DESIGN THEORY for innovation of classroom-based information systems

Submitted by

Wayne Hellmuth

BSc, BSc Applied, MEd (Research)

This thesis is presented as part of the requirements for the award of

Professional Doctorate in Information Technology

Queensland University of Technology

Gardens Point Campus

2 George St

BRISBANE QLD 4014

Science and Engineering Faculty

Principal Supervisor: Professor Glenn Stewart

Associate Supervisor: Doctor Taizan Chan

2015

STATEMENT OF SOURCES

This thesis has not previously been submitted for the award of any degree or diploma in any other tertiary institution.

This thesis is written with knowledge of the University laws and contains no material previously published or written by another person unless it is referenced in the thesis itself.

All research methods stated in this thesis have received the approval of the Queensland University of Technology Ethics Committee. Permission to conduct the research at the case study site has been obtained by the participating organisation.

Karl Craig provided professional copyediting and proofreading services according to the guidelines laid out in the University-endorsed national policy guidelines.

QUT Verified Signature

Signature:

Date: 31-08-2015

ABSTRACT

Data and its use to inform practice is vital for the continuous improvement of both student and education services (Lambert, 2003). Data within the education context, however, has been found to be irrelevant (Marsh, Pane & Hamilton, 2006; Park & Datnow, 2009), invalid (Ikemoto & Marsh, 2007), inaccessible (O'Day et al., 2006) and untimely (Choppin, 2002; DeLoach, 2012). This study uses a design science research methodology to untangle a range of complex factors that act as barriers to the continuous improvement cycle for one education service. It is recognised in this thesis that the environmental conditions in schools (in terms of data entry, data retrieval, and data evaluation) are unique to other industry contexts. These differing environmental conditions uniquely and negatively affect the quality of data generated and, therefore, its subsequent use to facilitate quality outcomes is reduced. This thesis designs, develops, instantiates and evaluates a novel artefact using Enterprise Information Architecture standards and a design science research methodology. The purpose of this artefact is to improve data collection, data quality, and its resultant use in the classroom. Through improving the accuracy, consistency, completeness and the timeliness of data, it is expected that the utilisation of this data will be enhanced, and better teacher practices and student outcomes will be realised. This thesis uses a number of measurement techniques to evaluate the impact of the new artefact to both the individual and the organisation including: the Unified Theory of Acceptance and Use of Technology (UTAUT) Scale, IS-impact Scale, and Convergent Interviewing techniques. The results from this thesis showed that the instantiation of the newly designed artefact improved data quality and its subsequent use, thus facilitating and enabling continuous improvement cycles to the teaching and learning process. The results shown in this thesis, however, demonstrate that exogenous factors to the artefact, categorised as socio-political factors, anchored the use of this quality data to inform and improve teacher practice.

ACKNOWLEDGEMENTS

I would like to formally thank the following people:

1. Professor Glenn Stewart and Dr Taizan Chan for their support and assistance in the development of this thesis.

2. Steven Jiang who was always happy to talk me through the difficult algorithms and programming constructs.

3. Dennis and Brendan from PCSchool. Without their assistance and cooperation this research would not have been possible.

4. My wife Tracy Walsh for her love and encouragement throughout this long and extended process.

EXECUTIVE SUMMARY TO THE SOFTWARE INDUSTRY

INTRODUCTION

The Doctor of Information Technology is a research doctoral degree located at level 10 of the Australian Qualifications Framework. To be awarded the degree, a graduate must demonstrate the use of specialised research skills. Through an applied investigation of a complex problem, the graduate demonstrates a systematic and critical understanding of a complex problem and proposes or develops a solution to this problem. Through the development of such a solution, both professional and industry practices are advanced.

This Executive Summary describes a complex research problem within the field of education. It also describes in detail the information technology artefact that has been developed specifically to address this education problem. Within this summary, six design problems with existing education-based information systems are described, and six solutions to these problems are subsequently presented. This Executive Summary describes the success of the instantiated artefact in this research context. It also describes its future potential in advancing professional practice within the information technology and education industry.

Case Context

This research is concerned with the development of a new set of IT artefacts complementing organisational processes and systems within the context of a large, co-educational school providing education, complemented by a rich set of co-curricular and pastoral care services for grades 5-12. The school is independent within the Catholic education system and espouses an education that is Catholic and Franciscan. It encourages its students to achieve personal bests and to develop skills through its co-curricular activities of music, sport, drama and service. In addition, it has a very strong pastoral care system that it seeks to support through a richer reporting of behaviour management. There are many clients including the teachers, the parents, the pastoral care staff and the senior management of the school. Each has a different set of requirements of and expectations for such a system. Behaviour Management systems historically have tracked negative behaviours and the application of a scaled set of responses. The philosophical orientation of the school staff was towards improvement, so a new system tracking and rewarding positive behaviour was required. In addition, the system needed to work in the co-curricular environment, which often was not in a classroom. So additional features provided through the 3G and 4G mobile environments were also utilised to provide system access in the public and sporting spaces often used in the delivery of the co-curricular experiences.

Specifically the artefact developed for this thesis is an iOS based behaviour management app. The app is carefully architected using Enterprise Architecture principles. In particular the app utilises Bluetooth technology to improve its usability both internally and external to the classroom. Using this Bluetooth technology, much of the data entry process that would normally be required is automated, thus, making it more conducive to use in general. The app is fully integrated with the existing Student Information System (SIS) using a series of complex web services. The existing SIS contained a behaviour management module, however, users required a series of steps to authenticate, navigate, and create data. The SIS behaviour module, therefore, was inconsistently used leading to poor quality data. No previous mobile based classroom software has taken this approach. Through this improved usability and other architectural considerations, the data quality that describes the student's classroom behaviour was significantly improved.

The design principles forwarded in the rigor chapter of this thesis has the potential to be applied to other classroom based teaching and learning applications. Further work is needed to validate the application of the design principles forwarded in this thesis to other classroom based teaching and learning software particularly when looking to improve data quality.

Classroom scenario

Teachers in schools are required to deliver curriculum work programs that contain an increased level of learning content (Lujan & DiCarlo, 2006). This increased level of content compromises the ability of students to acquire a deep understanding of the subject matter – but, more importantly, students consequently receive less feedback about their learning and critical thinking skills. While the student's ability to acquire content has been measured historically through the use of exams, the measurement of a student's learning and critical thinking skills has not been addressed in any meaningful way. Due to the requirements associated with delivering content, the measurement of a student's ability to learn and progress through the curriculum has not been successfully implemented using a systematic approach. The importance of addressing weaknesses that hinder a student's ability to learn and progress cannot be understated.

To improve a student's learning and critical thinking skills, teachers must create thinking and learning skills frameworks, and then measure the student's abilities against these frameworks. With already too many requirements of the teacher in the classroom, how can this important requirement be realised? In practical terms, this thesis addresses the problem of how technology can be designed and instantiated so that quality data about a student's learning progress can be collected in the classroom without detracting from the teacher's core business of teaching and learning.

Research problem

Quality management within schools is dependent on quality data; however, previous literature within the education context shows that the use of existing information systems (IS) in the classroom generates data that is inaccurate, inconsistent, untimely, and incomplete. As a result of this poor-quality data, teachers have been reluctant to use the data produced by these information systems. Instead, teachers rely heavily on anecdotal observations and measurement instruments, such as exams. These measures, however, lack the systematic and incremental requirements needed for student progression and the continual improvement of classroom-based education services. This research acknowledges the need for improved information systems design to ensure the usability of information systems in the classroom. Through improved information systems design, it is the purpose of this research to: first, improve the ability of teachers to produce quality data; second, to improve information systems design so that data produced by classroom-based information systems can be used in ways that facilitates continual improvements to the teaching and learning process – and, therefore, student learning outcomes.

The design theory proposed in this research describes a successful approach for the development of classroom-based information systems and its potential product structure. The design theory expounded in this article is described using Gregor and Jones (2005) units of design theory.

Research scope

To scope this research, a Service Oriented Architecture (SoA) development approach was first used to map the services a school provides to its stakeholders. To address the problem of data collection in the classroom, a classroom-based service was targeted for this research. The artefact development requirements for such a service also needed to be of appropriate complexity and work for a doctoral study. The development of an artefact that collected data about a student's pastoral care activities was deemed most appropriate. It was projected that any findings made by developing an artefact for pastoral care services could be transferrable in the development of artefacts for 'curriculum services', given that these two services have similar principles in terms of data collection and data-quality requirements.

Research solution

To design and develop an artefact that facilitates the continual improvement of classroom-based services, six key design problems are identified with existing education-based information systems. To address these six design problems, six design responses were developed: i) to ensure the validity and relevancy of the information system to teachers while in the classroom; ii) to ensure that the information system can be used in the classroom without disrupting the teaching and learning process; iii) ensuring data accuracy; iv) ensuring data consistency; v) ensuring data timeliness; and vi) ensuring data completeness.

Design problem 1 – validity and relevancy to practice in the classroom

Through the use of an interview technique, feedback from teachers indicated that they could not identify any valid reason for using information systems within the classroom. This perception existed even with the knowledge that it was a business requirement to provide specific data about student behaviours. It was a commonly shared perception among teachers that the legacy IS lacked utility and relevancy to their teaching practice within the classroom. The first goal of this research, therefore, was to develop a method for determining the scope and requirements for the design and development of the artefact. The method developed needed be generalisable to any education-based service. This method would ensure that the artefact was perceived as a valid and relevant tool to teachers in the context of their teaching practices within the classroom.

Design response 1 – validity and relevancy to practice in the classroom

Validity and relevancy of the artefact is first achieved through identifying the exact needs of the IS artefact using Enterprise Information Architecture (EIA) methods, as specified by the Open Group Architecture Framework (TOGAF – v 9.1). The purpose of the EIA was to model the entities of the enterprise and the relationships that exist between each of them. Specifically, the requirements defined in the Strategy and Business layers of the EIA (specific to the service unit) guide the scope and design requirements for the artefact. As a result of these requirements, further changes to the information systems and technology architectures were identified and completed. The figure below shows the various screens developed for the artefact. Each screen offers utility for the teacher in managing student behaviours in the classroom. These screens assist teachers in realising the service strategy that is specified in the Strategy Architecture, as well as those best-business practices specified in the Business Architecture.

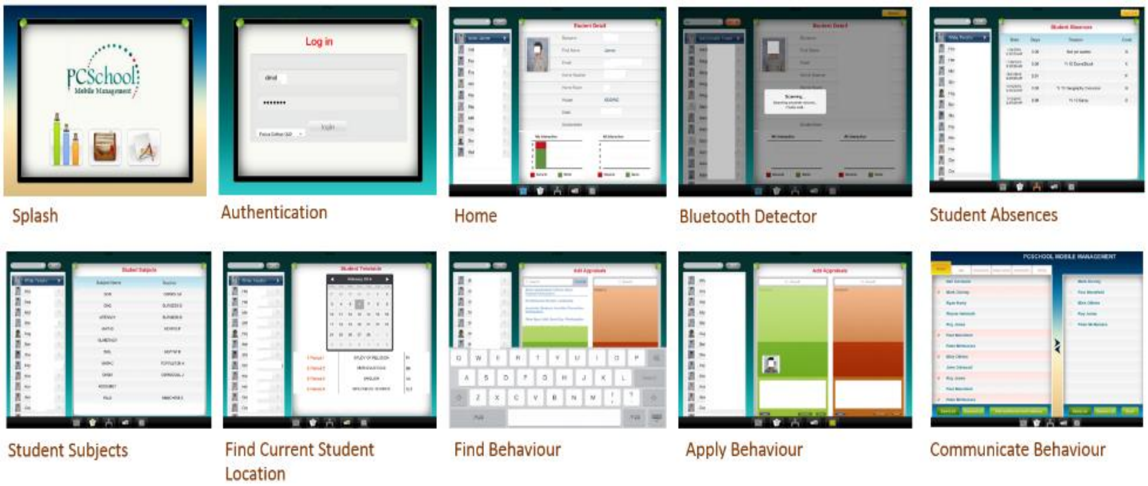


Figure ES1: The figure above depicts the main screens developed for the mobile-based artefact. Each screen has been developed to ensure validity and relevancy to the teacher in the classroom.

Design problem 2 - information systems usability

A second major gap that disengaged teachers from using the information system in the classroom centred on the disruptive nature of the data collection process in parallel to the teaching and learning process. Using the legacy IS, teachers were required to move to a central teacher computer so that they could enter student data. This computer is often located away from where student behaviours occurred. This was seen as undesirable. “Proximity is important in managing behaviours”. Another problem communicated was the time taken to navigate to pertinent fields within the IS. In a traditional IS, a teacher is required to open up the application, navigate to the module, find the student, find the behaviour and then apply a behaviour entry against that student. To report a single behaviour for a class of 30 students, a teacher would require a minimum of 92 separate user actions (shown in Figure ES2).

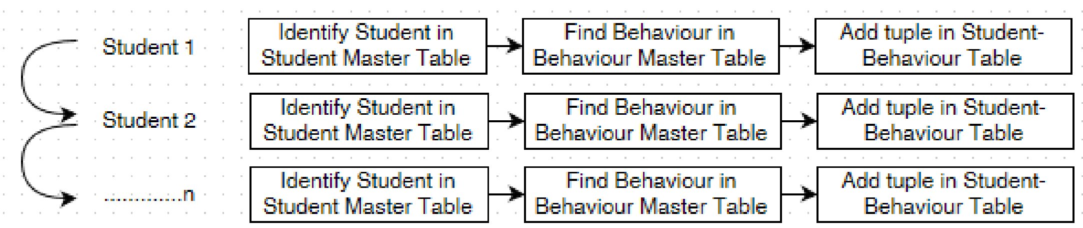


Figure ES2: The figure above shows the process of adding information to a student’s record.

This was seen as a time-consuming process within the context of the classroom environment. The time taken to enter data was seen to detract from the teaching and learning process and, therefore, counterproductive. A new artefact design was needed to ensure that technology complimented the behaviours of teachers in the classroom rather than 'compete' with it.

Design response 2 - information systems usability

To ensure that the new information system was usable within the classroom, a redesign of the interface was required. This ensured the teachers could collect data without diverting their attention from the teaching and learning process. This was achieved through a two-part procedure: i) the automation of data look-ups based on the proximity of the teacher to the student; and ii) the assigning of behaviour (entry of a data record) through drag and drop processes.

The artefact instantiated for this study is described as a system of two mobile iOS based apps: a teacher app, and a student app. Two screenshots from the teacher app are shown in Figure ES3. The first one allows the user to detect students via Bluetooth signal, thus automating the first part of the data entry process. The second screen shows the ability to simply apply multiple students to a single behaviour through a drag and drop process. This design minimised the need for teachers to divert from the teaching and learning process.

Figure ES3: The figure shows two of eleven screens developed for the artefact. Through the use of these two screens a more efficient data entry process is achieved.

Both the teacher app and student app write data to and from a Student Information System (SIS) using web services. As part of the Bluetooth Low Energy (BTLE 4.0) framework in iOS, these apps are often referred to as a Master App and a Child App. The BTLE 4.0 framework is a set of Objective-C 'methods' that allows multiple slave devices (in this case, student iPads) to be detected and 'paired' to a master device through the Bluetooth signal. This capability is instantiated as a 'teacher app' with the ability to detect multiple student iPads. Once the teacher app and the student app have 'connected', small bits of information can be exchanged between them. The framework is not designed to allow for large data streaming between apps, but rather the communication of small bits of information. In this case, the master app receives two bits of information from the slave device: the Unique Device Identifier (UDID), and its Bluetooth signal strength. When the slave app is first used, the UDID (code generated) is written to the SIS. The UDID is then used by the master app to automatically obtain student data from the SIS. Through this process, much of the work that is normally associated with data entry is automated. Using the Bluetooth signal, the UDID of the closest student iPad is used to automatically look up the student's details. The student information and student progress information retrieved from the SIS is automatically displayed on the teacher app when in proximity to the student. The process described above is represented in Figure ES4. The number of interactions required by teachers using this model is reduced to approximately one-third of those required by the legacy IS.

In addition to this novel functionality, the app includes all the requirements documented in the Enterprise Information Architecture document: the requirements to realise the service strategy; enable business functions; and to ensure the applications and technology layers have the correct functional design.

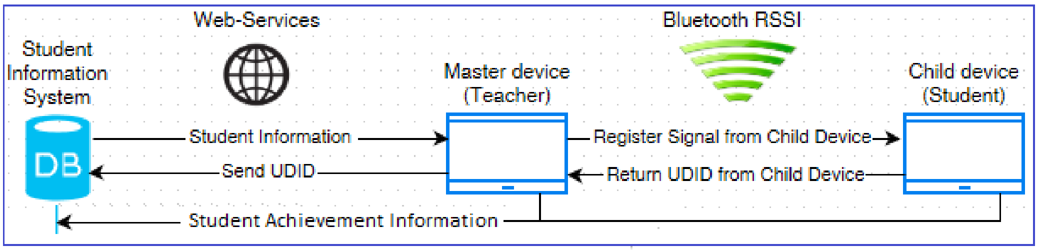


Figure ES4: A model representing the novel technology.

Design problem 3 – poor data quality

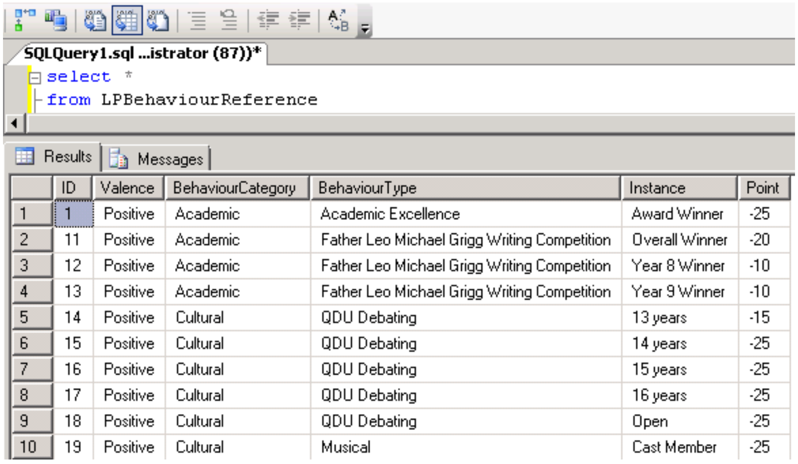
'Data Quality' is described as a multidimensional construct with the dimensions of quality including accuracy, timeliness, consistency, and completeness (Fox, Levitin & Redman, 1994). As part of the relevance cycle method, an analysis of the SQL database was conducted to review the quality of data written to the database through the use of the legacy IS, and analysis showed that it was compromised. As a result of this low-quality data, teachers disengaged with data throughout the subsequent stages of the continuous improvement cycle. It was the purpose of this research to improve data quality by addressing each dimension of it. Through the careful design of the novel artefact, it was projected that teachers would evaluate the data made available by the new artefact as having utility. Therefore, it was expected that teachers would incorporate the use of this data as part of their daily practice in the long term.

Design problem 3 – data accuracy

Data accuracy refers to the "measurement or classification detail used in specifying an attribute's domain" (Fox, Levitin & Redman, 1994, p. 14). In this research, data accuracy refers to how it describes a single or series of student learnings, reflecting their progress in the context of a classification schema that defines the pedagogical learning approach and framework adopted by the school. It has been incumbent on teachers to either use data from external sources to the school, or to produce data themselves through the application of local measurement instruments. Both of these scenarios have proven relatively ineffective in producing accurate and timely data. While data collected external to schools have well-developed metadata models to measure specific outcomes, these instruments have been shown to have little relevance and validity to student outcomes (Ikemoto & Marsh, 2007; Marsh, Pane, & Hamilton, 2006). In contrast, data collected by school-based personnel is often limited in quality due the lack of skills, time and organisational structures to effectively produce and use it (Love, 2000; Bernhardt, 2000). Problems with relying on teachers to collect data have been reported by Marzano (2003), who stated that data collected on student performances are often indirect measures with no explanatory model to interpret it. In these cases, a metadata model has not been correctly incorporated as part of the improvement program. As a result, data collected and reported by teachers is often of the wrong type or format and, therefore, is reported as irrelevant, invalid, or inaccurate (Olson, 2002; Rudner & Boston, 2003).

Design response 3 - data accuracy

To respond to this design problem, the redesign of the artefact included the development of a metadata model, which was realised as 294 different behavioural comments in a SQL database. A screenshot of the data is shown in Figure ES5.



SQLQuery1.sql ...istrator (87))*

```
select *
from LPBehaviourReference
```

Results | Messages

	ID	Valence	BehaviourCategory	BehaviourType	Instance	Point
1	1	Positive	Academic	Academic Excellence	Award Winner	-25
2	11	Positive	Academic	Father Leo Michael Grigg Writing Competition	Overall Winner	-20
3	12	Positive	Academic	Father Leo Michael Grigg Writing Competition	Year 8 Winner	-10
4	13	Positive	Academic	Father Leo Michael Grigg Writing Competition	Year 9 Winner	-10
5	14	Positive	Cultural	QDU Debating	13 years	-15
6	15	Positive	Cultural	QDU Debating	14 years	-25
7	16	Positive	Cultural	QDU Debating	15 years	-25
8	17	Positive	Cultural	QDU Debating	16 years	-25
9	18	Positive	Cultural	QDU Debating	Open	-25
10	19	Positive	Cultural	Musical	Cast Member	-25

Figure ES5: A presentation of the metadata developed for the newly instantiated artefact.

Each behavioural entity in the framework is described using a nomenclature with four dimensions: Valence; Behaviour Category; Behaviour Type; Behaviour Instance. Through the use of web-services, behaviours were filtered for the user at the interface based on temporal parameters. For example, during pastoral care periods, a returned search of behaviours would be ordered to return the most relevant pastoral care records. This further minimised the time needed by the teacher to interact with the information systems artefact. Data returned to the artefact were presented in ‘combo-boxes’ within the application.

