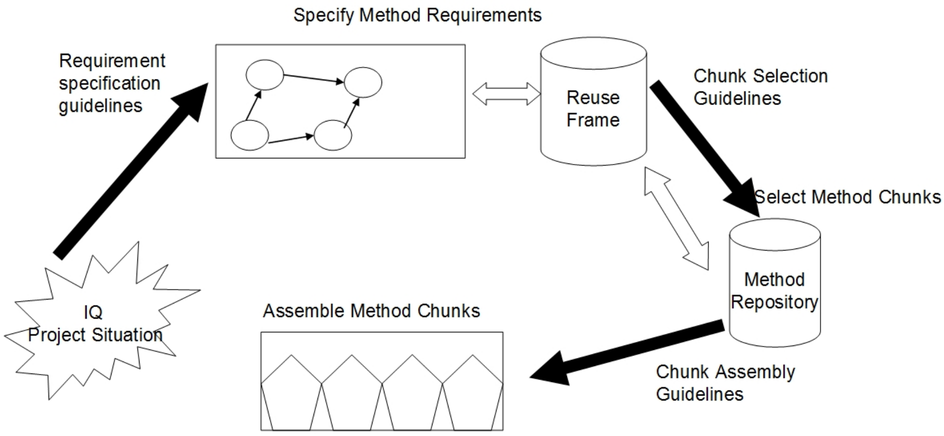


Figure 7.1: Potential Situation Aware IQ Application

The possibility of extending our research to other domains over a longer time period has the potential to enhance our findings. More in-depth analysis of individual dimensions over a longer time period and an examination of their relationship with other dimensions would also greatly enhance our work. The employment of design science techniques in our research enabled the systematic construction of our method. Refinements of approaches to IQ research and design science could therefore have potential for a more widespread adoption of this research methodology in the field of IQ research.

The application of our method has allowed us to take into account the situation, user and tasks. We have demonstrated that changes in the situation can be measured in the context of dimensions that are important to the user. Furthermore the experiment demonstrates that traditional static application of IQ frameworks may not provide a clear view of the exact nature of IQ for a given IS. The application of the method as outlined also demonstrates that there are clear dependencies between IQ dimensions. These results can be further analyzed in our future work in order to examine dependencies among a larger set of IQ dimensions. Future work also intends to concentrate on comparison of scores from both objective and subjective measures.

As IQ becomes more widely accepted and employed by organisations the need for systematically and methodically constructed artefacts will become imperative. The findings of our experiment along with our method provide a means for enhancing IQ research and practice. The phenomenal penetration of IS into all aspects of society will drive the need for information of the highest quality. Our research provides the necessary structures, methods, approaches, and guidelines that are required to facilitate IQ in these ever evolving and diversifying IS situations.

Appendix A

AIMQ Survey Instrument

All items are measured on a 0 to 10 scale where 0 is not at all and 10 is completely. Items labels with (R) are reverse coded.

Table A.1: AIMQ Survey Instrument Part 1 [88]

Dimension	**Questions**
Accessibility	This information is easily retrievable.
	This information is easily accessible.
	This information is easily obtainable.
	This information is quickly accessible when needed.
Appropriate Amount	This information is of sufficient volume for our needs.
	The amount of information does not match our needs (R).
	The amount of information is not sufficient for our needs (R).
	The amount of information is neither too much or too little.
Believability	This information is believable.
	This information is of doubtful credibility (R).
	This information is trustworthy.
	This information is credible.

Table A.2: AIMQ Survey Instrument Part 2

Dimension	Questions
Completeness	This information includes all necessary values. This information is incomplete (R). This information is complete. This information is sufficiently complete for our needs. This information covers the needs of our tasks. This information has sufficient breadth and depth for our task.
Concise Representation	This information is formatted compactly. This information is presented concisely. This information is presented in a compact form. The representation of this information is compact and concise.
Consistent Representation	This information is consistently presented in the same format. This information is not presented consistently. (R) This information is presented consistently. This information is represented in a consistent format.
Ease of Operation	This information is easy to manipulate to meet our needs. This information is easy to aggregate. This information is difficult to manipulate to meet our needs. (R) This information is difficult to aggregate.(R) This information is easy to combine with other information.
Free of Error	This information is correct. This information is incorrect (R). This information is difficult to manipulate to meet our needs. (R) This information is accurate. This information is reliable.
Interpretability	It is easy to interpret what this information means. This information is difficult to interpret (R). It is difficult to interpret the coded information (R). This information is easily interpretable. The measurement units for this information are clear.

Table A.3: AIMQ Survey Instrument Part 3

Dimension	**Questions**
Objectivity	This information was objectively collected. This information is based on facts. It is difficult to interpret the coded information (R). This information is objective. This information presents an impartial view.
Relevancy	This information is useful to our work. This information is relevant to our work. This information is appropriate for our work. This information is applicable to our work.
Reputation	This information has a poor reputation for quality. This information has a reputation for quality. This information is appropriate for our work. This information comes from good sources.
Security	This information is protected against unauthorized access This information is not protected with adequate security (R). Access to this information is sufficiently restricted. This information can only be accessed by people who should see it.
Timeliness	This information is sufficiently current for our work This information is not sufficiently timely. (R). This information is not sufficiently current for our work (R). This information is sufficiently timely. This information is sufficiently up-to-date for our work.
Understandability	This information is easy to understand. The meaning of this information is difficult to understand (R). TThis information is easy to comprehend. The meaning of this information is easy to understand.

Appendix B

Workshop Themes

Table B.1: IQ Themes and Attitudes

Theme	Questions
Overall Business	How does your organisation manage IQ? Are policies and procedures in place? Does poor IQ inhibit the organisations ability to achieve its goals?
Individual	Does poor IQ inhibit your work? Who is responsible for IQ in your organisation? How does poor IQ affect your work routine? Have you ever been involved in an IQ audit?
IS Situation	What devices are used to access the IS? Are there any polices with respect to the introduction of new IS access devices? Do IQ policies allow for diverse IS situations?
IQ Dimensions	What IQ dimensions are important? Do these IQ priorities change over time? Are these priorities allinged with your organisations priorities?

Appendix C

Method Application - Phases

Table C.1: Stakeholder Questions - Focus Groups

Phase	Questions
Diagnosing	What stakeholder group are you a member of? What device do you normally use to access the IS?
Action Planning	What IQ dimensions are important to you?
Action Taking	How do you think IQ should be measured?
Evaluation	How can the IQ experience be improved ? Do you expect IQ priorities to change over time? Are the IQ priorities allinged with your priorities?

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