Design problem 4 – data consistency

Data consistency refers to the “probability that an item will perform a required function under stated conditions for a stated period of time” (Fox, Levitin & Redman, 1994, p 15). For reported data to be considered consistent, the data collection process should be stable and consistent across collection points and over time. Progress toward student learning goals should reflect real changes rather than variations in data collection approaches or methods. Data consistency remains the biggest challenge to the generation of quality data, particularly in secondary schools. Students have multiple teachers across several subjects, and across year levels. Variations in collection frequency, as well as variations in subjective evaluations of a student's progress, leads to inconsistent data and, therefore, reduces the validity and relevancy of the data to the quality management program.

Design response 4 – data consistency

Figure ES6 below shows two teacher feedback mechanisms (through the use of graphs) that have been developed to address the issue of data consistency in teacher reporting.

Figure ES6: Immediate feedback provided to the teachers about the consistency of their judgements.

These graphs are found on the home screen and are made obvious to the user. The first graph represents the teacher's interactions with the student. According to behaviour management, a teacher should provide a student with eighty per cent positive feedback (represented in green in the graph) and twenty per cent negative feedback (represented in red). This behaviour management principle is considered best business practice and is defined in the Business Architecture. The second graph represents the interaction of all other teachers with the student. In this instant, no other teachers have reported any behaviours for the student. As documented in the Strategy Architecture, an important part of the service strategy is to ensure consistent feedback to the student. According to behavioural theory, consistent feedback on behaviour increases reinforcement strength to that behaviour. In this example, the data can be used to encourage other teachers to interact with this student to affirm or distinguish certain behaviours.

Design problem 5 – data timeliness

From a timeliness perspective, data in the education context should be captured as quickly as possible after the student's attempt at a learning activity so that it can be available as a feedback and analysis tool. Various authors, however, discuss that the frequency of measures available that define improvements from the input/benchmark to the output, as 'too low' (Choppin, 2002; Marsh, 2006; Hanks, 2011; DeLoach (2012). Marsh (2006) for example, reported that, in general, teachers preferred the use of classroom data to periodic external exams, stating that external exams did not provide useful data in a timely fashion. Teachers could not act on this data, as students had already moved on to another teacher and/or grade level. "For this reason many districts and schools have adopted formal local tests that are issued more frequently throughout the year, thus providing diagnostic information that could be acted on immediately" Marsh, (2006, p. 114). Historically, the problem with relying on teachers to collect data is that such a process is resource intensive and is, therefore, limited in its frequency. The infrequent collection about a student's progress leads to problems associated with data inconsistency.

Design response 5 – data timeliness

In traditional IS, the mechanism for providing feedback to users has been through reports. These have the potential to provide a detailed understanding across a number of different dimensions about a particular student related phenomenon. However, they are not designed to assist teachers and students to adjust to their practices inside the classroom. According to behaviour management theory, reinforcement to behaviours is strengthened if they are reinforced immediately after they occur. It is recommended for this research that pertinent data be provided to teachers and students in a 'live format'. The type of data provided should be in context of the defined service, and business strategies that are defined in the Service and Business Architectures. Figure ES6 shows the two graphs available to teachers. These contain data that is updated immediately and contain brief but pertinent information about the students/teacher's performance according to the service strategy and best business practices.

Design problem 6 – data completeness

Data completeness refers to the "degree to which a data has all the attributes of all entities that are supposed to have values" (Fox, Levitin & Redman, 1994, p. 15). The data requirements that describe student-learning outcomes should be clearly specified based on the information needs of the school and defined by their pedagogical framework. Data collection processes should be developed to capture the entities required to evaluate the progress of students with respect to the student's needs in achieving outcomes within the pedagogical framework. Improved data accuracy and data consistency increases the completeness of the data. The results of this study clearly showed improved data completeness, and this is depicted in Figure ES7.

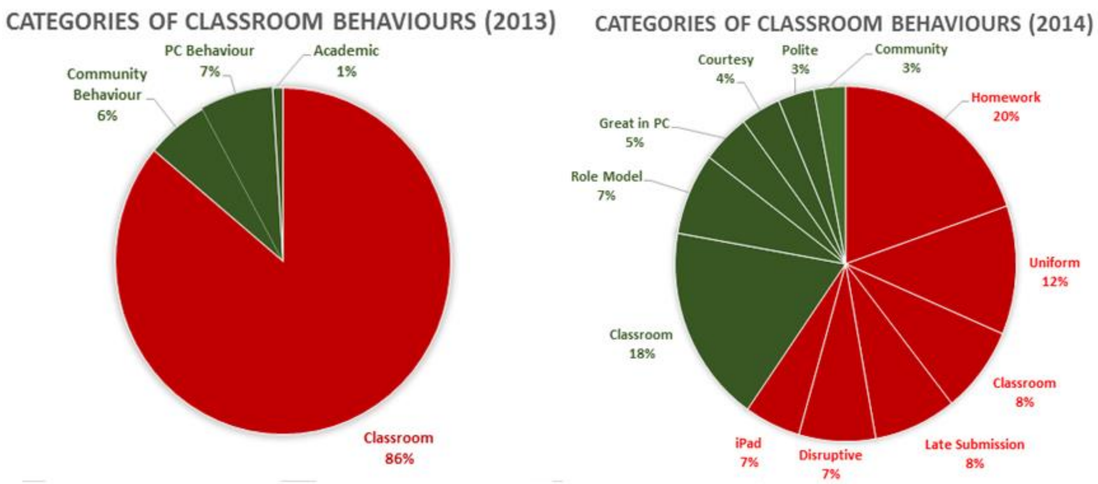


Figure ES7: A comparison of reported behaviours between pre and post instantiation of the artefact.

Figure ES7 shows that the total number and type of appraisals given to students increased post instantiation of the artefact.

Summary

This executive summary highlights the design challenges and responses developed for this research. The results showed that through the redesign of the artefact, teachers accepted it as valid and relevant to their practice. Their level of use of the artefact was substantially more than for those teachers who continued to use the existing IS during the trial period. The artefact had a positive impact on both the individual and the organisation. System quality, data quality, and information quality were perceived to have improved through the instantiation of the artefact. There was clear evidence, however, that the use of the artefact to realise the service and business strategies was hindered by exogenous factors to the information system.

Through the instantiation of this artefact, and the measurement of the resultant sociotechnical response, this research has made several contributions to the Information Technology industry, as highlighted in Table ES1.

Table ES1 – Key research contributions to industry

1	Recognised that current IS design is a barrier to use in the classroom.
2	Recognised that current IS design limits the quality of data that describes student learning in the classroom.
3	Modelled the efficacy of using EIA modelling for the developing artefact structures.
4	Produced novel IS technology that compliments the teaching and learning process, thereby, increasing its usability in the classroom.
5	Produced theory describing artefact structure that facilitates data accuracy, data timeliness, data consistency and data completeness with respect to describing student learning in the classroom.
6	Produced theory describing artefact structure that facilitates the continuous improvement cycle to teacher practices and student learning in the classroom.
7	Identified endogenous and exogenous barriers to IS use in the classroom, for the purpose of identifying change management practices for future IS implementations.

Limitations to the research

The research results have limitations. Given that the research is experimental, it is difficult to find organisations willing to engage with new 'untested' software on a large scale. Consequently, sample sizes for the design science research tend to characterised as small. The generalisability of the results to the wider population needs to be made with a degree of caution.

A threat to the external validity of this research centres on the use of iOS as a development platform. The artefact originally developed for this research used version 6.0 of the Apple operating system (iOS 6.0). Within this framework, programmers could capture the UDID of other devices when they were paired using the Bluetooth framework (BTLE 4.0). This process contained many ‘bugs’, most notably the app’s premature termination when null UDID values were returned if no slave app could be registered. Apple was formally engaged to fix these bugs in the successive operating release. In that release of iOS (6.1), Apple removed the ability to detect the UDID of a secondary device for ‘security’ reasons. Consequently, an iteration to this study’s artefact was needed.

Given that the identification of the child iPads was crucial to the solution, a ‘work around’ to this change in the BTLE 4.0 framework was made. In this iteration to the artefact, the user of the second device is identified when the child device opens the ‘App’ on the child device. The app first reads a table (specifically developed for the artefact) in the SIS and determines the highest integer. The app then generates a UDID (an integer which is n+1) and writes this to the local app and the SIS. It is recommended before this study is replicated that a formal discussion with Apple is undertaken to ensure that this method does also not violate their security standards.

Refinements to future solutions

Further refinement to the artefact can be realised in subsequent research and/or development stages. Further changes to the BTLE 4.0 framework can potentially make future solutions more elegant. Originally, the artefact developed for this study continually polled the Bluetooth devices in the classroom to determine the closest student to the teacher. Testing of this artefact version revealed too many short latency periods, thus increasing the need for teacher attention on the artefact. This was seen as undesirable. The solution was, therefore, designed with a manual button. This was seen as less disruptive to the teacher than the solution with continual polling.

Future applications of this theory to curriculum-based services require some deep thinking and collaboration with education departments to develop and manage metadata requirements. There are future design challenges around developing consistent but agile and flexible information systems for the management of this metadata. There are possibilities for future design science researchers to investigate and develop artefacts for the management of school-based metadata.

Potential of the solution

The design theory (DST) presented in this thesis describes the process and product structures for the development of classroom-based information systems. It is believed that the theory presented in this thesis is applicable to all such education services. The omega state for classroom-based information systems is one where students and teachers collect and are provided live-quality data that enables the teacher to logically progress the learning skills and the learning outcomes of each individual student. This thesis has provided some insights into achieving this end state.

EXECUTIVE SUMMARY TO ACADEMIA

The purpose of this executive summary is to describe the academic contributions made by this research, which is classified as a multi-methods research with design science as its main research method. Design science is a research method particularly well suited for developing theory about information systems design processes and products (Gleasure, 2013). The design science research (DSR) method usually contains three cycles of development, known as the Relevance, Design and Rigor cycles (Hevner, March Park and Ram, 2004). This executive summary discusses the adoption and rigorous execution of the methods used for each of these cycles within this DSR. The methodology used in this study, although adopted from Alturki, Gable and Bandara (2011), differs in that emphasis is placed on formalising an approach for completing the relevance cycle. Specifically, this newly developed relevance cycle method is used to classify and define the research problem and to define the artefact's development requirements – it compliments and extends the Alturki, Gable and Bandara (2011) roadmap.

Research contribution – relevance cycle method

Several research papers distinguish design science from Solutions Engineering based on whether the research problem being investigated is classified as wicked (Buchanan, 1992; Coyne, 2005; Hevner & Chatterjee, 2010). Previous to this research, no rigorous methods were available for scoping, classifying, and defining the nature of wicked problems. In a comprehensive literature review on DSR methodology, Alturki, Gable and Bandana (2011) identified fifteen key DSR papers that explicitly discuss DSR methodology. Of these, five papers briefly deal with the concept of problem wickedness and problem relevancy. These five papers, however, only briefly provide insight to the problem of establishing research relevancy (March & Storey, 2008; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Vaishnavi & Kuechler, 2004; Hevner, March, Park & Ram, 2004; Cole, Purao, Rossi, & Sein, 2005). A wider review of papers from the Engineering and Design fields reveals greater insights and perspectives into the nature and structure of wicked problems (such as Walls, Widmeyer & El Sawy, 1992; Eekels & Roozenburg, 1991; Nunamaker, Chen, Purdin, 1990; Takeda, Veerkamp, Tomiyama, & Yoshikawam, 1990). These papers, however, do not provide any detailed means for defining, classifying, documenting or communicating the nature of the wicked problem being addressed. They merely discuss what is and is not a wicked problem. The Alturki, Gable and Bandara's DSR (2011) roadmap, therefore, simply describes the relevance cycle as 'needs' (p. 111, 2011).

Rittel and Webber (1973) make a number of pertinent points about the nature of wicked problems in their seminal paper. Importantly, they state that "the formulation of the wicked problem is the problem!"; and "the process of formulating the problem and of conceiving a solution are identical" (Rittel and Webber, 1973 p. 161). Given that wicked problems are defined as complex problems where defining solutions to these problems are anchored by human finitude and normative constraint (Farrell and Hooker, 2013), then it is clear a more formalised approach to defining the wicked research problem was required.

The use of an Enterprise Information Architecture (EIA) technique is used to classify and define the wicked problem within the relevance cycle of this study. This method is shown in Figure ES8, which shows that the current state of the problem space. The research problem is defined using the abstract layers as defined by TOGAF – v.9.1. As part of this definition, the relationship between each layer is also defined. The future state of the problem space is then defined, and then a gap analysis between the current and future state is performed. A number of iterative changes to the EIA layers may further occur to achieve the final state of the novel artefact.

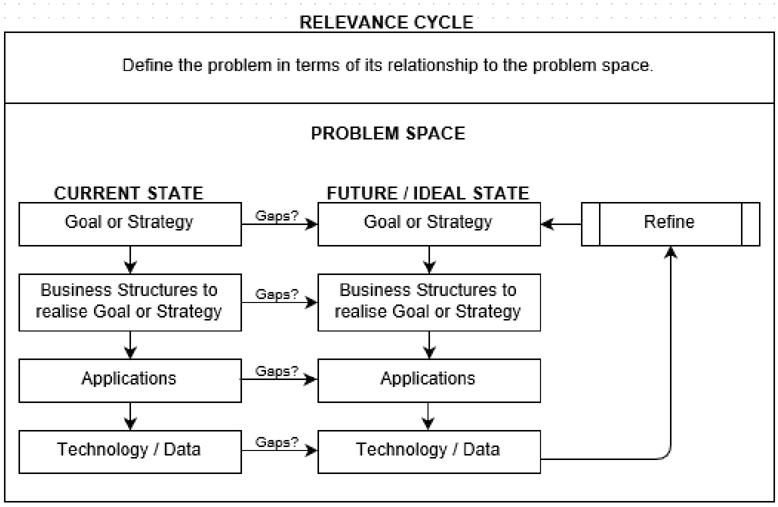


Figure ES8: A graphical representation of the method used for the relevance cycle in this DSR

In this research, the problem space was the entire enterprise, but it is projected that this method could be scalable for problem spaces that do not span the entire enterprise.

The application of this EIA modelling method has been shown to be useful for: i) classifying, defining and modelling the wicked problem; ii) proving problem wickedness and relevancy; iii) a mechanism for stimulating design pathways for artefact development; and finally iv) developing design theory according Gregor and Jones (2005) units of design theory. These benefits are further elaborated in Hellmuth and Stewart's (2014) paper on the use of Enterprise Information Architecture methods in DSR.

Design cycle

Once the wicked problem and the solution requirements had been defined, steps 5–12 of Altuki, Gable and Bandara's DSR roadmap were completed. For this research, steps 1–4 of the design cycle are completed in the Relevance Cycle, and steps 13–15 are completed in the Rigor Cycle. Steps 5–12 of the DSR roadmap were evaluated as appropriate and effective in the development of the resultant artefact. The description of the artefact is further articulated in the 'Executive Summary to Industry' and Hellmuth and Stewart's (2015) paper.

Rigor cycle

Within the Rigor Cycle of this research a number of methods are used to evaluate the sociotechnical effect of the artefact – to both individual users, and 'the problem space' being investigated. This study adopted three measures to examine the sociotechnical effect: i) unified theory of acceptance and use of technology; ii) IS-impact; and iii) convergent interviewing techniques.

Unified theory of acceptance and use of technology (UTAUT)

The UTAUT was applied in this study to measure the acceptance of the artefact. The results showed some volitional issues with its application. An important relationship to the validity and predictability of UTAUT centres on the relationship between behavioural intention (BI) and use. In the results of this study, there were no significant differences between the BI construct pre and post measures. Given that significant differences were found pre and post application of the artefact for the 'use' construct, the BI construct should similarly have been significantly different. This is problematic, particularly given the importance of BI to predicting IS use. A possible explanation for this result could be related to questions that make up the construct of BI. Questions in the UTAUT scale that measure the BI construct included: *I intend to use the artefact in the future* and *I plan to use the artefact frequently*. Teachers who participated in the trial might signal that they would not continue to use the artefact in the future based on the premise that the use of the artefact was just a trial. One limitation of this study, therefore, is the reliability and validity of the UTAUT scale. The questions on the UTAUT scale appear to be engineered more for an ex-post facto research design than for an experimental research type design. A major limitation to this research, therefore, is the construct validity of UTAUT. No conclusions with regards to behavioural intention could be made from this research. Modifications to the scale are required in research where information systems are trialled for a set period of time.

IS-impact scale

For this study, the Gable, Sedara and Chan (2008) IS-impact scale had appropriate construct reliability and was perceived as an appropriate measure. The IS-impact, together with the UTAUT results, represented the quantitative results for the study. One of the limitations of the design science methodology is related to the sample size. Given that design science requires the implementation of ‘experimental artefacts’, it is difficult to implement such ‘risky’ artefacts on a large scale. Quantitative results, therefore, often require the use of qualitative techniques to give further validity to the results found using quantitative techniques. This study used two additional techniques to study the effects of the instantiated artefact. The first is described as an analysis of SQL data, for examining the data accuracy, data timeliness, data consistency and data completeness. The second one involved the use of convergent interviews.

Convergent interviews

Convergent interviews are conducted to gain a qualitative understanding of the wicked problem and the artefact’s effect in solving the stated business problem. Convergent interviews allow for feedback from a diverse array of organisational stakeholders in the application domain – therefore, they have the potential to provide rich insights to those factors that lead to, or act as, barriers to use. Convergent interviewing is a recommended technique when complex issues need to be identified. It differs from other methods of interviewing in that it focuses on interviewing participants who are characteristically different. Through interviewing a full range of end users, key issues related to the problem set can be attained (Jepson & Rodwell, 2008). Convergent interviewing is characterised as a technique that is applied a number of times in the application domain, and converges on the issues with each round of interview. Convergent interviews have been found to be valid and reliable across a variety of settings (Lincoln & Guba, 1985). In this study, the convergent interview technique is applied to a range of user types for investigating their interaction with the artefact.

For this study, the use of the convergent interview technique revealed information that may not have been yielded using other interview techniques. Through the use of the convergent interview techniques, similarities and differences between the various user perceptions could be discerned. A rich and diverse range of perspectives was gained by using this technique.

Design theory

Finally, with respect to the rigor cycle, this summary describes the use and application of the Gregor and Jones design principles for defining the design science Theory (DST) emanating from this research. This research is the first of its kind to use the Gregor and Jones (2007) technique for describing DST. In the rigor section of this thesis, the eight DST elements are successfully described: ‘purpose and scope’, ‘constructs’, ‘principles of form and function incorporating the underlying constructs of the artefact’, ‘artefact mutability’, ‘testable propositions’, ‘justificatory knowledge’, ‘principles of implementation’, and ‘expository instantiation’. By using this technique, this study forwards grounded theory for the design, development, and instantiation of classroom-based information systems. Further elaboration on IS design theory for classroom-based education software are made explicitly in the Conclusion of this thesis.

The following table (ES2) highlights the contributions this research has made to academia, the education industry and information systems design science research.

Table ES2 – Key research contributions to academia

1	Shaped the characteristics of quality management programs for education.
2	Framed the requirements for data quality as part of quality management programs within education.
3	Modelled the link between IS quality, use, data quality, and continuous improvement in education.
4	Highlighted volitional issues with the UTAUT scale in IS studies.
5	Affirmed the utility of the IS-impact scale in IS studies.
6	Affirmed the utility of the Convergent Interview technique in IS studies
7	Provided an evaluation of the utility of the Alturki, Gable & Bandara (2011) roadmap.
8	Extended the relevance cycle within the Alturki, Gable & Bandara (2011) roadmap.
9	Produced design theory for classroom based behaviour IS’ using Gregor & Jones (2007) units of design theory.

Communication of research

Finally, an important part of research is the communication of the findings and theory produced from research. The following papers have been either accepted, submitted, and completed or partially completed at the time of submission of this thesis.

Table ES3 – Journals for communication of this research

1	Hellmuth, W. J., & Stewart, G. (2014). Using Enterprise Information Architecture Methods to model wicked problems in Information Systems Design Research. Paper presented at the 18th Pacific Asia Conference on Information Systems, Chengdu China.
2	Hellmuth, W. J., & Stewart, G. (2015). Information Systems Design for Continuous Improvement in Teaching and Learning. Paper submitted to the European Conference on Information Systems, Munster Germany.
3	Hellmuth, W. J. & Stewart, G. (2015). Design theory for Education Based Information Systems. Paper submitted to the Conference on design science research in Information Systems, Dublin Ireland.
4	Hellmuth, W. J. & Stewart, G. (2015). Reflections on, and additions to the design science research Roadmap. Paper in progress.

TABLE OF CONTENTS

ACRONYMS USED IN THIS STUDY

Acronym	Meaning
ADM	Architecture Development Method
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
ANTA	Australian National Training Framework
AQTF	Australian Quality Training Framework
BLL	Business Logic Layer
BMS	Behaviour Management System
BPM	Business Process Management
BPMN	Business Process Modeling Notation
BSC	Balanced Scorecard
BTLE	Bluetooth Low Energy
CDR	Central Design Repository
CI	Continuous Improvement
CIT	Convergent Interview Technique
DDDM	Data Driven Decision Making
DMAIC	Define, Measure, Analyse, Improve and Control
DSE	Department of School Education
DSR	Design science research
DST	Design Science Theory
EIA	Enterprise Information Architecture
HE	Higher Education
HG	House Guardians
IEEE	Institute of Electrical and Electronics Engineers
iOS	i Operating System
IS	Information Systems
ISS	Information Systems Success
IS-impact	Impact of Information Systems Scale
KPI	Key Performance Index
LAN	Local Area Network
MAC	Media Access Control (Address)
NAPLAN	National Assessment Program – Literacy and Numeracy
NCLB	No Child Left Behind Act
OL	Organisational Learning / Learning Organisation
OQ	Organisational Quality
PM	Performance Metrics
PNR	Positive Negative Ratio
QA	Quality Assurance
QC	Quality Control
QCT	Queensland College of Teachers
QI	Quality Inspection
QM	Quality Management
QSA	Queensland Studies Authority
SQL	Structured Query Language
RAD	Rapid Architecture Development
ROI	Return of Investment
RSSI	Radio (Received) Signal Strength Indicator
SIS	Student Information System
SoA	Service Oriented Architecture

Acronym	Meaning
SME	Small to Medium Enterprise
SPC	Stage Progress Cycle
SRC	Stage Refinement Cycle
UTAUT	Unified Theory of Acceptance and Use of Technology Scale
TAFE	Technical and Further Education
TOGAF	the Open Group Architecture Framework
TQM	Total Quality Management
TRA	Theory of Reasoned Action
TTF	Teaching Teachers for the Future
UDID	Unique Device Identifier
URL	Universal Resource Locator

TABLE OF FIGURES

TABLE OF TABLES

CHAPTER 1: OVERVIEW OF THE STUDY

1.1 INTRODUCTION

Total quality management (TQM) has been a priority issue in education since its adoption in management (Abernathy & Serfass, 1992). Within education there are numerous cases where there have been attempts to improve quality or implement quality improvement programs. Many of these programs fail or make little difference to education quality from the perspective of the teacher or student (Scott, 1999). Two major reasons for these failures centre on the lack of understanding of the definition of quality, and a lack of understanding of how to implement an effective TQM within an education system (Cheng, 1993; Cheng & Tam, 1997). This research attempts to address these two challenges.

This research, therefore, provides two valuable knowledge inputs for the enhancement of TQM systems within education. The first knowledge input provides a clear definition for what organisational quality (OQ) is in the education context. It also identifies what barriers prevent OQ according to this definition. This research thoroughly investigates and documents those barriers that prevent the generation of quality data and, subsequently, its use as part of the continuous improvement to teaching and learning processes. A second and more important contribution to improving OQ in schools is the understanding of why these barriers exist and how they might be overcome.

This thesis:

- Recognises that the environmental conditions in schools (in terms of data entry, data retrieval, and data evaluation) are unique within industry contexts.
- Shows that these differing environmental conditions uniquely and negatively affects the quality of data generated.
- Shows that the use of data to drive decision-making is subsequently adversely affected.
- Designs, develops, instantiates and implements a novel artefact for the purposes of improving data collection, data quality and its resultant use in informing teacher practice (through improving the accuracy, consistency, completeness and timeliness of

data, it is expected that the use of this data will be enhanced and better teachers' practice realised).

- Uses a number of measurement techniques to evaluate the impact of the new artefact to both the individual and the organisation. Through this 'sociotechnical evaluation' specific software design recommendations based on design theory can be made for future iterations.

1.2 LITERATURE OVERVIEW

The first objective of this thesis was to provide a definition for the dependent variable (Organisational Quality, OQ). This definition is provided within the literature review. To provide a context for this definition, the literature review provides a brief history of the evolution and application of quality management (QM) programs external to education. It discusses the various types of QM programs and the reasons for successes and failures. Further to this, previously implemented QM programs in the Australian education context are examined, as well as the underpinnings of these programs, and discusses the reasons for their limited success.

Within the education context, there is debate about what constitutes organisational quality. OQ is a reality composed of a plurality of entities and perspectives. Within the education context, the various perspectives on how OQ can be achieved and evaluated are detailed in Chapter 2. This thesis, however, takes a single perspective. It argues that for a school to be perceived as having OQ, it must incorporate the practice of continuous improvement (CI). CI forms the basis of total quality management (TQM). Within the literature review, it is argued that TQM can help schools systematically and incrementally improve OQ, that TQM tools provide the vehicle for data analysis and decision-making, and that accountabilities and standards are met through these 'Quality Systems' (Deming, 1986).

The idea of using data to inform decision-making and process improvement is not new within schools. Chapter 2 provides a number of relevant case studies of this type of practice in the United States of America (USA). Schools within the USA have for more than a decade been focused on using data to improve outcomes for students (Coburn & Turner, 2012). This is the result of the ‘No Child Left Behind Act’ (NCLB, 2001). Within education, the use of data to improve student outcomes has become known as Data Driven Decision Making (DDDM). The concept of DDDM is defined in Chapter 2, and success of DDDM as a QM program is also explored. Within Chapter 2, many research papers that highlight the barriers to DDDM are presented. The purpose of this presentation is to model the various confounding factors in the relationship between DDDM and OQ. Two broad categories describe the barriers to DDDM: ‘individual issues’ and ‘system issues’. The identified barriers categorised as ‘system issues’ form the initial requirements for the design scope for this study. These system barriers, identified through the literature, include: i) access to data; ii) timeliness of data; iii) relevance of data; and iv) validity of data.

Identifying the exact nature of how and why these barriers to quality data exist is often difficult – finding a solution to them can be even more difficult. Within the literature review, these problems are referred to as *wicked problems*. Buchanan (1992; citing Rittel and Webber, 1973) defines a wicked problem as class of social system problems that are ill formulated, where the information is confusing, where there are many clients and decision-makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing. The ‘system issues’ identified in the literature review contribute to the wicked problem of data quality and its subsequent use to inform student and teacher practice.

From a research perspective, wicked problem types are usually addressed using a design science research (DSR) methodology. DSR is class of information systems (IS) research that is particularly well suited for identifying, designing, developing, instantiating, and evaluating solutions to wicked problems (Gleasure, 2013; Hevner, March, Park and Ram, 2004).

1.3 METHODOLOGY OVERVIEW

This study is classified as a mixed methods research design with design science research (DSR) as the main methodological approach, which is detailed in Chapter 3. The DSR methodology follows the DSR roadmap suggested by Alturki, Gable and Bandara (2011); however, the relevance cycle procedures used in this study have a more detailed one suggested by Alturki, Gable and Bandara (2011). Justification for this change to the relevance cycle methodology is made in section 3.6. The DSR methodology used in this research contains three major development cycles: the relevance cycle, the design cycle, and the rigor cycle. The purpose of the relevance cycle is to establish the design requirements for the new artefact, while the design cycle's purpose is to design, develop and instantiate an artefact. The rigor cycle evaluates the artefact and communicates the new knowledge and theory that has been generated as a result of the instantiation of the artefact. These cycles are, respectively, the focus for chapters 4, 5, and 8.

1.4 RELEVANCE CYCLE OVERVIEW

The aim of the relevance cycle within this DSR was twofold. First, to define the problem in relation to the problem space as recommended by Hellmuth and Stewart (2014). As Rittel and Webber (1973) state, "defining the problem is the problem!"(p.162). Once the problem is defined, to prove the 'relevance' of this study, it will need to be determined that the identified wicked problem(s) cannot be engineered with existing technology or solutions. Developing novel solutions to wicked problems is a key requirement of the design science research method.

The second aim of the relevance cycle is to determine the artefact's design requirements, and these are then directly incorporated as part of the artefact's functional design. These two requirements of the relevancy cycle are discussed in the next two parts.

1.4.1 Modelling the wicked problem

Previous to Hellmuth and Stewart's (2014) paper on the modelling of wicked problems, no research had forwarded methods or provided a framework for defining, classifying, documenting, and communicating the nature and structure of 'wicked problems'. Hellmuth and Stewart (2014), state that wicked problems cannot be separated from the problem space. IS problems and artefacts should be viewed as part of, and not separate to, sociotechnical spaces: "The objectives of IS design science research is to develop practical knowledge for the design and realisation of different classes of IS initiatives, where IS are viewed as sociotechnical systems and not just IT artefacts" (Gregg, Kulkarni, Vinzé, 2001).

Given this, it was determined that this study's methodology should include detailed modelling of the problem space within which the problem exists. By doing this, the 'wicked problem' can be exposed and defined. The enterprise information architecture (EIA) techniques used to model the wicked problem in this study follow the standards of 'the Open Group Architecture Framework (TOGAF – v. 9.1).

In sections 5 to 8 of the relevancy cycle chapter, the EIA of the application domain is described using four abstract layers: the strategic layer, business layer, application layer, and the data/physical layer (technology layer). Within each of these abstract enterprise layers, an EIA identifies the entities and their attributes within that layer. The relationships between each of these are modelled to highlight gaps or misalignments between each entity and the entity groups to the desired enterprise state. These gaps and misalignments are scoped from the perspective of information quality and its use within a continuous improvement cycle.

1.4.2 Determining the design elements for the artefact

This study follows Robertson-Dunn's approach for the development of the solution requirements. Figure 1.0 below shows the direct relationship between the business architectures (enterprise) and system architectures (artefact). The figure shows that the business goals and business problems need to be identified to ensure they are included within the system architecture.

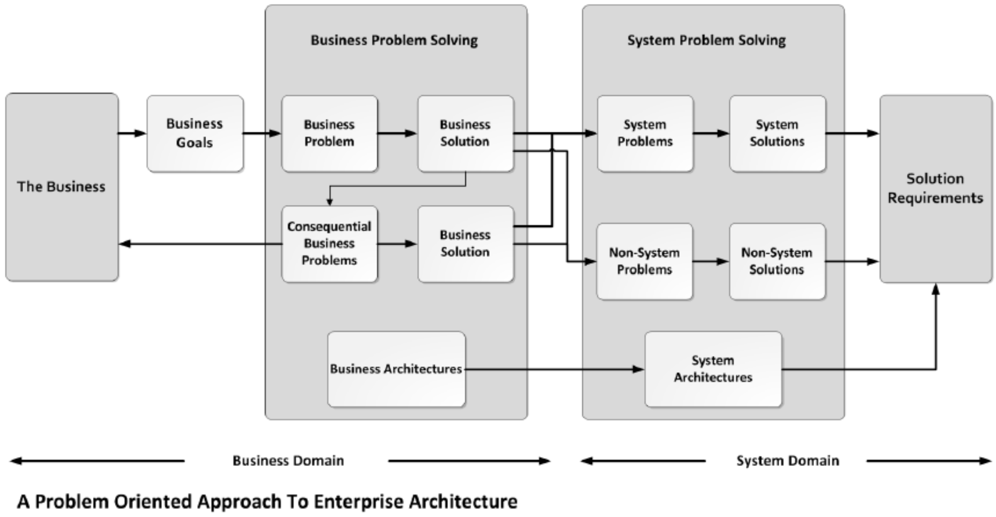


Figure 1.0: A problem-oriented approach to EIA (Robertson-Dunn, 2012, p. 61)

The artefact developed for this thesis incorporates all of the design considerations documented in the strategic, business, application and data/physical layers of the EIA. Therefore, the business goals associated with the research problem were achieved as recommended by Robertson-Dunn (2012) through the articulation and inclusion of both the business needs and solutions that dealt with the identified business problems. Through aligning the artefact's abstract layers to the enterprise's abstract layers, the 'quality' of the artefact, from the perspective of the end user, is assured. The design cycle chapter devotes considerable space to discussing the relationship between the alignments of the enterprise, its artefacts, and quality outcomes.

1.4.3 Designing for wicked problems

Once the business problems (gaps) between the current and desired states of the enterprise had been documented, these business problems were further analysed. If it was determined that these problems could not be addressed through existing technology, then a novel artefact could be developed and the relevance to the research problem would be formally established. The element of 'novelty' is a key requirement for artefact development in design science research.

Through the use of the methods adopted in the relevance cycle, six key design problems are identified within existing education-based information systems: i) the need to ensure validity and relevancy of the information system to teachers in the classroom; ii) to ensure that the information system can be used in the classroom so as not to disrupt the teaching and learning process; iii) to ensure data accuracy; iv) to ensure data consistency; v) to ensure data timeliness; and vi) to ensure data completeness.

Design problem 1 – artefact validity and relevancy

Through the interview technique, feedback from teachers indicated that they could not identify valid reasons for using information systems within the classroom. This perception existed even with the knowledge that it was a business requirement to provide specific data about student behaviours. It was a commonly shared perception among teachers that the legacy IS lacked utility and relevancy to their teaching practice within the classroom context (see section 2.9). The first goal of this research, therefore, was to develop a method for determining the scope and requirements for the design and development of artefact. The method developed needed be generalisable to education-based services. This method would also ensure that the artefact was perceived as a valid and relevant tool to the teachers in the context of their practices in the classroom.

Design problem 2 – information systems usability

A second major gap, one that disengaged teachers from the information system in the classroom, centred on the disruptive nature of data collection, particularly during the teaching and learning process. Using the legacy IS, teachers were required to move to a central teacher computer to enter data about student behaviours. This computer is often located away from where these behaviours occurred – this was seen as undesirable: "Proximity is important in managing behaviours". Another problem communicated was about the time it took to navigate pertinent fields within the IS. In a traditional IS, the teacher is required to open the IS application, navigate to the module, find the student, find the behaviour, and then apply an entry against that student. To report a single behaviour for a class of 30 students, a teacher would require a minimum of 92 separate user actions (shown in Figure 1.1).

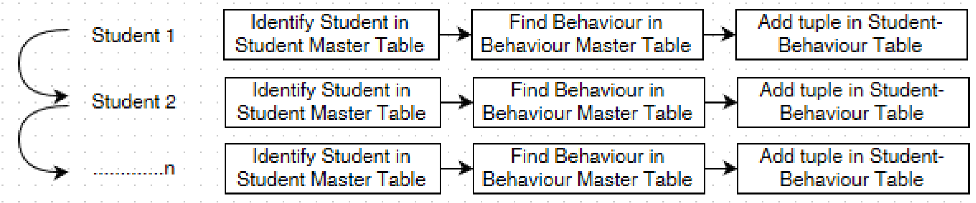


Figure 1.1: This figure shows the process of adding information to a student's record.

This process was seen as time consuming within the context of a classroom environment. The view was that the time taken to enter data detracted from the teaching and learning process and, therefore, was counterproductive. A new artefact design was needed to ensure that the use of technology complimented the behaviours of teachers in the classroom rather than 'compete' with it.

Design problem – poor data quality

'Data quality' is described as a multidimensional construct including accuracy, consistency, timeliness, and completeness (Fox, Levitin & Redman, 1994). As part of the relevance cycle method, the SQL database was analysed to review the quality of data written to it through the use of the legacy IS, and showed that the data quality was compromised. Therefore, several design considerations were required to ensure the accuracy, consistency, timeliness and completeness of the data.

Design problem 3 – data accuracy

Data accuracy refers to the "measurement or classification detail used in specifying an attribute's domain" (Fox, Levitin & Redman, 1994, p. 14). In this research case, data accuracy refers to how data describes a single or series of student learnings, reflecting their progress in the context of a classification schema that defines the pedagogical learning approach and framework adopted by the school. It was incumbent on teachers to use either data from external sources to the school, or to produce data themselves through the application of local measurement instruments. Both scenarios proved to be relatively ineffective in producing accurate and timely data. While externally collected data have developed metadata models to measure specific outcomes, these instruments are shown to have little relevance and validity to student outcomes (Ikemoto & Marsh, 2007; Marsh, Pane, & Hamilton, 2006). In contrast, data collected by school-based personnel is often limited in quality due the lack of skills as well as time and organisational structures to effectively produce and use data (Love, 2000; Bernhardt, 2000). Problems in relying on teachers to collect data were reported by Marzano (2003), who stated that data collected about student performances are often indirect measures without explanatory model to interpret it. In these cases, a metadata model was not correctly incorporated as part of the improvement program. As a result, data collected and reported by teachers is often of the wrong type or format, and is reported, therefore, as irrelevant, invalid, or inaccurate (Olson, 2002; Rudner & Boston, 2003).

Design problem 4 – data consistency

Data consistency refers to the "probability that an item will perform a required function under stated conditions for a stated period of time" (Fox, Levitin & Redman, 1994, p. 15). The data collection process should be stable and consistent across collection points and over time. Progress toward student learning goals should reflect real changes rather than variations in data collection approaches or methods. Data consistency remains the biggest challenge to generation of quality data, particularly in the secondary school context. Students have multiple teachers across several subjects and across year levels. Variations in collection frequency, as well as variations in subjective evaluations of student progress, leads to inconsistent data and, therefore, reduces the validity and relevancy of the data to the quality management program.

Design problem 5 – data timeliness

From a data timeliness perspective, data in the education context should be captured as quickly as possible after the student's attempt at a learning activity so that it can be available as a feedback and analysis tool. Various authors, however, discuss that the frequency of measures available that define improvements from the input/benchmark to the output, as 'too low' (Choppin, 2002; Marsh, 2006; Hanks, 2011; DeLoach (2012). Marsh (2006), for example, reported that teachers preferred the use of classroom data to periodic external exams in general, stating that external exams did not provide useful data in a timely fashion. Teachers could not act on this data, as students had already moved to another teacher and/or grade level. “For this reason, many districts and schools have adopted formal local tests that are issued more frequently throughout the year, thus providing diagnostic information that could be acted on immediately” Marsh, (2006, p. 114). Historically, the problem with relying on teachers to collect data is that such a process is resource intensive and, therefore, limited in its frequency. The infrequent collection about a student’s progress leads to problems associated with data inconsistency.

Design problem 6 – data completeness

Data completeness refers to the “degree to which a data collection has all the attributes of all entities that are supposed to have values” (Fox, Levitin & Redman, 1994, p 15). The data requirements that describe student-learning outcomes should be clearly specified based on the information needs of the school, and defined by their pedagogical framework. Data collection processes should be developed to capture the entities required to evaluate the progress of students with respect to their needs to outcomes with respect to the pedagogical framework. Through the realisation of data accuracy and data consistency, an increase in the completeness of data is also achieved.

The final part of the relevancy cycle was to clearly define the units and entities that make up the wicked problem. As this study concerns itself with redesigning these units and, therefore, changing the relationships between them, a clear definition for each unit of the artefact was required. These definitions and their relationships are detailed in section 8.3, and are measured pre- and post-instantiation of the artefact to evaluate the effectiveness of the design changes with respect to the research goals.

1.5 DESIGN CYCLE OVERVIEW

Once all of the design considerations were collected and the specifications created, the design cycle commenced. The purpose of the design cycle was to design, develop and instantiate the artefact into the application domain. The design process contained eleven steps as outlined in

Alturki, Gable and Bandara's (2012) DSR roadmap. This included considering a number of potential solutions for the design and development of the artefact. The potential artefact design needed to consider: automation triggers; data exchange and signal triangulation; signal types; Bluetooth BTLE 4.0 framework; authentication models; web-services development and testing; RSSI signal strength; and discrimination tests. The advantages and disadvantages for each of these solutions were evaluated and the justification for the final solution instantiated is made. Once these alternative pathways had been considered, the exact blueprint for the artefact was developed, which models the architectural requirements, functional requirements, and design and technical requirements for the new artefact.

1.5.1 Description of the instantiated artefact

The artefact consists of six main design constructs: i) functional design elements (defined through the EIA) ensuring utility (relevancy and validity) of the artefact – it is expected the sum of these would lead to increased use within the classroom; ii) the proximity detector, which improves usability of the software in the classroom; iii) development of a metadata model to improve data accuracy; iv) development of teacher and student feedback mechanisms to moderate user behaviour towards best business practices, thus aligning to the defined service strategy; v) development of the artefact to ensure any feedback mechanisms presented data in a 'live' and well formatted way; and vi) artefact design to ensure valid and timely data was available to teachers to facilitate accurate judgements about a student's progress. These design responses are described below.

Design response 1 – validity and relevancy to practice in the classroom

Validity and relevancy of the artefact is first achieved through identifying the exact needs of the IS artefact using enterprise information architecture (EIA) methods as specified by the Open Group Architecture Framework (TOGAF) v 9.1. The purpose of the EIA was to model the entities of the enterprise and the relationships that exist between each of these entities. Specifically, the requirements defined in the strategy and business layers of the EIA (specific to the service unit) form the scope and design requirements for the artefact. Because of these requirements, further changes to the information systems and technology architectures were identified and completed. Figure 1.2 below shows the various screens developed for the artefact, and these are described in detail in the Design chapter.

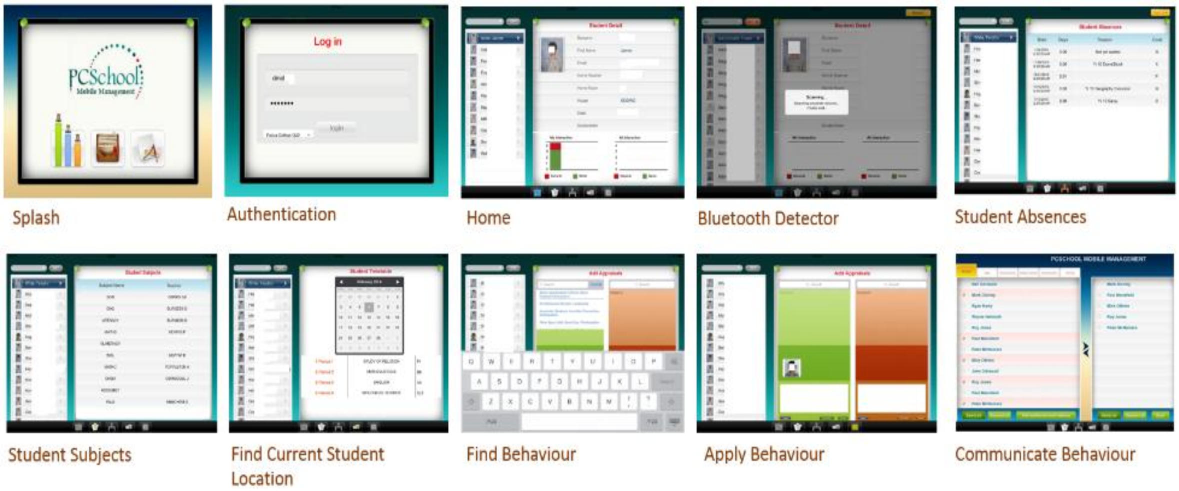


Figure 1.2: Depicts the main screens developed for the mobile-based artefact.

Design response 2 – information systems usability

To ensure the new developed information system was usable within the classroom, a redesign was required for the interface, one that would ensure that the teacher could collect data without taking their attention away from the teaching and learning process. This was achieved in a two-part process: i) the automation of data look-ups based on the proximity of the teacher to the student; and ii) the assigning of behaviours through drag-and-drop processes.

The artefact instantiated for this study is described as a system of two mobile iOS based apps: a teacher app, and a student app. Screenshot examples are shown in Figure 1.3. The first allows the user to detect students via Bluetooth signal, thus automating the first part of the data entry process. The second screen shows the ability to simply apply multiple students to a single behaviour through a drag-and-drop process. This design minimised the need for teachers to divert attention from the students.

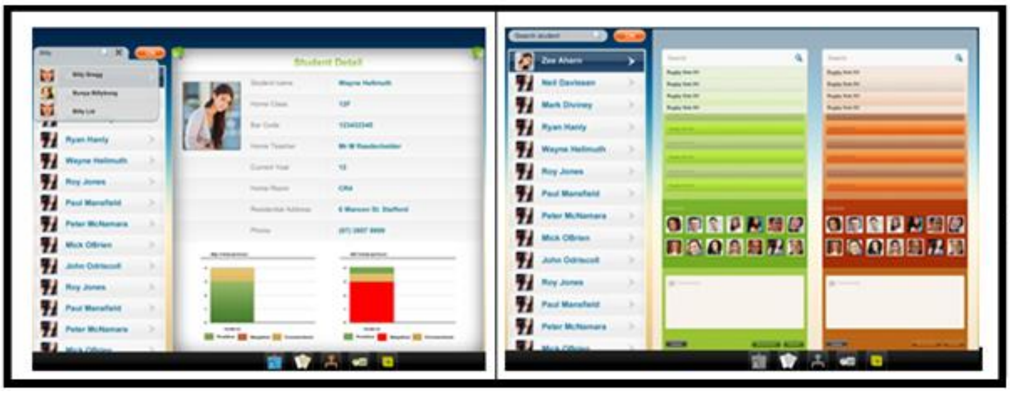


Figure 1.3: Shows two of eleven screens developed for the artefact. The screens depict a more efficient data entry process.

The number of interactions required by teachers using this model is reduced to approximately one-third of those required by the legacy IS (shown in Figure 1.4). In addition to this novel functionality, the app includes all of the requirements documented in the *Enterprise Information Architecture* document (i.e. the requirements to realise the service strategy, enable business functions, and to ensure the applications and technology layers have the correct functional design).

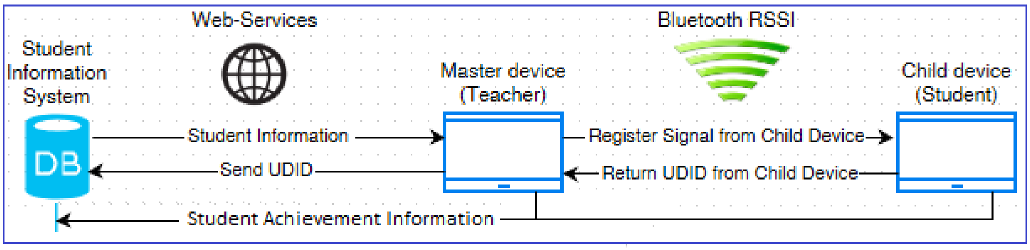
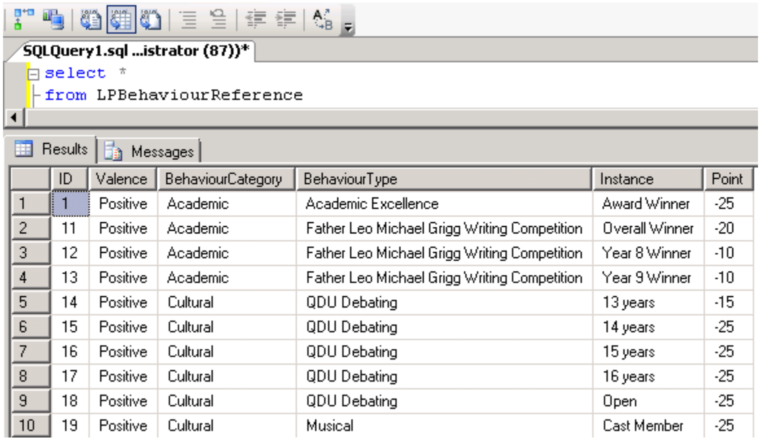


Figure 1.4: A model representing the novel technology.

Design response 3 – data accuracy

To respond to this design problem, the redesign of the artefact included the development of a metadata model. This was realised as 294 different behavioural comments in an SQL database, as shown in Figure 1.5.



SQLQuery1.sql ...istrator (87))*

```
select *
from LPBehaviourReference
```

Results | Messages

	ID	Valence	BehaviourCategory	BehaviourType	Instance	Point
1	1	Positive	Academic	Academic Excellence	Award Winner	-25
2	11	Positive	Academic	Father Leo Michael Grigg Writing Competition	Overall Winner	-20
3	12	Positive	Academic	Father Leo Michael Grigg Writing Competition	Year 8 Winner	-10
4	13	Positive	Academic	Father Leo Michael Grigg Writing Competition	Year 9 Winner	-10
5	14	Positive	Cultural	QDU Debating	13 years	-15
6	15	Positive	Cultural	QDU Debating	14 years	-25
7	16	Positive	Cultural	QDU Debating	15 years	-25
8	17	Positive	Cultural	QDU Debating	16 years	-25
9	18	Positive	Cultural	QDU Debating	Open	-25
10	19	Positive	Cultural	Musical	Cast Member	-25

Figure 1.5: A presentation of the metadata developed for the newly instantiated artefact.

Each behavioural entity in the framework is described using nomenclature that has four dimensions: Valence; Behaviour Category; Behaviour Type; and Behaviour Instance – though web-services behaviours were filtered for the user at the interface based on temporal parameters. For example, during pastoral care periods, a returned search of behaviours would be ordered to return the most relevant pastoral care records, further minimising the time needed by the teacher to interact with the information systems artefact. Data returned to the artefact were presented in combo-boxes within the application.

Design response 4 – data consistency

Figure 1.6 (below) shows two teacher-feedback mechanisms (through the use of graphs) that were developed to address the issue of data consistency in teacher reporting.

Figure 1.6: Immediate feedback provided to the teachers about the consistency of their judgements.

These graphs are found on the home screen and are obvious to the user. The first graph represents the teacher's interactions with the student. According to behaviour management, a teacher should provide a student with eighty per cent positive feedback (represented as green in the graph) and twenty per cent negative feedback (represented as red in the graph). This principle is considered to be best business practice and is defined in the business architecture. The second graph represents the interaction of all other teachers with the student. In this instance, no other teachers have recorded any behaviours against the student. As documented in the strategy architecture, an important part of the service strategy is to ensure consistent feedback to the student. According to behavioural theory, consistent feedback on behaviour increases reinforcement strength to that behaviour. In this example, the data can be used to encourage other teachers to interact with this student to affirm or distinguish certain behaviours.

Design response 5 – data timeliness

In traditional IS, the mechanism for providing feedback to users was through the use of reports. These have the potential to provide a detailed understanding, across a number of different dimensions, about a particular student-related phenomenon. However, they are not designed to assist teachers and students to adjust practices inside the classroom. According to behaviour management theory, reinforcement to behaviour is strengthened if it is reinforced immediately after it occurs. It is recommended, for this research, that teachers and students be provided pertinent data in a ‘live format’ – data that should be in context as defined in the service and business architectures. Figure 1.6 (above) shows the two graphs available to teachers. These contain data that is updated immediately with brief but pertinent information about the student/teacher’s performance according to the service strategy and best business practices.

Design response 6 – data completeness

Through the realisation of data accuracy and consistency, the completeness of data is also achieved. The results of this study clearly showed improved data completeness, and this is discussed in the results section of this thesis.

1.5.2 Construction and evaluation methods

Section 10 of the Design Cycle chapter describes the construction methods for the artefact, and section 11 discusses the methods used for evaluating it. Two types of evaluation methods are used to appraise the artefact: artificial, and naturalistic; and there are two types of artificial evaluations methods: white box testing, and black box testing. Black box testing refers to evaluation methods that examine the functionality of the software, but not the internal structures of the software (Edwards, 2001; Beizer, 1995); white box testing, conversely, examines the internal workings of the software (Ostrand, 2002). The naturalistic evaluation methods are outlined in the Methodology, and include the UTAUT scale, IS-impact scale, convergent interviews, and descriptive statistics.

1.5.3 Validity threats

The final section of this chapter discusses the relevant validity threats to this study, and includes: nomological, construct, predictive, content, discriminant and convergent, internal, instrumental, inter-rater, and statistical conclusion validity. This section also provides a summary of the completed design cycle.

1.6 RIGOR CYCLE OVERVIEW

The Rigor Cycle within this study consists of three chapters: the first contains the results from the naturalistic evaluations (Results chapter); the second contains a discussion that evaluates these results in the context of the stated goals of this study (Discussion chapter); the final section describes the theory and the components of this theory as described by Gregor and Jones (2007).

1.6.1 Results

The purpose of the results section was to state the results of the naturalistic evaluation methods (i.e. the sociotechnical interactions). An important part of understanding the effect of the artefact on the environment is to measure the change in behaviours at both pre and post implementation of the artefact. The data analysis methods employed to prove the hypotheses are explicitly stated in this results section.

Construct validity

Importantly, in section 6, the Chronbach alpha's for each of the constructs used within the UTAUT and IS-impact scales are stated. This section shows that the internal reliability of all constructs was considered acceptable. System Quality (IS-impact) and the Habit (UTAUT) constructs had an alpha of 0.63 and 0.67 respectively. All other constructs had a Chronbach *Alpha* score > .07. Pearson's r correlations are used to examine the correlations between all constructs, and to determine whether these relationships fit within the accepted model (the UTAUT and IS-impact models).

The results of this thesis showed that the expected correlations between the various constructs of the UTAUT model were not replicated in the pre-test – however, they were replicated in the post-test. In Venkatesh's et al. (2003) UTAUT model, the correlation between behavioural intent and appraisal behaviour is considered crucial for the understanding user behaviour. The results of this study showed that 'use' behaviour was not related to behavioural intent prior to the instantiation of the artefact.

The artefact effect

Paired sample t-test (repeated measures) and mixed between-within analysis of variance (*ANOVA's*) are used to determine if there is a significant before-and-after affect with respect to the entire set of constructs used within this study.

In terms of user acceptance (UTAUT), the implementation of the artefact was significantly different pre and post-tests for the constructs of performance expectancy, effort expectancy, facilitating conditions, hedonic motivation, habit, and appraisal frequency. The constructs of social influence and behavioural intention were not significantly different between the pre and post-implementation of the artefact.

In terms of the impact the artefact had on the organisation, the results of the IS-impact survey showed that there were significant differences between measures for the constructs of individual impact, organisational impact, information quality, system quality, and satisfaction pre and post-test.

To provide a greater understanding to the quantitative results, qualitative data from convergent interviews are provided as well as descriptive statistics. These showed the impact of the artefact in terms of the number and types of appraisals awarded in direct comparison to the legacy IS during the same period. The full detailed set of results can be found in the results chapter.

1.6.2 Summary of the discussion section

The results confirmed that, through the use of the EIA, the quality of the artefact was perceived by teachers to have improved, and this enhanced the use rate of the artefact within the classroom. It could not be discerned, however, whether this outcome was due to the changing intent of the teachers. The data quality did improve because of the use of the artefact; however, this did not meet the standards that are considered best practice. There was little data to support the theory that teachers made better subjective evaluations with respect to behaviour management from using the artefact.

In general, two factors influenced teachers' beliefs about the importance of data in making decisions: i) their beliefs about behaviour management; and ii) their knowledge and understanding of behaviour management theory. These factors are described as exogenous variables to the user in the discussion section.

The feedback from the convergent interviews confirmed the quantitative results with respect to the measurement of the sociotechnical response of the newly instantiated artefact. Teacher feedback mainly focused on the utility of the artefact (i.e. 'it saved me time and effort'). House Guardians (teachers responsible for managing student behaviours at a group level), however, showed a greater appreciation of the artefact, due to its power to change behaviour through appraisals delivered in a timely manner. This feedback affirmed many of the design decisions made in the design cycle. More information can be found in the results section of this thesis.

1.6.3 Outputs of design science theory (DST)

From the analysis in the discussion chapter, the power of the EIA to address the critical business components of artefact was evident. The elements of wickedness have also shown to be effectively addressed through the application of rigorous application of EIA methods. The resultant information system is the sum of the artefacts revealed through this analysis.

This design science Theory (DST) section addresses how the use of the methodological approach has facilitated the development of theory due to the instantiation of the IS artefact. The methodological approach developed in this case study has addressed all the required elements to define, delineate, and develop design science research theory. This DST section contains eight parts, each part listing the elements of, and outputs of, DSR – as advocated by Gregor and Jones (2007): ‘purpose and scope’; ‘principles of form and function incorporating the underlying constructs of the artefact’; ‘artefact mutability’; ‘testable propositions’; ‘justificatory knowledge’; ‘principles of implementation’; and ‘expository instantiation’.

Purpose and scope

According to Gregor and Jones (2007), the DSR theory element ‘purpose and scope’, defines the relationship between the artefact and its environment. The nature of this relationship defines the boundaries of the research and, therefore, the boundaries of the theory being evaluated. Within this research, the strategy layer of the EIA defined the problem space. The relevancy cycle within DSR is defined as the process of identifying multiple entities that are related through their participation in a common function. This function may have a micro or macro focus. This function is theoretically aligned with the goals outlined in the strategic layer; however, the ill-defined relationship between the multiple entities and their attributes, prevents the goals stated in the strategic layer from being realised. The scope of the artefact design for this study is established to address these misalignments. The relationship between the artefact and its environment is facilitated and clearly established through the use of EIA.

Constructs

To clearly define relationships between entities, as well as the artefact to its environment, it is vital that the *constructs* used in the research are clearly defined. Walls, Widmeyer, and El Sawy (1992), based on work from Dubin (1978), state four considerations for describing constructs: the units of interaction; law of interaction between the units; boundaries to which the theory is expected to hold; and system conditions where the theory is not expected to hold.

The example provided in this study used the techniques recommended in TOGAF – v 9.1 EIA to deconstruct the problem space. Through undertaking this process, the units and their interactions were described. Through focusing on problem interactions between units, the laws that drive these interactions were defined and redefined through research testing. Through applying research to these defined ‘laws of interaction’, the application and limitations of these laws of interaction were also defined.

Principles of form and function

Once the constructs of the problem space are defined, they can be used to describe the architectural and functional structure of the artefact. The purpose of the DSR theory output ‘principles of form and function’ is to describe the artefact by mapping its conceptual structure, functions, attributes and properties (Gregor and Jones, 2007). Within the Rigor chapter (Table 8.0), a concept map defining the artefact is developed as part of this research, and it provides a conceptual overview of the artefact’s form and function. The artefact is described as an IS object design (using van Aken’s, 2004, classification), at the application layer and data layer. The artefact incorporates a process redesign at the business layer, and it is developed to meet the realisation design described in the strategy layer.

Further detailed elaboration on the design is completed in the research in the context of the problem space, which was described using the EIA. The entities and components of the wicked problem are categorised according to the abstract layers of an EIA.

Artefact mutability

Artefact mutability refers to the change in state of the artefact anticipated in the theory. The rigor chapter discusses the likely future iterations that could be made to the artefact. It is proposed in this section that iterations to the artefact will be dependent on the business goals and service strategy of the organisation. Further iterations to the elegance of the novel component of the artefact are also dependent on the improvements to the Bluetooth (BTLE 4.0) framework.

Testable propositions

Testable propositions, or hypotheses about an artefact's effect on the problem space, are an important part of establishing design science theory (DST) in DSR. Gregor and Jones (2007) state that "these propositions can take the general form: if a system or method that follows certain principles is instantiated then it will work, or it will be better in some way than other systems or methods." Considering the artefact example provided in Table 8.0, the testable proposition is that an artefact with the specific architecture (as defined in the business, application and data layers) will have an effect on specific goals stated in the strategic layer. Specifically, with the use of Bluetooth sensors, the number of user interactions per data entry can be reduced, thereby facilitating increased use and better quality data throughout the continuous improvement cycle.

The success in achieving those goals at the strategic layer is gauged through both qualitative and quantitative measures established at the start of the project. Walls, Widmeyer, and El Sawy (1992) define design theories as "composite theories that further encompass those kernel theories from natural science, social science and mathematics". They differentiate design theories from natural and social sciences, in that design science is the application of natural and social sciences in practice. Through applying these theories in practice, empirical support for that theory can be obtained.

The use of an EIA in this research allowed for the easy identification of those natural and social science theories that needed to be further explored and tested as part of DSR. The kernel theories, explored for this research, aligned to those goals outlined in the strategic layer. The theory of reasoned action (TRA) and the theory of planned behaviour are used extensively to explain the sociotechnical interactions found in this study.

Principles of implementation

For this research, the *principles of implementation* were determined from an analysis of those gaps that exist in the problem space. A review of the dependencies and co-dependencies between each of the entities was initially completed, and those identified as having the greatest number of dependencies became the initial focus for design. A review of the solution pathways was then conducted to evaluate if there was a need to develop novel solutions to the identified focus problems. A cascade approach for development was then undertaken. Through using this approach, it was believed that the core of the wicked problem was addressed, with all other dependencies appropriately documented, and included as considerations in the design and development of the novel artefact.

Expository instantiation

This thesis describes the expository instantiation as the sum of all of the elements described above that make up the artefact developed for this study.

1.7 CONCLUSIONS AND RECOMMENDATIONS OVERVIEW

Within this chapter, the purpose and content of this research is described. The previous section summated the purpose of this research by stating the DSR components that must be communicated in order to define design theory. The communication of theory is the major output of this research.

The conclusions and recommendations section of this paper discusses all of the elements of the research and its contribution to the production of design science theory. The second last section of this paper discusses the limitations of this study and, therefore, the limitations to theory. This last section makes remarks and recommendations about the product and design process.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The aim of this thesis is to design and develop an information system (IS) that facilitates the continuous collection and use of student data within the classroom. It will facilitate the continuous collection of 'behaviour related' information about a student. The key differentiator between the profiling software designed and developed for this thesis and other behaviour management software lies in the design of the software. Teachers report that they are reluctant to collect student data in the classroom because it detracts from the teaching and learning process. They also question the validity and relevancy of using data within the classroom.

The novel design of the IS artefact developed for this thesis facilitates the collection of student data without the need for teachers to divert their attention from the teaching and learning process. The IS artefact is also designed to ensure its validity and relevance for use in informed decision-making. It is envisaged that the outcomes from the implementation of this IS artefact will be: the continuous collection of student behaviour data; improved data quality; improved engagement with data and the use of IS' in the classroom; improved teacher practices; and improved student outcomes.

The objective of this thesis was: (i) to develop a type of classroom based information system that allows for ongoing, timely collection of data at the point of occurrence of student behaviour; (ii) to investigate the benefits of the system for students, teachers and the organisation, and; (iii) to reflect on the implications of such a system for other classroom based systems.

The purpose of this literature review, therefore, is to provide a context for this study. This context will emphasise the importance of this study to the larger research problem set which is improving organisational quality in schools (OQ). OQ in education is a complex phenomenon; so, to position this study, this literature review provides the theory to OQ and highlights a framework of issues associated with achieving quality in schools. By framing the literature in this systematic way, research gaps that exist in this research realm are exposed. Key concepts and terms are defined in this chapter as part of this systematic review. Literature (including published research papers, theses, models, and case studies) is provided to assist in the development of this review. Stemming from the purpose of this study as stated in the preceding paragraph, this literature has a number of objectives:

1. To provide a definition for quality and quality management (QM) in the education context. Quality is multidimensional in its meaning, and this review discusses the difficulties in defining it. A number of definitions for quality are provided, and this paper proposes that ‘transformational quality’ is most suitable definition of quality when describing school quality.
2. To provide a brief history of the development and application of quality management (QM) principles in organisations external to education. QM is a concept that has its roots in business and, therefore, section 2.6 of this chapter contains definitions for this concept in a broader organisational context. This is done so that the applicability of QM principles to education can be examined and, within this context can, begin to be defined. This section provides a number of school-based examples of these ‘quality improvement programs’, and formally categorises these programs within a QM program type. By doing this, the role of data can be presented for each QM type.
3. To assess how data is currently being used within schools that have attempted to implement a total quality management (TQM), or a quality improvement program. In section 2.9, the concept of data driven decision-making (DDDM) in education is defined. Many research discussions are presented on the limitations of data use in education programs. The purpose of this section is to model the various confounding factors in the relationship between data collection and student learning outcomes. At the end of this section, a model of DDDM associated issues is presented and referenced in the final discussion of this thesis.
4. To justify the need for this study, taking into account the preceding objectives. This literature review highlights the current limitations of data collection procedures, and proposes that those using an ex-post facto type method (exams) limit educational programs that seek to continually improve the learning of students. This study suggests that to attain curriculum quality in schools, data should be collected in an

iterative and ongoing way and, therefore, a redesign of a specific artefact is proposed and justified. This IS redesign is forwarded in Chapter 5 of this thesis.

The next section of this thesis begins the literature review by defining and discussing the concept of quality

2.2 DEFINING QUALITY

Implementing 'quality' in education is an exercise in rhetoric. This argument stems from the difficulty in defining exactly what 'quality' is (Wittek & Kvernbekk, 2011). The term has its epistemological beginnings in Plato's writings on beauty (Dickie, 1971). Like beauty, quality is a 'platonic form' and, therefore, is a term that cannot be defined. Philosophers in the past have argued that these terms are transcendent and can only be understood after the viewer has experienced a series of objects that displays it characteristics. "It is an unanalysable property that we learn to recognise only through experience" (Garvin, 1986). Quality, therefore, is not an absolute term, but is conditional to subjective experiences and personal meaning. A further difficulty in defining quality is the application of the term to systems like schools. The key defining difference between fixed objects and systems is the need for systems to constantly adapt and change. The subjective and absolute meaning of quality, therefore, also changes when applied to schools (Westerheijden, Stensaker & Rosa, 2007). Most school reform processes are initiated when the reformist sees differences between their own subjective meaning of quality and their observations of a current system. The goals of these reform projects are to close the gap between the two states of perceived quality. Many education reform projects fail due, in part, to the majority of participating stakeholders failing to implicitly share and value these differences between the two quality states (Fullan, 2001).

Given the problem of defining this transcendent value, various authors have attempted to ground the meaning of quality and, therefore, it has been given a number of derivative meanings. Within the manufacturing industry, quality has been described from a product-based perspective, asking: "does the product meet predefined criteria?" Australian higher education (HE) currently has a number of researchers that adopt this perspective. One of two current discourses on improving quality in HE focus on ensuring that students have specific qualities needed by employers, thereby ensuring high employment rates of graduates (Emery, Kramer & Tian, 2003; Stensaker, 2007; Sahney, Banwet & Karunes, 2008). The other discourse concludes that universities should have a service focus, rather than a product one, with an emphasis on creating a service-oriented business architecture (SoA) (Kanji & Yui, 1997; Sahney et al., 2003; Kanji, Malek & Tambi, 2010).

Quality has also been defined from a user-based perspective, postulating that it is only achieved when: a product meets or exceeds the user's expectations (Parasuraman et.al, 1985; Dotchin and Oakland, 1994; Asubonteng, McCleary & Swan, 1996); the product or service is fit for use (Juran, 1982; Juaran & Gryna, 1988); or when the demand for the product or service increases (Dorlman & Steiner, 1954). Quality has also been described as a value-based proposition, such as: what does the product or service provide for the given price of the product or service (Feigenbaum, 1991)? This paper only touches on the multitude of research papers that provide various definitions and perspectives for quality in organisations. After 70 years of attempting to define and ground the definition of organisational quality, the perspectives provided by each still suggest that the meaning of quality is conditional to subjective and personal meaning (Fuller, 1986; Hughes, 1988).

Given that quality cannot be separated from subjective and personal meaning, schools are left in the unenviable position of ensuring that the product or service produced by schools meets the ever-changing and shifting meanings of 'quality'. Given that schools change procedures and processes at an increasingly rapid rate, it is the proposition of this research that quality in a modern school will be defined by the school's agility and capability to continuously refine it processes to produce specific services that meet the subjective and changing definition of absolute quality (Berry, 2002). A school, for example, that is slow to respond by changing processes and creating new outputs is more likely to be evaluated as having poorer quality than one that responds rapidly to the changing needs of multiple stakeholders.

The argument for obtaining absolute quality within education research, therefore, should be de-emphasised, with the new focus moving towards 'quality as a system'. Specifically, how schools should be structured to ensure their ability to continually change to meet the expectations of internal and external stakeholders. The key challenge for future school leaders is in understanding how to engineer an agile organisation to continually and quickly adapt to constantly changing needs (Saiti, 2012).

2.3 QUALITY AS A SYSTEM

There has been significant research focusing on quality management in education (Sallis, 1993; Green, 1994; Idrus, 1996; Harvey and Knight, 1996; Cheng and Tam, 1997: Weidmer & Harris, 1997; Kanji et al., 1999; Berry, 2002). Previous research and discussions on quality management in education contains multiple perspectives and dimensions with respect to its definition, applied quality management programs, and assessment/measurement. This has led to difficulties in conceptualising the application of quality management in education.

This research applies a 'systems view' (Cheng, 1995; Cheng and Tam, 1997) of conceptualising quality management in education. This defines quality as a constituent of subsystems and processes, comprising of inputs, processes and outputs. Figure 2.0 highlights 'quality as a system'. Section 2.4, contains discussion on education programs that have focused on improving education quality. In general, these quality improvement programs can be classified according to which component of the quality system they have sought to improve. Section 2.4 provides several examples of education programs that have targeted the input, process, and output quality of the education system.

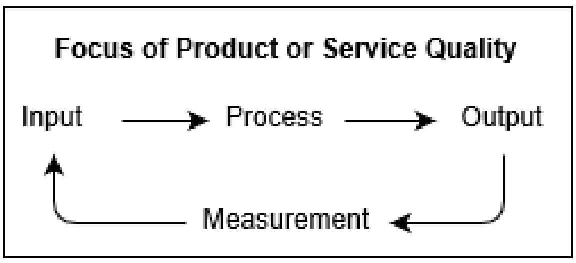


Figure 2.0: Component of an organisational system

With respect to Figure 2.0, an *input* is defined as the 'raw materials' that are put into the quality system, and considered to be the first stage of a system that produces quality. The *processes* defined in this model refer to the internal functions of the school, and the *outputs* refer to the relative standard of the improved input against a defined standard. Measurement in this systems model provides the tool for analysis and improvement.

2.4 EDUCATION QUALITY FROM A SYSTEM'S VIEW

2.4.1 Education quality as an input

Many existing education programs aim to improve the quality of 'inputs' into an education system. For example, given the strong research concluding a positive correlation between student learning outcomes and teacher quality, many quality programs focus on teacher quality as an input. (Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2007; Ferguson, 1991; Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004; Sanders & Rivers, 1996; Goe, 2007). For example, within Australia, the state-based teacher registration authorities, such as the Queensland College of Teachers (QCT), partake in joint initiatives with the federal government to improve teacher quality. QCT states, "The agreement acknowledges that teacher quality is the single greatest influence on student engagement and achievement. It aims to support all teachers and school leaders to strengthen the quality of teaching in every classroom, every day" (QCT, 2013).

The objective of this program is to clearly improve the education system by improving the input of the 'teacher quality'. Through improving this input, it is perceived that there will be improvements to the overall quality of the education system. Several other research and education reform programs also seek to improve the quality of inputs into the education systems: facilities quality; community involvement (Uline & Tschannen-Moran, 2008). Table 2.0 displays the various considerations to a quality system.

Table 2.0 - Considerations to 'quality as a system'

	Input	Process	Output	Feedback
Quality measurement type	Absolute	Relative-procedural	Relative-compliance	Transformational
Quality improvement program type	Inspection	Quality assurance	Quality control	Total quality management
Measurement tools	Benchmarking	Procedural data (e.g. audits, BPM)	Output data e.g., Examinations	Change (Δ) data (e.g. performance metrics

The columns represent the four stages of the quality system. Each stage of a quality system has a specific quality measurement types: absolute quality, procedural quality, compliance quality, and transformational quality (Sallis, 1993). Using industry standards, absolute quality is measured through inspection, procedural quality through quality assurance (QA) programs, quality compliance through quality control (QC) programs, and transformational quality through total quality management (TQM) programs. TQM encompasses the previous three quality types, as well as the function to continually improve the overall system through feedback and analysis.

As Table 2.0 suggests, the input to a quality system is measured in absolute terms. Absolute quality, was introduced in section 2.2, and is defined as an ideal, or as the highest possible, standard with no exceptions. It is distinctive and out of the ordinary. This concept of quality is not judged against criteria – it is just 'quality' (Elken, 2007). As a result, absolute quality can only be measured through a subjective evaluation of the quality state (inspection). The inspection process determines whether gaps exist between the inspectors' subjective beliefs about quality and their observations of current system quality.

2.4.2 Education quality as a process

Other authors define quality as a measure of compliance to a process in the development of a product or service (Tribus, 1993; Juran & Gryna, 1988; Peters & Waterman, 1982; Gilmore, 1974). It is the belief that by improving the processes of a system, the overall quality of the system can be improved. There are a many education-based process improvement programs that aim to improve the system in this way. For example, within Australian education throughout the 1990s, a greater emphasis was placed on developing quality processes, particularly within universities (Atkinson, 1994; Kaufman & Zahn, 1993; Sallis, 1993) and technical and further education (TAFE) institutions (Freeman, 1993).

In 2001, the Australian National Training Authority (ANTA) developed the Australian Quality Training Framework (AQTF). This allowed students enrolled in schools and TAFE colleges to undertake nationally recognised and standardised education and training courses. The framework at the time required any institution providing these courses to comply with twelve rigorous AQTF standards, and the ability to provide these courses was conditional on the institution attaining compliance at an annual audit. Accreditation of courses by ANTA assured industry, employers, and universities that the standards were achieved for the delivery of vocational education training and the quality of graduates.

Other examples of process compliance include the implementation of compliance audits for Queensland matriculation subjects. In 2002, the Queensland Studies Authority (QSA) began conducting bi-annual audits of Authority registered subjects offered within secondary schools, thus ensuring compliance to set curriculum standards. Further educational examples include the Department of School Education (DSE) in New South Wales that, in 1992, began conducting external school reviews to assist schools in the development and provision of quality processes to meet the needs of greater public accountability of school quality (Cuttance, 1994).

In a business context, and more often in the education context, process compliance is improved through the use of a quality assurance (QA) program. The emphasis of QA is on ensuring that defined systems and procedures are being followed. This is seen as a method that will produce a standardised and, therefore, a quality outcome (Cheng & Tam, 1997). So, quality is achieved by putting standard systems and practices in place and ensuring they are adhered to. Compliance is measured through the use of specific compliance indicators, which can characterise whether the product or service conforms or complies with a predefined specification.

2.4.3 Education quality as an output

The term 'quality' in Australian education is externally perceived by the outputs of the education system. Outputs include school or centrally administered examination success, school performance on national literacy and numeracy testing (NAPLAN), OP results in published league tables, and set government standards. These outputs associated with the education system have traditionally been the focus of quality programs within the education sector.

The output component of a quality system is typically measured through the use of exams, and seeks to implement quality control. Quality control refers to the detection and elimination of components or final products that are not up to standard. It is an after-the-event process, concerned with detecting and rejecting defective items.

2.4.4 Why education quality programs fail.

McLaughlin (1990) notes that very few federally funded education reform projects have been successfully implemented; only 18% were deemed successful. Elmore (1995) states that there are few educational examples where the majority of teachers engage in teaching practices shaped by educational reform projects. A key reason for these failures is the central belief that improving the quality of one component, that of the 'system', will improve the overall quality.

Consider the example (provided in section 2.4.1 of this thesis) where the state-based teacher registration authorities are attempting to improve the quality of education through improving the input quality of teachers. A key strategy of these authorities is to ensure rigorous school and personal development of each teacher. Many education research papers have expressed the importance of schools being a 'learning organisation' (OL). The basic premise of this concept is that the teaching and learning quality will increase if members of the organisation continually develop their practice through targeted professional learning. It is assumed that teachers will bring innovation and ideas back to the organisation with a view to integrating them (Argyris, 1993).

Armstrong and Foley (2003) heavily criticise the notion of OL: “Organisational Learning is nothing but a whore, and the teachers are the hapless pimps”. The point that Armstrong and Foley (2003) make is that the incorporation of new knowledge and ideas into daily teaching practice is unlikely because of the inflexibility of schools. The critics of OL, such as Coopey (1995), state that OL is counterproductive to an organisation unless it has the capability, capacity, and agility to incorporate new knowledge and practices. In other words, schools would need the capacity to quickly transform their current processes to incorporate these new ideas and to ensure teacher compliance to the new processes.

Let us consider the second example presented in this paper, which highlights the implemented QA programs for improving vocational education and training in university. The goal of these programs is to ensure that teaching and learning is delivered according to pre-established education standards – but a key problem with them is that they only evaluate compliance to standards; they have no capacity to identify issues that emerge in education as a result of changes to the external environments (Mattson, 1992). There is no capacity to improve the quality of education, just a capacity to maintain the quality of education.

Education projects that focus on improving the ‘quality as an output’ are most ineffective when we consider education quality as a ‘system’. Quality control refers to the detection and elimination of components or final products that are not up to standard; it is an ‘after-the-event’ process, concerned with detecting and rejecting defective items. Examinations are a form of quality control, and, therefore, their role in education from a systems perspective is to test for the defects in the learning process. When we consider that examinations are an ‘after-the-event process’, they produce little contribution as a single unit to the overall quality of the education system.

2.4.5 Education quality as system

Finally, some authors define quality as the sum of inputs, processes, outputs. Sahney et al. (2003, p. 503), for example, concluded “education institutes should aim to satisfy the needs of various stakeholders, through the design of an appropriate system comprising a management system, a technical system and a social system. Hence, defining quality in education from an overall perspective would mean including within its domain the quality of inputs, the quality of processes and the quality of outputs". From an industry perspective, the approach of focusing on 'quality as a system' is commonly known as 'total quality management'.

TQM is formally defined in BS 7850-1 as "a management philosophy and company practice that aims to harness the human and material resources of an organisation in the most effective way, in order to achieve the objectives of the organisation". TQM incorporates quality inspection (QI), quality assurance (QA), quality control (QC) and continuous improvement (CI). It consists of a number of common practices including: committed leadership; strategic planning; process management; a cross-functional design of the product or service; information metrics; feedback from customers and employees; cross-functional training; and supplier quality management (Cua, McKone, & Schroeder, 2001). TQMs seek to improve the transformational quality of the organisation, which is that ability to continually change to meet the changing needs of stakeholders. While the procedural quality component is about *proving*, the transformation approach is about *improving*. TQM is an organisational mindset that sees continuous improvement at the very heart of the quality process.

The next section of this literature review provides a context to the business architecture of continuous change. The previous section discussed the need for continuous improvement from a systems perspective. To provide further evidence of the importance and appropriateness of CI as a model 'business architecture' the product-process model is discussed.

2.5 THE CHANGING MANAGEMENT MODEL IN SCHOOLS

Research suggests that the basic operational architecture of organisational systems can be determined using the product-process change matrix (Boynton, Victor & Pine, 1993), as seen in Figure 2.1. This model illustrates that, at its most basic level, organisations can have one of four underlying operational architectures: mass production, mass customisation, continuous improvement, and invention. The type of underlying operational architecture of an organisation is dependent on whether the changes to their product and processes occur in an evolutionary way, or rapidly.

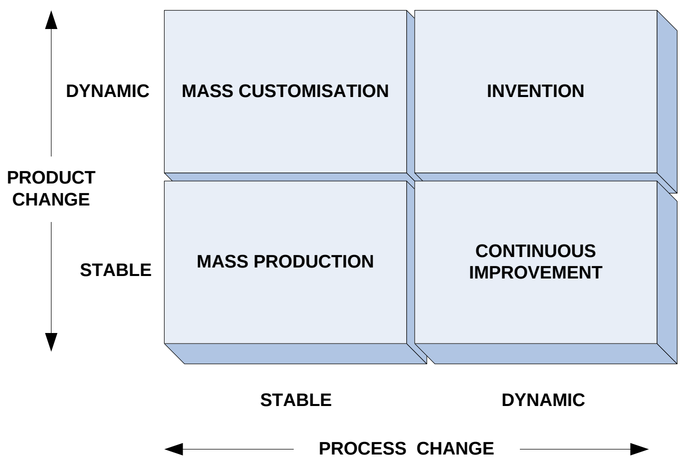


Figure 2.1: Organisational system as a combination of its products and processes.

Within this matrix, *product change* is defined as the demands for new products or services, while *process change* is described as the changes to the techniques and procedures in the delivery of the products or services. Stable change is slow and evolutionary, while dynamic change is rapid and sometimes unpredictable. Traditionally, education over the last century could be described as having both a *stable product* and a *stable process*. As the product-process change matrix suggests, *mass production* has been the basic architecture of education systems over this time. Increasingly, many education advocates and researchers have expressed concerns with the continued use of this architecture model for schools (Robinson, 2013). Although this model is considered to be efficient, it does not consider students as individuals with different talents and educational needs.

While the core product of teaching and learning has remained relatively the same, the process of teaching and learning is changing rapidly. The introduction of ICT into schools, greater school accountability, evolved teaching and learning techniques, and an increasing availability of resources at the disposal of teachers is testament to this. Additionally, the changing cultural norms of students with respect to their engagement with curriculum is rapidly shaping the teaching and learning process. Clearly, the procedures for delivering education are changing. Given that the education product is stable and the process change is dynamic, the basic operational architecture of an education system, according to the product-process matrix, should be one of continuous improvement.

2.6 THE APPLICATION OF TQM IN EDUCATION

Many authors claim that the TQM concept originated from the research and teachings of Deming (Juran, 1989; Feigenbaum, 1991; Martínez-Lorente, Dewhurst & Dale, 1998); however, it evolved from ongoing 'quality research' and business improvement practices within the manufacturing industry in the 20th century (Ackoff, 1999). "TQM did not appear fully formed, but emerged in the 1980s as popular representation of 50 years of development of quality theory and practice in manufacturing industries" (Houston, 2007, p. 4).

Although Demming is not solely responsible for the development of TQM, it is clear that he was responsible for its popular representation throughout the 1980s. The basis of Deming's TQM were the four steps: plan, do, check and action. These steps have become known as the Continuous Improvement Cycle (Deming, 1986). Although the practice and implementation of TQM principles advocated by Deming and his colleagues were not initially adopted broadly in the USA, executives in Japan embraced the concept. When post-war economic analysis predicted that Japan would fall behind the more modern industrialised nations, Japan achieved remarkable success, contrary to the economic forecasts at the time (Izumi, 1995). This success was attributed to TQM. Other authors, such as Duffin (1994), state that Japan's success was not only due to TQM, but related to the fact that they did not face the same constraining labour laws as the USA, thus giving them the "perfect ingredients" for manufacturing success.

There are many examples in business and industry over the past 60 years where mistakes were made in the attempt to develop quality systems. Although quality management within education is in its infancy, there are many lessons to be learned from these mistakes. For example, the success of quality programs has been questioned in organisations that have achieved ISO9000 status (QA program). These organisations mistakenly compare their ISO9000 status, a quality assurance (QA) program, to TQM. Research by Idrus (1996) on current organisations that had achieved ISO9000 found that more than twenty organisations had closed their business or were facing serious business problems. Chittenden et al. (1996) examined the suitability of ISO 9000 registration in small to medium enterprises (SMEs) and found that a TQM such as ISO 9000 had the potential to increase operating costs, increase costs associated with enforcing and monitoring compliance to standards, reduce organisational flexibility, and increase labour costs. These issues with QA programs strongly parallel those faced within the education context.

Chittenden et al. (1996) concluded that one-time quality was not the benchmark for organisational survival – rather, continuous improvement, a trademark of the TQM, was the key to continuing organisational improvement. This is similar to criticism made by Sterman, Repenning and Koffman (1997), who suggest that quality programs need to improve quality not just maintain it.

TQM, although largely hailed as a successful business model, is not the panacea for organisational success. Giaever (1999), for example, when studying the appropriateness of TQM in knowledge-intensive organisations, found that it had the potential to restrain innovation. Peters and Waterman (1982) reported that many manufacturing businesses that adopted TQM have "faced serious problems". Various authors have studied the suitability of TQM across various industries and types, and have found exceptions to the applied success of TQM principles. Argyris (1994), for example, questions the suitability of TQM for organisations that regularly undertake radical organisational changes, such as military organisations.

Despite the criticisms of the TQM concept, there is currently an abundance of literature that advocates TQM as the 'Holy Grail' for organisational success (Idrus, 1996). So much was the success of the TQM concept at the time that the global diffusion and implementation of TQM within organisations has been on the increase since 2000 (Ehigie & McAndrew, 2005).

Within education there are numerous cases where there have been attempts to improve quality or implement a quality improvement program. Many of these programs fail, or make little difference to the outcome of the quality of education for students. For example, four years after the Australian Federal Government funding for 1:1 computer provision was distributed, the literacy and numeracy results – as measured by NAPLAN (National testing for literacy and numeracy) – had not improved (Allan, 2010).

The main reason for these failures centres on the lack of understanding of the definition of ‘quality’, and a lack of understanding on how to implement an effective TQM within an education system (Dimmock, 2013; Cheng, 1993). Regardless of these failures, many authors advocate the potential success of TQM within schools.

2.7 WHY HAVE TQM IN SCHOOLS?

“It is difficult to conceptualise a situation where anything less than total quality is perceived as being appropriate or acceptable for the education of children” (West-Burnham, 1997, p. 17). Regardless of those issues associated with applying appropriate QM strategies, as stated in the previous section, there still remains an imperative to work towards achieving systems quality within schools. This imperative is driven by the moral obligation of all educators to provide the best educational opportunities for children. Stemming from this imperative is the need for teachers to apply the best pedagogical practices and for leadership to develop the most conducive environment in supporting these practices. Aside from the moral obligations to the children, schools have become subject to constant changing public accountabilities and standards. These accountabilities and standards can to be met through ‘quality systems’. Berry (2002, p. 203) states implementation of any quality system in schools needs to be implemented from a system’s perspective ensuring ‘cyclical action learning’ and process improvement. TQM can help schools systematically bring about change as: “Its holistic approach accents system theory. Its tools provide vehicles for data analysis and decision-making. Its principles accent the importance of each person in the system to strive for continuous improvement”. Research shows that the leaders of quality award-winning schools are more likely to be familiar with, and have positive perceptions towards, TQM programs (Jauch, 2010).

2.8 WHAT IS THE FOCUS OF TQM?

The objectives of TQM in education are to use the collective knowledge and skills of educators to identify, analyse, and implement strategies to improve education practices. It includes everything related to the student learning experience, including: administrative processes, care services, teaching techniques, teaching content, examinations, leadership, and governance. All elements of the school system must be examined, as quality is dependent on the continual improvement of all elements within it (Weidner & Harris, 2008).

This research uses a customer process view to highlight the focus for TQM in an education setting, which is a model of those services that are offered by an organisation. Typically, this kind of model is used to as part of a service oriented architecture approach (SoA), one that is underpinned by the philosophy that an organisation should be structured according to the services it offers. By structuring this way, and continually improving those services, the customer, typically, will see the organisation as having greater quality (Cross, 2001; Krafzig, Banke, Slama, 2005). See Figure 2.2 below, for an example of a customer process view. This figure shows some of the potential services delivered by the school's service units. It structures the partial stages of the student experience throughout the school cycle. Furthermore, it defines partial services that must be created to support this student's experience. Each partial service created for the student can be sourced internally or provided by an external service provider. This view serves as a foundation for defining a school's process design.

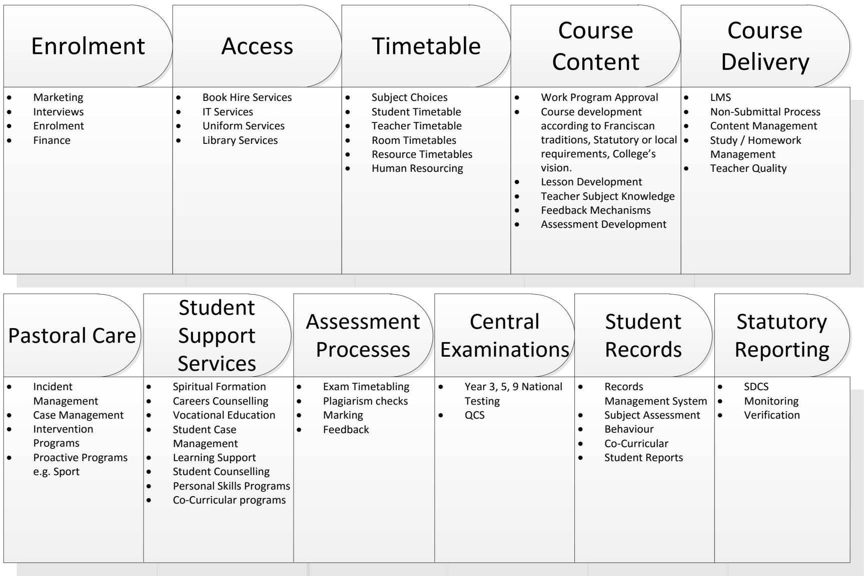


Figure 2.2: Example of a potential customer process view for a school.

Various authors express the importance of the student learning experience as the basis for school-based TQMs. For example, according to Kwalwasser (2012) and Laevers (1994), the end product of any school must be based on the quality of student experience. Unless it has this focus, it will not make any significant contribution to the quality of learning (Sahney et al., 2003; Dotchin and Oakland, 1994; Asubonteng et al., 1996). Additionally, various authors declare that it is essential that the student's requirements and expectations are identified, and that the service system is designed to ultimately satisfy these requirements (Parasuraman et al., 1988; Babakus & Boller, 1992; Joseph & Joseph, 1997). To support this notion, research on TQMs already implemented within HE has found that 'stakeholder focus' emerges as one of the critical success factors for them (Bayraktar et al., 2008, Asif, Awan, Khan & Ahmad, 2013; Saraph, Benson & Schroeder, 1989; Anderson, 1995). This research, therefore, adopts an SoA in defining the foci for TQM programs within schools.

As shown in Figure 2.2, the student's first experience with the college may be the 'enrolment process'. Once enrolled, the student is given access to a number of services within the college, and can take either school-based or TAFE-based subjects. The timetable for the student is then developed. For each subject, the course structure, course content, and the course delivery mechanisms are developed. In alignment with the student's academic development, pastoral care and student support services are an integral part of the student's personal development. All students will complete subject-based assessments, as well as central examinations. Finally, student records and statutory reporting are prepared on behalf of the student.

The customer process view has highlighted those services provided to a student throughout his or her lifecycle in a school. Any one or all of these services may be the focus of quality improvement programs.

2.9 MEASURING SERVICE QUALITY

Various authors have expressed the importance of data and appropriate data systems for facilitating continuous change. They have shown that without the use of data or data systems, school personnel are unable to identify school problems, analyse them from a quantitative viewpoint, and develop appropriate solutions with appropriate benchmarks (Ikemoto, Pane, & Hamilton, 2006; Dembosky, Pane, Barney, & Christina, 2005; Mason, 2002; Choppin, 2002). Other comparative case studies have justified the need for data and measurement with their research results, indicating that greater improvement in student outcomes occurs where teachers utilise data to make school-based decisions. For example, using a comparative case study, Dial (2011) found differences in student maths outcomes between two underperforming schools. One school used data to inform practice while the other did not. Additionally, Simpson (2011) found, when studying measurement, that data availability had the capacity to improve teaching strategies to meet individual student needs. The abundance of research finding that correlate data availability with student performance has, ultimately, led to a call for greater data use in schools.

This call for increased use of data as a management tool in education has led to debate on what are valid, reliable, and replicable measures of ‘education quality’. Research into conceptualising quality and its assessment and measurement is vital for improving education. Measurement is needed to continually improve and test whether education programs are appropriate (Kwalwasser, 2012).

A key challenge faced by education researchers, therefore, is to understand what quality issues impact on student learning experiences – and then to identify and implement the most appropriate programs in response to these issues (Oldfield & Baron, 2000; Sureshchander et al., 2002; Welsh & Dey, 2002; Hill et al., 2003). Section 2.8 discussed the need for all aspects of an 'education system' to be reviewed for how it provides quality. In particular, quality programs should target those services experienced by students, with a focus on classroom teaching and learning experiences. Figure 2.2 shows an example of the services that students might experience from enrolment to graduation.

There is no doubt that educators have understood the importance of measurement in improving education quality. Proof of this is evident in the USA where there has been significant growth in the collection and use of data. The term for using data to determine school-management strategies has become known as data driven decision-making (DDDM). DDDM is an education-based concept that has evolved as part of attempts to implement TQM is schools. The collection and use of student data, as well as the implementation of TQMs, is on the rise in the USA because of the *No Child Left Behind Act* (2001) (NCLB) (Danielian, 2009). DDDM is characterised by the systematic collection and analysis of data by school educators. It includes input data, process data, outcome data and satisfaction data. This data is used to help guide the design of the 'education system' so that it might improve the quality of schools and student learning outcomes (Marsh et.al. 2006). Figure 2.3 illustrates the various components of an education system.

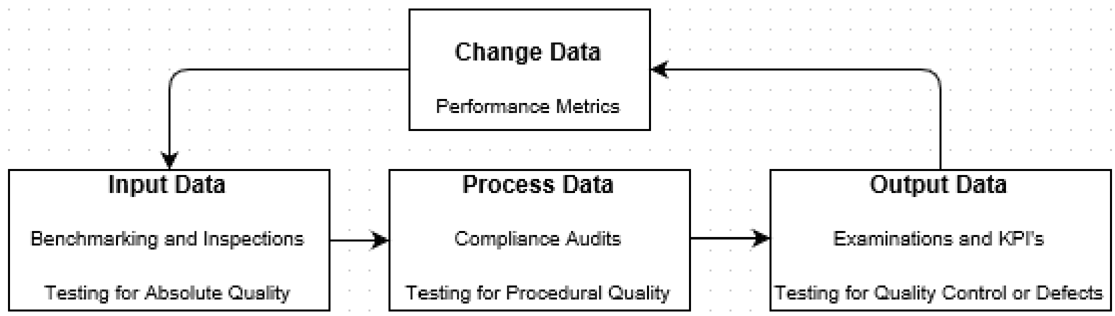


Figure 2.3: Shows the various component of an education system.

This figure shows the types of data that can be collected at the various stages of this education system. In more recent times, the use of the term 'performance metrics' (PMs) has become the predominant one associated with measurement in education. PMs is a term used to measure the change that has occurred from implementing set processes. It is the difference between the benchmarks (inputs) and the outputs of the system. Performance metrics are described as discreet, relevant, and reliable measures, and allow schools to compare or benchmark achievements (Alonso & Starr 1987; Espeland, 2001; Davis et al. 2010). Through the use of data like PMs, school leaders and teachers can define whether the school is realising its aims and objectives for set service outcomes (Stinchcombe, 2001). Colyvas (2012, p. 168) discusses the importance and power of performance metrics in facilitating continuous change: “If we measure what matters and make those measurements public, people will adjust their behaviour and practice will improve”. From a systems perspective, all three types of measurement are required to make discerning assessments about improvements in quality to a system. For example, input and output data are clearly needed to measure changes; however, a school leader would be unable to determine whether the applied processes were contributing to the rise or fall in quality if they could not determine the compliance or non-compliance to those procedures used in producing the outcome.

Using lessons learnt from the NCLB program, we find there are many other constraining factors to produce effective PMs for schools, and these are modelled in Figure 2.4. The documented problems associated with implementing DDDM are extracted from previous research papers and categorised according to two dimensions. The first comes from the change research of (Cummings & Worley, 2009) who state that most groups will only change when they are empowered to do so, when they see the change as legitimate, and when the need for change is urgent. This dimension can be seen on the left of Figure 2.4.

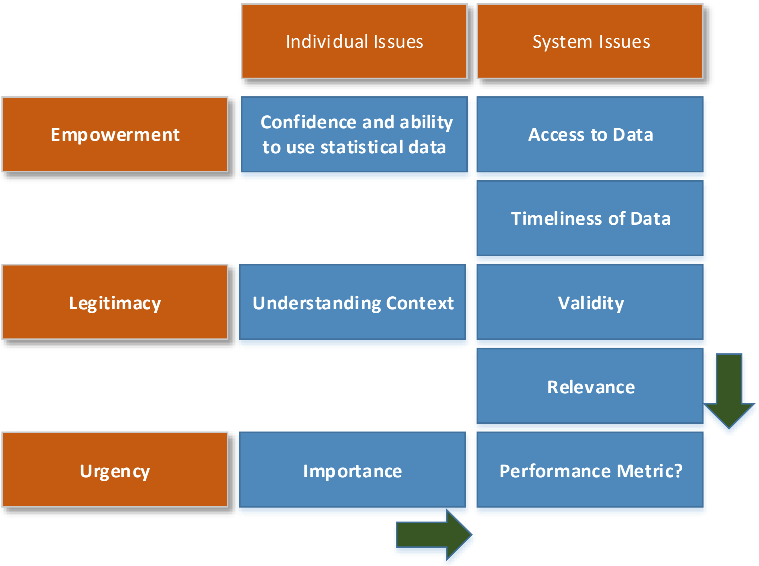


Figure 2.4: Model of issues associated with data collection and data use.

The second dimension categorises the issues faced by teachers in producing performance metrics as either individual or system issues. In this diagram, system issues are also considered to be ones that affect the individual, but are classed as systems issues for the purposes of this illustration. The various categories of 'data use issues' are included in this diagram due to their frequency within the literature, and include: confidence and ability to use statistical data; understanding the context for this data use; and the importance of the using data in solving quality issues. From a systems perspective, issues include: the provision of data; making the data available in a timely manner; and the validity and relevance of data. Examples of each research are included in Table 2.1.

Table 2.1 – Research highlighting issues associated with data use and decision-making

	Empowerment	**Legitimacy**	**Urgency**
Individual issues	*Confidence to use data* Wallman (1993) Pierce & Chick (2011)	*Importance* Luo (2008)	*Understanding context* Little (2012)
	Data used in negative ways Marsh et.al. (2006) Honig & Venkateswaran (2012)	*Interpretations* Park, Daily & Guerra (2012) Goren (2012)	
System issues	*Access to data* O'Day et.al, 2004 Marsh et.al. (2006)	*Relevance* Park & Datnow (2009) Marsh et.al. (2006)	*Performance metric* Ikemoto & Marsh (2007)
	Timeliness of data DeLoach (2012) Choppin, (2002)	*Validity* Marsh et.al. (2006) Ikemoto & Marsh (2007)	

As this research is primarily concerned with systems quality, this paper seeks to design an IS that addresses those issues in Table 2.1 that are associated with the ‘system’, which include access to data, timeliness of data, validity of data, relevance of data, and the ability of the data to effectively measure performance effectiveness through process improvement. The ‘individual issues’ with effective data use identified in Table 2.1 are not considered as part of the scope of this research.

2.10 SYSTEM ISSUES AND DATA QUALITY

A key issue emerging from the NCLB research is that data quality is related to the frequency of the data cycle as the production of measures that define improvements from the input/benchmark to the output (Marsh, 2006; Hanks, 2011). Marsh (2006), for example, states that many teachers prefer and rely on data sources that provide a greater frequency of updates to student’s performances, such as classroom tests, assignments, and homework. This data is more highly regarded than end-of-semester or end-of-year exams, as it gives students the opportunity to reflect on the feedback. As Boston (2002) states, regular student feedback can be used as an effective tool for learning. Marsh (2006) also reported that, in general, teachers preferred the use of classroom data to periodic external exams, stating that external exams did not provide useful data in a timely fashion. Teachers could not act on this data, as students had already moved to another teacher and or grade level. “For this reason many districts and schools have adopted formal local tests that are issued more frequently throughout the year, thus providing diagnostic information that could be acted on immediately” Marsh, (2006, p. 114).

2.11 JUSTIFICATION FOR RESEARCH

It is clear from the research discussed in section 2.10 that data about a student’s learning should act as a feedback tool for both the teacher and the student. The problem with traditional methods of data collection on a student’s performance (such as exams) is that the frequency of data collection is too low. Schools do not have the structures in place to fix issues identified through infrequent examinations. As mentioned previously, exams are simply a quality control process to detect defects. A greater frequency and immediacy of feedback on students' performance has the potential to increase learning for the teacher and the student. For example, defects in a student's learning can be made a lot earlier, and timely corrections made. A problem of collecting greater amounts of data about a student's progress is the potential to take away from the teaching and learning time.

With advances in both technology and school funding, new solutions can potentially be developed to facilitate a greater frequency of data collection that measures student activity and behaviour in the classroom. It is the thesis of this research that by building better profiles of student achievement, through a greater frequency of data collection, the student's quality of learning can be increased. Through better IS design this increase in frequency of data collection can be achieved without the need for teachers to reduce their teaching focus or teaching time in the classroom.

2.12 RESEARCH QUESTION CONSTRUCTS

This study seeks to investigate three research questions. These research questions and associated hypotheses are presented in section 6.2 within the results chapter. Sections 2.12.1 to 2.12.4 describe the constructs that are researched as part of this study: i) stakeholder's engagement with IS in the classroom (use); ii) The impact of the instantiated artefact; and iii) the use of this quality data to continually improve student pastoral care.

2.12.1 – Artefact use

This research expects, using the methodology described in Chapter 3, that the artefact developed for this thesis will be perceived as having utility and value in the classroom. The attitudes towards the artefact and its actual use will be measured using the UTAUT scale. The reasons for changes in attitude and use will be reflected by changes to those constructs found within the UTAUT scale. Given that one of the goals of the artefact is to facilitate a continual flow of information across stakeholder groups, this research measures the acceptance of the instantiated artefact across the various stakeholder groups. Figure 2.5 highlights the major stakeholder groups within the application domain for the target service, and stakeholders are shown on the Y axis: pastoral care coordinators (middle managers), heads of departments, and teachers. The figure also displays the five-stage CI framework adopted for this study: define, measure, analyse, improve and control (DMAIC).

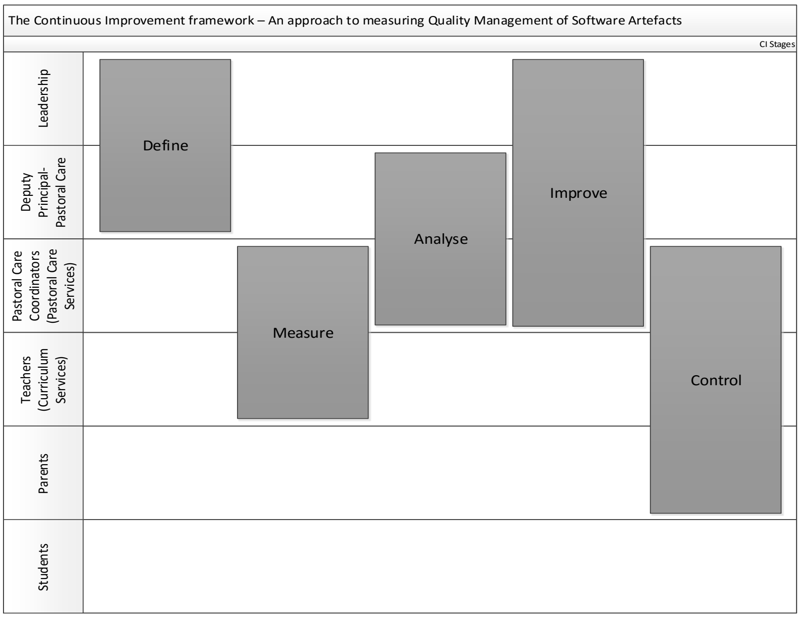


Figure 2.5: Software artefact use by various stakeholders throughout the CI cycle.

The primary role of the pastoral care coordinators and teachers is in the process of inputting data (measuring) into the Behaviour Management System (BMS). Pastoral care services, which consist of the deputy principal (pastoral care) and the pastoral care coordinators, meet weekly to determine trends and issues of student behaviour. It is, therefore, vital for this team to be able analyse collected behavioural data. It is expected that an artefact that improves the collection of data will increase the quality of that data – and, therefore, its analysis. Given this improvement, it is expected that the new IS will have more of an impact on house guardians than on teachers. The acceptance of the artefact by various stakeholder groups will be measured using the UTAUT scale.

2.12.2 – Impact of the artefact

The second goal of this data was to determine the impact of the instantiated artefact. This study uses the IS-impact scale to determine: i) if the artefact had any impact at the individual or organisational level; and, ii) if either 'information quality' or 'organisational quality' were significantly different between the pre- and post-implementation of the artefact. Having established improvements to information quality, this study completes an analysis of the SQL data, where the various dimensions of data quality (accuracy, consistency, completeness and timeliness) are examined.

2.12.3 – The use of information to inform practice

The third goal of this research was to investigate how teachers viewed the utility of the artefact in relation to their roles. Various factors that encourage and inhibit the artefact's use were investigated. Importantly, probing questions were asked during the convergent interviews to determine the correlation between the artefact quality, data quality, organisational factors, and the use of data.

2.13 CONCLUSION

This literature review has provided a working definition for quality in education. 'Quality' was defined from a systems perspective; 'organisational quality' was defined as being dependent on the transformational quality of the organisation. It justified the need for schools to have continuous improvement architecture through discussing the moral, public, and organisational imperative. The concept of the TQM was introduced, its history from a business perspective was presented, and its architecture and applicability to education was explained. The concept of a service-oriented architecture was introduced, the role of data in effective TQMs was detailed, and the need to change the model of data collection in organisations that constantly transform their practices was justified. In particular, the need for more frequent data availability for use as a learning tool for both teachers and students was discussed. This need was identified as a major gap in DDDM research. Finally, this literature review introduced the constructs inherent to the research questions, framed quality issues in schools, and clearly defined the need for exploiting and developing new technologies to promote a greater collection of data that ultimately leads to informed teacher practice and, therefore, improved student learning experiences.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the methodological elements used in this study and accepts the principle that the research questions drive the research and data collection methods (Howe & Eisenhart, 1999). In alignment with these principles, therefore, the research questions stated in section 3.3 are used to determine the optimal research and data collection methods for this study.

Apart from this introduction, there are fifteen sections of this chapter. The research scope and the research problems are stated in section 3.2. Subsequently, the research objectives and research questions are stated in sections 3.3. The expected contribution to knowledge within the natural and design science realms is specified in section 3.4. The research design used to investigate the research questions for this thesis is stated in section 3.5. There are three major development cycles in this design science investigation: relevance, design, and rigor cycles. The relevance cycle method is described in section 3.6; the design cycle method in section 3.7; and the rigor cycle method is described in section 3.8. Sections 3.9 to 3.15 consist of details concerning: data collection sites (3.9); population (3.10); sample (3.11); research period (3.12); data analysis techniques (3.13); the central design repository (3.14); and the components of design theory (3.15).

This chapter closes with two sections: 3.16 comments on the validity concerns associated with the study's methodology; and 3.17 is a summary of the chapter. Collectively, the information contained within all sections in this chapter provides a comprehensive description of this study's methodology.

3.2 RESEARCH SCOPE

To scope this research, a service-oriented architecture (SoA) development approach was first used to map the services a school provides its stakeholders. To address the problem of 'data collection in the classroom', a classroom-based service was targeted for this research. The artefact development requirements for such a service needed to be of appropriate complexity and work for a doctoral study, and one that collected data about a student's pastoral care activities was deemed most appropriate. It was projected that any findings made in developing an artefact for pastoral care services would be transferrable to the development of artefacts for curriculum or classroom-based services, as these services have similar principles for data collection and quality.

This research, therefore, concerns itself with the development of a new set of IT artefacts complimenting organisational processes and systems within the context of a large, co-educational school providing education, and complimented by a rich set of co-curricular and pastoral care services for grades 5 to 12. The school is independent within the Catholic education system, and espouses an education that is Catholic and Franciscan. It encourages its students to achieve personal bests and to develop skills through its co-curricular activities of music, sport, drama, and service. In addition, it has a strong pastoral care system that it supports through rich reporting of behaviour management. There are many clients, including the teachers, the parents, the pastoral care staff, and the senior management of the school. Each has a different set of requirements of and expectations for such a system.

3.2.1 Research Problem

Obtaining quality data about organisational practices is an essential component of any organisational quality framework. External to the education industry, quality frameworks such as total quality management (Baird, Hu & Reeve, 2011), Six Sigma (Taner, Sezen, & Atwat, 2012), and continuous improvement (Bernhardth, 2013) all require data to inform and improve practices and processes. Data collection is deemed an essential step, in a series of steps, to achieve quality organisational practices. In an attempt to develop quality frameworks in education, there has been an increase in the number of studies focused on a practice called data driven decision-making (DDDM), which is defined as the process of aggregating and analysing student data from a various array of sources, mainly formal test scores, to inform teacher practice (Hayes, 2004; Stringfield, Wayman, & Yakimowski-Srebnick, 2005; Wayman, Stringfield, & Yakimowski, 2004). Gathering data in education, however, encompasses challenges not seen in other industries. Problematic to the collection of data for classroom-based education services is the disruption it causes in the teaching and learning process. The optimal site to collect data about the student is in the classroom; however, the teaching and learning process is seen as sacred, and interruptions to this process are perceived as counterproductive to student learning. As a result, therefore, engagement has been low with previous IS designs that facilitate data collection in the classroom (Spillane, 2012).

Therefore, the research problem this study seeks to address is: how can IS be redesigned to collect data, both within and external to the classroom, without being perceived as disruptive to the teaching and learning process? And the corollary of this question is: if ‘low disruption’ data collection methods can be developed, how might the artefact be designed so that it is perceived as a valid and relevant tool for informing practice?

3.3 RESEARCH OBJECTIVES

The research goals for this study fall into three categories that are defined and explained in section 2.12: i) stakeholder engagement with the artefact (use); ii) the impact of the artefact; and iii) the use of data to improve student behavioural outcomes. The research questions and hypotheses for this research are shown in Table 3.0 under those three categories.

RESEARCH QUESTIONS

Table 3.0 - Research Questions investigated in this study	
RQ1	Does the specific IS design lead to improved engagement with the artefact?
h1	The new artefact will positively influence teacher's intention to use it.
h2	PE, EE, SI, FC will mediate teacher's intention to use the new artefact.
h3	The new artefact design will have an impact on the individual.
h4	The new artefact design will lead to increased use.
RQ2	What was the impact of the newly instantiated artefact?
h5	The new artefact will improve perceptions about the System and Information Quality.
h6	The new artefact will have a positive Impact on the Individual and the Organisation.
h7	The new artefact will improve the quality of data measuring student behaviours.
RQ3	How was data perceived and used as a tool for improving student pastoral care?
h8	Teachers will perceive the artefact has having utility for their role.
h9	Teachers will use the artefact uninhibited by exogenous factors to the artefact.
h10	Stakeholders will perceive a positive relationship between artefact quality and their reporting behaviours.
h11	Teachers will perceive a positive relationship between their reporting behaviours and student outcomes.

PE *– Performance expectancy,* ***EE*** *– Effort expectancy,*
SI *– Social influence,* ***FC*** *– Facilitating conditions*

3.4 CONTRIBUTION TO THE KNOWLEDGE BASE

This research intends to provide an in-depth knowledge of the required design elements for classroom-based IT artefacts and information systems (IS). It will produce best-design guidelines for IT artefacts where data collection and data use can improve outcomes within the classroom. The full contribution this research makes is detailed in the final chapter.

Through enhanced artefact utility, it is projected that use of the artefact will be improved and, therefore, the subsequent information quality will be better, – and, therefore, teachers will be more likely to use the artefact to inform their decision-making. Finally, this research examines organisational factors that promote or limit informed decision-making. Conclusions in regards to this are presented as concluding remarks in the final chapter of this thesis.

In this section, the research problem, goals, questions, and its contributions to the scientific knowledge base have been stated; the next section contains a detailed description of the research design.

3.5 RESEARCH DESIGN

This section describes the research design adopted for this study. This description contains three parts: i) a general description of design science research; ii) the justification for the use of the design science methodology over other methodologies; and iii) a description of the specific research design used in this study.

3.5.1 Methodological framework

Description of design science research

The research design adopted for this study is classed as a mixed methods procedure with design science research (DSR) as its main methodological approach. DSR is a problem-solving paradigm with its origins in the engineering and science of the artificial (Simon, 1996). It is described as a research paradigm where knowledge and understanding of design problems is gained through the building and application of IT artefacts (Hevner & Chatterjee, 2010; March & Smith, 1995). "IT artefacts consist of constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems)" (Hevner, March, Park & Ram, 2004).

Justification for the use of the research design used in this study

As this study seeks to determine software design principles that best facilitates the collection of data in the classroom and co-curricular settings, a DSR methodology is determined to be most the appropriate. A DSR methodology, however, can consist of a number of varying research techniques that investigate both design and natural science phenomena. Davis and Olsen (1995) argue that IT research is situated within both the design and natural sciences, and both research paradigms are needed for effective IT research. Further studies have supported this notion (Lee, 1999; Lee, Mitchell & Sablynski, 1999; March & Smith, 1995). This study, therefore, uses both qualitative and quantitative research techniques to investigate artefact design, and the natural phenomena associated with its implementation.

Description of the research framework used in this study

The (DSR) framework used for this study contains three major stages of development (Hevner, March, Park & Ram, 2004). Although many other studies use varying steps within their methodologies, they generally subscribe to the relevance, design, and rigor cycles. (Aken, 2004; Baskerville, Pries-Heje & Veneable, 2009; Cole, Purao, Rossi & Sein, 2005; Hevner, March, Park & Ram, 2004; March & Smith, 1995; March & Storey, 2008; Nunamaker, Chen & Purdin, 1991; Peffers, Tuunanen, Rothenberger & Chatterjee, 2007; Pries-Heje, Baskerville, & Venable, 2008; Rossi & Stein, 2003; Vaishnavi & Kuechler, 2006; Veneable, 2006; Walls, Widmeyer, & El Sawy, 1992).

Within each of these research stages, further research methods are adopted. The methodological framework used for this study is presented in Figure 3.0. This shows three distinctive cycles with the activities for each cycle highlighted. The sum of these activities defines the method for this study.

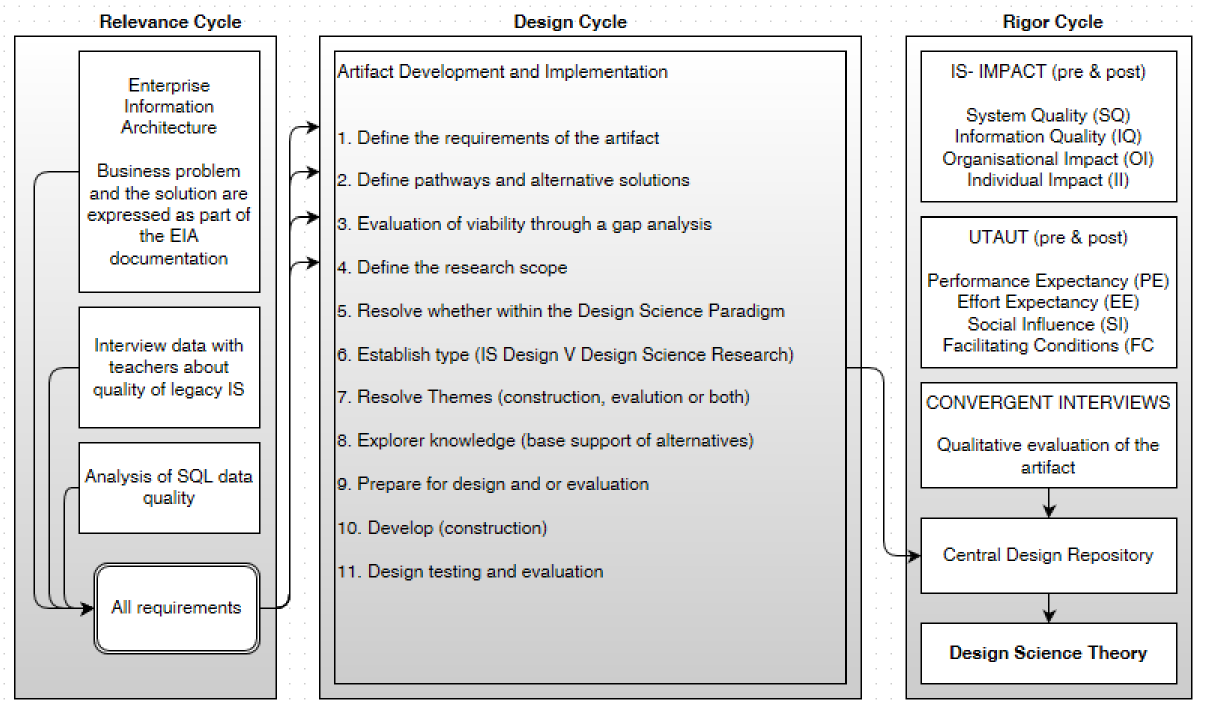


Figure 3.0: The design science methodological framework used for this study.

The two goals of the relevance cycle are to define the wicked problem and to determine the design elements required for the design cycle. Hellmuth and Stewart (2014) propose that the optimal method for achieving these goals is through developing an enterprise information architecture of the application domain and, through this, the relationship between the wicked problem and the environment can be established. The ill-defined units of the enterprise and their relationships can be defined and realigned by using the EIA. Within the relevance cycle, feedback from end-users about their perceptions of the legacy IS can also elicited. This feedback shapes the design of the new artefact, and its validity is triangulated through analysing the quality of the existing SQL data.

Figure 3.0 also highlights the major steps undertaken within the design cycle, and these are the procedural steps suggested by Alturki, Gable, and Bandara (2011). Further elaboration on these methodological steps and justification for their use can be found in section 3.5.

The final cycle, as shown in Figure 3.0, is the rigor cycle. In this cycle, both the IS-impact and UTAUT scales are applied twice: pre-implementation and post-implementation of the artefact – the convergent interviews are only applied post-implementation.

At every stage of the research, all documentation relating to activities is maintained. Alturki, Gable and Bandara (2011) refer to this knowledge base as the central design repository (CDR), which is used to build a central repository of documentation relating to all design decisions and procedures within the research project. This documentation serves to justify the iterative series of design decisions and procedures within the project. The CDR can be found in Appendix 8. The final step of the rigor cycle communicates the design theory produced as a result of the instantiated artefact.

This section provides an overview of the research methodology used in this study, as well as an overall description of the three stages of the design science methodology. In the next section, each element of the relevance cycle is described in detail.

3.6 RELEVANCE CYCLE METHOD

The purpose of the relevance cycle in design science is to define the wicked problem, determine the requirements for artefact development, and to determine the measurement instruments that will define how effective the artefact is in addressing the stated wicked problem (Hevner et al., 2004). Apart from this introduction, this relevance section contains two parts:

1. The differences in the methodological procedure suggested by the Alturki, Gable, and Bandara (2011) and the methodological procedure used in the relevance cycle for this study are defined and justified. The measurement tools used to measure the success of the instantiated artefact are introduced in the rigor section of this chapter.
2. The process for describing the current and the future desired state of the application domain is stated. This is completed using an EIA, which uses the Open Group Architecture Framework (TOGAF-v 9.1) for its standards and, within this framework, a rapid architecture development (RAD) process is used to develop the EIA.

3.6.1 Justification for the relevance cycle method used in this study

This section discusses the differences between the relevance cycle methodology used for this study and that documented by Alturki, Gable and Bandara (2011). This study varies the methodology because of the potential issues associated with defining the exact nature of the business problem. In this section, therefore, the difficulties in defining the exact nature of the business problem are explored.

Alturki, Gable and Bandara (2011), in their paper on design science methodology, simply express the method in the relevance cycle as the importance of ‘discovering the needs’ and ‘determining important unsolved problems’. Hevner et al. (2004), in describing DSR, places a high priority on the relevance of the IS design in the application domain. Aligning with Hevner et al. (2004), this research advocates the need for rigor in determining the exact nature of the business/research problem.

This study initially used two sources of evidence to prove the relevancy of this research: previous research, and end-user feedback. Although feedback from end-users is important to design (Brosnan, 1999; Metsala, Mikkola & Saastamoeinen, 2008), this research quickly identified a number of issues with the validity of the initial data, and these issues are discussed in the next section.

Potential sources of error in defining the business problem

The need to extend the Alturki, Gable and Bandara (2011) relevancy framework is based on the potential sources of error that were initially observed when collecting information from end-users about the perceived business problem. These are discussed briefly using a hypothetical model that describes the different interactions between the user and the various components of an IS. Figure 3.1 shows a basic model of interaction in information systems.

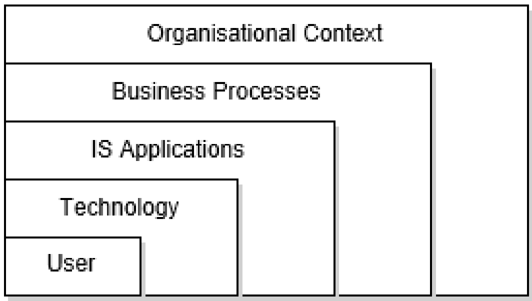


Figure 3.1: A basic model of interaction in Information Systems. The model indicates that the quality of interaction between the user and the application can be dependent on the quality of any of these elements of the Enterprise and the interaction between them.

This model shows that the user's perception of an IS equates to the sum of their interactions with an artefact that consists of one or more further entities working together. An artefact within an enterprise can consist of entities including the application, business processes, and the physical IT environment itself. The quality of these multiple systems is reflected in the user's interaction with the IS application.

Using this model as a reference, the first potential source of error in determining the exact nature of IS problems relates to the ability of the end-user to articulate the exact nature of the problem. IS can be complex, and articulating problems associated with this complexity can be difficult. Users are often the first to report IS problems; however, their ability to report the exact nature of the problem is limited given the complex interactions within these systems. The second potential source of error relates to the user's interaction with the IS. In the target domain a user may only use a partial set of IS functions, which means the user's knowledge of the problem may also be partial. The same design problem(s) may manifest itself in different ways in the various sub-systems of the IS.

A third potential problem with determining the exact nature of the business problem may relate to the architecture of the IS solution. Users may incorrectly attribute problems with IS design, when the problem may be actually be related to the constraints placed on the IS architecture or the IT environment of the application domain. The architecture of the application domain may be the ongoing root cause of a less than optimal IS design. Clearly, a holistic measure is needed to ensure a broad understanding of the relationship between design and wicked problems.

This thesis recommends, therefore, that a full EIA of the application domain be conducted to attain a full understanding of the wicked problem. The EIA of the application domain describes the interaction of people, organisational systems, and technical systems in the context of the stated business problems. With its use, the functional requirements needed for the software design can be attained and it is, therefore, a necessary component of the relevance cycle (Henderson & Venkatraman, 1993).

This section has argued that in addition to obtaining feedback from users about their perceptions of the IS, it is also necessary to have a comprehensive method for determining the wicked organisational problem being studied. The section also discussed the potential for bias by only using end-user feedback. The next section contains a description of how the use of the EIA can fully identify and define the multidimensional nature of wicked problems.

3.6.2 Defining the wicked problem and its relationship to the application domain

Hevner and Chatterjee (2010) describe modern software architecture as consisting of a number of abstract layers. The make-up and structure of this software is dependent on the environment in which it is implemented. The artefact developed as part of this thesis could have many technical solutions; however, there will be an optimal solution based on design principles, the business requirements, and the environment in which the artefact will be implemented. Aligning the solution with the IT environment of the application domain ensures the optimal solution for end-users (Hevner, March, Park & Ram, 2004; March &

Smith, 1995; March & Storey, 2008; Nunamaker, Mider & Titus, 1991; Peffers, Tuunanen, Rothenberger & Chatterjee, 2007).

For the purposes of this thesis, the application domain is described through the documentation of an EIA, which seeks to model the various abstract layers of the organisation so that optimal software architecture can be developed for this environment. An EIA as defined by ANSI/IEEE Standard 1471-2000, as the "fundamental organisation of a system, embodied in its components, their relationships to each other and the environment and the principles governing its design and evolution" (Sessions, 2007). An EIA developed for the application domain is, therefore, fit for purpose as part of the relevance cycle in the design science methodology.

EIA and the Open Group Architecture Framework (TOGAF)

Enterprise information architecture, as defined by TOGAF (TOGAF-v 9.1), is represented by four layers of abstraction: the strategic, business, application, and the technology/data layer.

If the software architecture is developed by aligning with the EIA components, a number of organisational benefits can be obtained. As stated in the principles of TOGAF–v 9.1, a well-designed enterprise increases the efficiency of IT processes through: lower IT costs; increased integration of dependent software applications; improved network management due to IT component alignment; improved system-wide functions (such as security due to component alignment); and the ability to upgrade and replace legacy systems. The fully documented EIA of the application domain, with a focus on the pastoral care service, can be found in the relevancy chapter. As the purpose of the EIA is to determine what gaps exist between the current and desired states of the enterprise, an important output of the EIA document is to state those design considerations that address these gaps.

In the first part of this section, the differences in the methodological procedure suggested by the Alturki, Gable, and Bandara (2011) and the one used in the relevance cycle for this study were justified and defined. This relevancy section has described its purpose as the process of defining the wicked problem through mapping the entities and relationships of the wicked problem to the entities and relationship of the enterprise. This section justified the use of this method by highlighting the difficulties with identifying and classifying these problems. The next part of this chapter discusses the design cycle and the procedural steps that make up this cycle.

3.7 DESIGN CYCLE METHOD

The second stage of the design science methodology is the design cycle, which is central to the methodology. The design cycle can be described as set of iterative activities consisting artefact construction, its evaluation, and design refinement (Brooks; 1996, Hevner, March, Park & Ram; 2004). Similarly, Simon (1996) describes the design cycle as generating design alternatives and evaluating them against the requirements of the artefact. This process is iterative until the requirements of the artefact are achieved.

3.7.1 Justification for the design cycle method used in this study

A number of authors have published approaches to the design cycle in DSR – most notably, that suggested by Peffers, Tuunanen, Rothenberger and Chatterjee (2007) is often used. More recently, Alturki, Gable and Bandara (2011) have proposed a formalised set of iterative steps for the design cycle within the design science methodology. This formalised set of steps was compiled by conducting a comprehensive literature review on design science methodologies and, by aggregating all steps undertaken by previous DSR articles, a roadmap of activities was created. The steps provided by Alturki, Gable, and Bandara (2011), therefore, provide a comprehensive minimum checklist for future DSR. The design cycle methodology adopted for this thesis follows the formalised steps proposed by Alturki, Gable and Bandara (2011). Justification for the use of this methodology over other methodologies – for example, Peffers, Tuunanen, Rothenberger and Chatterjee (2007) – is justified, given its comprehensive nature.

3.7.2 Steps of the design cycle

This section contains eleven parts, each explaining the formalised steps of the design cycle. The fourteen steps of this formalised approach can be seen in Table 3.1.

Table 3.1 - Steps of the design cycle used in this study

Design step	Cycle
1. Document the spark of an idea / problem	Relevance
2. Investigate and evaluate the importance of the problem idea.	Relevance
3. Define research scope	Design
4. Evaluate the new solution feasibility	Design
5. Resolve whether within the design science paradigm	Design
6. Establish type (IS designs science vs. IS design research)	Design
7. Resolve theme (construction, evaluation, or both)	Design
8. Define requirements	Design
9. Define alternative solutions	Design
10. Explore knowledge base support of alternatives	Design
11. Prepare for design and/or evaluation	Design
12. Develop (construction).	Design
13 (a). Evaluate: ‘artificial’ evaluation	Design
13 (b). Evaluate: ‘naturalistic’ evaluation	Rigor
14. Communicate findings	Rigor

For the purposes of this thesis, steps 1 and 2 of this methodology are included within the relevance cycle, while step 13(b) and 14 are included as part of the rigor cycle. This study completes each of the stages of the design cycle by using the micro procedures of stage progress cycle (SPC) and stage refinement cycle (SRC) (Alturki, Gable & Bandara; 2011).

The steps of the design cycle used in this thesis are: i) define research goals (scope); ii) evaluate the new solution feasibility; iii) resolve whether within the design science paradigm; iv) establish type (IS design science vs. IS design research); v) resolve the theme of the research; vi) define DSR requirements; vii) define alternative solutions; viii) explore the knowledge base of alternatives; ix) prepare resources for the alternative design; x) develop (construct) the abstract design; xi) evaluate the abstract design: ‘naturalistic’ evaluation; xii) prepare resources for the solutions instantiation; xiii) develop the instantiation; and xiv) evaluate the instantiation: ‘artificial evaluation’. A brief explanation for each of these steps follows.

1. Defining the research scope

The initial scope and objectives for this research were documented as part of the relevancy cycle, and defined by the service strategy and the artefact’s relationship to it. As the process of developing the artefact progressed, there were a number of iterations to the scope of the project. This was necessary as the design and development process was a creative one and was, therefore, rather 'fluid' in its process. Each iteration of the design and its functionality were recorded as a version change in the CDR. The various versions to this scope are denoted by the version descriptor (see Figure 3.4) and, with each iteration of the artefact, design knowledge was also acquired. This new knowledge is also included in the CDR (*see Appendix 8 for more detail*).

2. Evaluate the new solution feasibility

An important part of developing novel or new artefacts is to investigate the solution's viability within the scope and limitations of a research project. This study investigated multiple solutions to meet those needs specified by the business problem. The results of this investigation are documented in design cycle (see section 5.3).

3. Resolve whether within the design science paradigm

As the solution to the business problem evolves, the researcher may find that it may not fall into the design science paradigm. Various authors make the distinction between design science and other research paradigms: Goldkuhl & Lind (2010); Iivari & Venable (2010); Jarvinen (2007); Nunamaker, Chen & Purdin (1991); Walls, Widmeyer & El Sawy (1992). A discussion on the final research paradigm this study falls within can be found in the conclusion chapter.

4. Establish type (IS design science vs IS design research)

Kuechler, Vaishnavi and Winter (2008) discuss the two sub-categories of design science research: i) 'design research' is defined as a type of research that "is aimed at creating solutions to specific classes of relevant problems by using a rigorous construction and evaluation process"; ii) 'design science' is defined as a research process that aims to create standards for its rigour". This research falls under the IS design science category. Discussion and justification for this classification can be found in section 5.4 of the design chapter.

5. Resolve theme (construction, evaluation, or both)

A design science research project usually consists of two major elements in artefact development: construction of an artefact and its evaluation (Hevner, 2007); however, in some circumstances, only one of those may be necessary as part of the design science research project. Where the artefact is particularly novel, for example, the evaluation phase of design science may not be necessary (March & Smith, 1995; Winter, 2008). As shown in the methodology chapter, this thesis undertakes both major elements of the design science research project.

6. Define requirements

Once the design objectives for the artefact were determined, a requirements schedule was developed that specified the technical skills and physical resources required to complete the artefact’s development. These requirements varied at each stage of its development. The various versions of the requirements schedule are documented in the CDR. See Table 4.6, in the Design Cycle chapter, to view the requirements schedule.

7. Define alternative solutions

Design is a creative process that entails exploring a number of viable option/solution sets, and seeks to test the applicability of these options to a specific problem. The various options are tested for their suitability, and the gaps and errors that arise from the application of the test solutions are identified (Hevner et al., 2004). Through this identification process, further refinement to the possible viable solutions for the business/research problem can be made. A gap analysis was conducted for each proposed viable solution and tested. See Table 4.0 in the Design Cycle chapter, for this exploration process.

8. Explorer knowledge base support of alternatives

An alternative solution for the business/research problem will be based on theoretical underpinning(s) – that is, the final solution design will encompass research principles based on some natural or social science kernel theory (Walls, Widmeyer, & El Sawy, 1992). The kernel theories that the design encompasses can inform design theory. Conclusions drawn from the design science project may also contribute to the nomological knowledge base of the kernel theory (Goldkuhl & Lind; 2010). This step of the design cycle entails investigating kernel theories that support and inform artefact design. More information on the kernel theory that underpinned the artefact by can be found in the discussion chapter. See the rigor and the discussion chapters for more details on the kernel theories that are used as part of the development of design theory in this research.

9. Prepare for design and/or evaluation

The specific task of requirements planning happens before the actual construction of the artefact can begin, and the evaluation methods to determine the artefact's success are also selected. The planning process consisted of documenting the artefact's representation, design principles, development methodology, construction method, functional specifications, metrics, and criteria (Hevner, March, Park & Ram, 2004). In the planning stage, the methods to determine the functional fit and performance of the solution are selected.

10. Develop (construction)

An instantiation of a novel artefact is developed during this stage of the design cycle, when the artefact's architecture, functionalities and properties are determined (Nunamaker, Minder & Titus, 1991; Peffers, Tuunanen, Rothenberger & Chatterjee, 2007; Hevner & Chatterjee, 2010). Knowledge obtained from the construction process is added to the CDR.

11. Evaluation of artefact

The aim of the evaluation stage is to determine how well the instantiation of the artefact meets the needs specified by the business/research problem, and will consist of both artificial and naturalistic evaluation methods. The artificial evaluation methods will determine whether the artefact is working without errors ('bugs') and whether it meets the functional specification. The naturalistic evaluation methods will determine whether the solution works according to naturalistic metrics – those used for this study included the administration of a second IS-impact, UTAUT questionnaire, and convergent interviews to evaluate the sociotechnical interaction that occurred because of the artefact. As a result, knowledge about design products and processes is produced.

Within this section, the purpose of the design cycle has been explained. Justification for the Alturki, Gable and Bandara (2011) design cycle was justified, and its various stages defined. The next section contains a description of the rigor cycle and its components: naturalistic evaluation methods, discussion of the sociotechnical interaction, and the resultant design theory.

3.8 NATURALISTIC EVALUATION METHODS

Apart from this introduction, this section is described in six parts:

Part 1 contains a summary of the data collection methods, the instruments used to address the proposed research questions, and the data analysis techniques employed.

Part 2 describes the data collection sites.

Parts 3 & 4 describe the population and sample.

Part 5 describes the research period.

Part 6 defines the purpose of the central design repository (CDR), its structure, and its use in this study.

3.8.1 Data collection methods, instruments and data analysis techniques

Table 3.2 highlights the various data collection methods used in this study. It shows the three sources of data collected in the Relevance Cycle.

Table 3.2 - Summary of data collection methods/instruments

Relevance Cycle	Design Cycle	Rigor Cycle
Enterprise Information Architecture Anecdotal Evidence	Interviews Focus Groups	SQL Usage Reports IS-impact Model
SQL data analysis	Software ‘Simulation’	UTAUT
		Convergent Interviews

These data sources are defined as: i) the documented gaps and artefact requirements through the use of the EIA; ii) feedback quality on the legacy IS through anecdotal evidence; and iii) and information on data quality through analysing SQL data. The data collected in the design cycle relates to testing the quality of the developed artefact through an ‘action research approach’ – that is, using feedback from interviews, focus groups, and software simulation testing. Finally, in the rigor cycle, the four formal measurement techniques (IS-impact, UTAUT, Convergent Interviews, and SQL reports) are applied to evaluate the effectiveness of the artefact.

Evaluation techniques – rigor cycle

The various data collection methods are shown for each of the DSR cycles in which they are employed. The collection methods for the relevance cycle data were discussed in the relevance section. The data collection methods for the design cycle form part of the black-box and white-box testing, and are discussed in the design cycle. The data collection methods for the rigor cycle are discussed in the next four sections.

SQL usage reports

This study analyses the quality of data written to the SQL database, which is the repository for all data written to and from the artefact once it has been deployed. A direct comparison of the quality of data between those who used the artefact and those that continued to use the legacy IS can be made.

IS-impact scale

The underpinnings of the IS-impact model (Gable, Sedera & Chan, 2011) originate from DeLone and McLean (1992). The purpose of DeLone and McLean’s seminal work was to develop a dependent variable that could measure the success of information systems (ISS). This ISS construct originally contained six dimensions: system quality, information quality, organisational impact, individual impact, satisfaction, and use (see Table 3.3 for definitions of these dimensions). Key recommendations from the Delone and McLean (1992) original research paper included a call to either validate or extend the definition of the proposed ISS model.

Since 1992, approximately 300 research articles have been published using DeLone and McLean's ISS construct, and have either sought to validate or propose changes to this model (Burton-Jones & Straub, 2006). Most notably, a theme emerging from these 300 articles highlights the importance of making changes to the ISS model based on the contextual factors related to that study. A prominent article by Seddon, Staples, Patnayakuni and Bowtell (1999), for example, proposed a matrix to determine the most appropriate constructs based on these contextual factors.

Table 3.3 shows the six constructs that make up the ISS construct and the various ways that they have been operationalised from 1992 to 2003. Table 3.3 shows the wide array, across the six dimensions, of measures that have been used according to the objectives and context of the study.

A decade after DeLone and McLean (1992) proposed their original model, they evaluated 100 research articles from *Information Systems Research*, *Journal of Management Information Systems*, and *MIS Quarterly* (DeLone & McLean, 2002). This review was to facilitate recommendations for future use of the ISS based on how these studies utilised the original model. In the conclusions to this paper, it is suggested that the selection success dimensions and measures should be contingent on the objectives and context of the empirical investigation; however, the number of variables used to measure ISS should be reduced so that the research results can be compared and findings validated.

Table 3.3 – IS-impact construct definitions and potential measures

CONSTRUCT	DEFINTION	MEASURES USED IN PREVIOUS LITERATURE
System Quality	System Quality is a measure of the performance of (the IS) from a technical and design perspective.	Ease-of-Use, Functionality, Reliability, Flexibility, Data Quality, Portability, Ease of Learning, Intuitiveness, Integration, and Importance
Information Quality	*Information Quality* defined as the quality of the information of IS system outputs. This includes any information the user interacts with, such as the user inter-face, or reports produced by the system.	Accuracy, Timeliness, Completeness, Relevance, and Consistency.
Organisation Impact	The change to the capacity and capability of the organisation, as a result of the implementation of the IS.	Organisational Costs, Staff Requirements, Cost Reduction, Overall Productivity, Improved Outcomes, Improved Outputs, Increased Capacity, Business Process Management.
Individual Impact	The change to the capabilities and effectiveness of the end-users in fulfilling their organisational role.	Decision-making Performance, Job Effectiveness, Job Performance, Quality of Work Environment, Decision Making Performance, and Quality of Work.
Satisfaction	How satisfied the users are with the IS system	Satisfaction, Enjoyment, System Quality.
Use	The amount of use of the IS system by the end user.	Frequency of Use, Time of Use, Number of Accesses.

A key finding of this review focused on ensuring an understanding of interactions between the dimensions of the dependent variable. This is considered important "in order to isolate the effect of various independent variables with one or more of these dependent success dimensions".

Incorporating these recommendations, Gable, Sedera and Chan (2011) recently developed an IS-impact model that extends the original ISS model. Its aim was to offer a common instrument to address all relevant system users in a holistic way. It is in this aim that the IS-impact model differs philosophically from the ISS construct, as it seeks to have a single measure for ISS regardless of the objectives of the study or its contextual factors. Further differentiations between IS-impact and ISS constructs lie in the number of sub measures. The IS-impact scale and its constructs are defined in Figure 3.2.

While DeLone and McLean (2003) continue to recommend the 'use' and 'satisfaction' dimensions of ISS, Gable, Sedara and Chan (2011) have removed them from the IS-impact construct. Instead, they propose ‘satisfaction’ and ‘use’ are phenomena that occur as a result of applying an artefact. In the IS-impact model, system quality is defined as a measure of the performance of the IS from a technical and design perspective. The information quality construct is a measure of the quality of the IS outputs, such as reports and the user interface. The organisational impact construct measures the extent to which the IS has led to improvement in organisational results and capabilities.

The individual impact construct measures the extent to which the IS has influenced the capabilities and effectiveness on end users within the organisation. The IS-impact dimensions and all of its scale items can be seen in Appendix 9.0, and an *a priori* model is shown in Figure 3.2

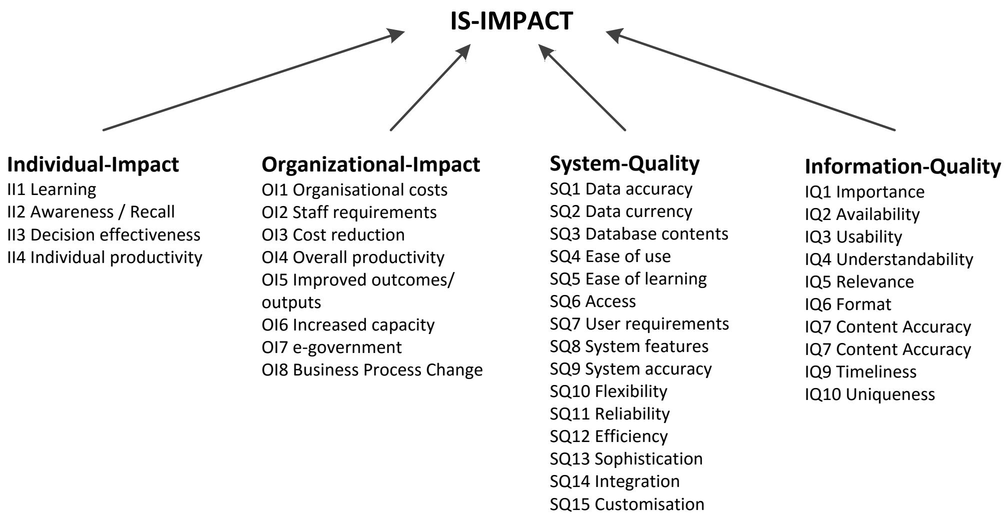


Figure 3.2: IS-impact a priori model

This IS-impact model has addressed many issues and recommendations made by Delone & Mclean (1992). Gable, Sedera and Chan (2010) proposed that the use of the IS-impact model would facilitate research results that would be generalisable and be comparable across time, stakeholders, different systems, and system contexts.

The use of the IS-impact scale in this study

The IS-impact scale was applied twice in this study, in the pre- and post-artefact instantiation. Given that the IS-impact construct measured the four dimensions of individual impact, organisational impact, system quality and information quality, a deeper appreciation of perceived issues with the existing IS could be discerned.

By reapplying the IS-impact questionnaire post application of the new artefact, its ‘net impact’ was observed. Not only could the improvements in the individual dimensions of the IS-impact be observed, but also how the changes to the artefact affected the perceived quality of the entire IS system. For this reason, the IS-impact model was chosen. The results obtained from the application of the IS-impact scale, and a discussion on the trends found in these results, are presented in section 6.7.3 of the results chapter. The dimensions of the IS-impact scale and its scale items can be seen in Appendix 9.

This section has defined the IS-impact construct and discussed its use within this study. The next section defines the Unified Theory of Acceptance and Use of Technology, and describes its use within this study.

Unified theory of acceptance and use of technology

In this section, the unified theory of acceptance and use of technology (UTAUT) is defined and its application in this study described. This section contains two parts: the first describes the UTAUT and it philosophical underpinnings; the second describes the application of UTAUT in this study. The scale items for UTAUT can be found in Appendix 9.

Defining the use of the UTAUT model

The UTAUT model tests the end-user’s ‘intent to use’ an IS, and their actual ‘use’ of it. UTAUT is a revised model of the technology acceptance model (TAM) first proposed by Davis (1989). The kernel theory for UTAUT comes from a number of others, including of “theory of reasoned action (Fishbein & Ajzen, 1975), technology acceptance model (Davis, 1986), motivational model, theory of planned behaviour (Ajzen, 1991), a combined theory of planned behaviour/technology acceptance model, model of PC utilization, innovation diffusion theory, and social cognitive theory” (Furneaux, 2005).

The theoretical framework for UTAUT is shown in Figure 3.3. The UTAUT seeks to model the 'intent' to use an IS, and the actual 'usage' of it. It shows the six constructs that lead to 'intent to use an IS' and subsequent use of an IS.

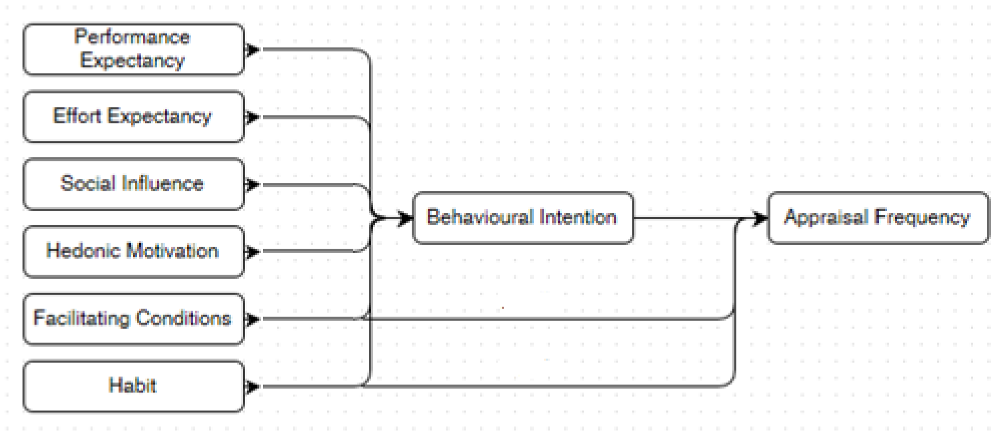


Figure 3.3: Unified theory of acceptance and use of technology (Source: Venkatesh, 2003)

The model shows that four main constructs of performance expectancy (effort expectancy, social influence, hedonic motivation, facilitating conditions and habit) are direct antecedents of 'intention to use an IS'. 'Facilitating conditions and habit' also directly affect use of the IS according to this model (Venkatesh et al., 2003). Gender, age, experience, and voluntariness of use (not shown) are covariates on the four key constructs that lead to usage intention and behaviour. The UTAUT construct has been validated in studies by Garfield (2005) and Venkatesh et. al. (2003).

Limitations of the UTAUT model centre on the relationship between intention and behaviour. The UTAUT model assumes that when someone forms an intention to behave, they will act out that behaviour. In practice, however, there are often constraints to acting out behaviour. IS 'use' factors (such as capability, capacity, environment, organisational constraints, and previous habits) will have an effect on the 'intention to behave – behaviour relationship' (Eagley & Chaiken, 1993).

The use of the UTAUT scale in this study

Within this study, the UTAUT is applied both before and after instantiation of the artefact. The antecedents of performance expectancy, effort expectancy, social influence, and facilitating conditions are measured using the UTAUT questionnaire. The scale used for this study can be found in Appendix 9. The results obtained from the application of UTAUT and discussion on the trends found in these results can be found in section 6.7.1 of the results chapter.

This section has defined UTAUT and explained it use within this study. The next section describes the convergent interview technique. This qualitative method is only applied post instantiation of the artefact. The purpose of the convergent interview is to gain qualitative data on user behaviour as a result of the intervention. In this study, therefore, the application of the convergent interviews is only required post instantiation of the artefact.

Convergent interview techniques

The previous two sections discussed the two quantitative measurements used in this study. Using the results from the application of these two quantitative measures, a general understanding of the effect of the artefact in resolving the wicked problem can be gathered. To gain a deeper understanding of the effect of the instantiated artefact, a third formal qualitative measurement technique, convergent interviews, is applied. These are conducted to gain a qualitative understanding of the wicked problem and the artefact's affect in solving the stated business problem. Convergent interviews allow for feedback from a diverse array of organisational stakeholders in the application domain and, therefore, have the potential to provide rich insight to those factors that lead to, or act as barriers to, use.

This section has 4 parts: i) the characteristics of the convergent interview technique (CIT) are detailed; ii) the process for selecting participants; iii) the interview method; and iv) the analysis method for each round of interviews.

Definition of convergent interviews

Convergent interviewing is a recommended technique when complex issues need to be identified. It differs from other methods of interviewing in that it focuses on the participants, who are characteristically different. Through interviewing a full range of end-users, key issues related to the problem set can be attained (Jepson & Rodwell, 2008). Convergent interviewing is characterised as a technique that is applied a number of times in the application domain, and converges on the issues with each round of interviews. They have been found to be valid and reliable across a variety of settings (Lincoln & Guba, 1985). In this study, the convergent interview technique is applied to investigate teachers' interactions with the artefact. This technique is also applied to examine those relationships identified for research hypotheses 8, 9, 10 and 11.

Process for the selection of participants

It was important that end-users in this study had particular characteristics. Given the potential length and iterative nature of the interviews, it was important that they had an interest in the instantiated artefact, used it regularly, and were willing to give time for the interviews. Participants who also had some general knowledge of information systems were also preferred. Twelve users of the trial artefact were chosen to participate in the convergent interview technique. It was imperative, as part of this technique, that this cohort represented a range of demographic profiles (Kalton & Moser, 1979). End-users of varying age, gender, academic position, academic department, and IT skills were selected. Once chosen, they were placed into similar demographic characteristics (position type) and sub-grouped into a further three groups: most knowledgeable about the problem; knowledgeable about the problem; least knowledgeable about the problem. Other than 'position type', the demographic characteristics of the participants in and across groups were diversified. Interviews were conducted according to the demographic group, with the 'most knowledgeable' participant selected to be interviewed first. The least knowledgeable person of that demographic group was interviewed last. Table 3.4 shows the participant groupings for the convergent interview technique, following the steps specified by Jepson and Rodwell (2008). Table 3.4 also contains data about interview groupings. Participants 1, 4, 7 and 10 were interviewed in the first round of interviews, and were diverse in their demographic profiles. The second round contained participants 2, 5, 8 and 11; while the final round had participants 3, 6, 9 and 12.

Table 3.4 – Participants groupings for the convergent interview technique

	House Guardian	Heads of Department	Teachers	IT Professionals
Most Knowledgeable	1	4	7	10
Knowledgeable	2	5	8	11
Least Knowledgeable	3	6	9	12

Interview process

Once the first four target participants for each demographic group were identified, they were told the nature of the research, including information such as the selection process, research ethics, the confidentiality of the data provided, the interview timelines, and the contact details of the researcher. Each round of interviews consisted of four interviews. The disparity in the demographic profile of participants in each round supported a diverse range of responses from them. In each interview, they were welcomed and the purpose of the research and interview reiterated.

The confidential nature of the research was explained to the participants and, subsequently, they were asked to sign an informed consent form, a copy of which can be found in Appendix11. The process and conduct of the interview was then outlined to the participants, including the process of gathering the data and how it would be used. Each participant was informed they could withdraw from the research at any point during the process.

The convergent interview technique consisted of three essential elements that were necessary to ensure validity for the interview process:

1. The initial questions were open-ended and broad to allow the participants to express their own ideas. Initially, the interviewer had little input into the conversation, facilitating an open platform for free expression.

2. The focus and clarity of the questions were designed to fit the experiences and demographic profiles of the participants.

3. The questions used in the interviews were designed so that they could adaptable to the experiences of the participants while keeping their intent and meaning.

The finish of each interview consisted of three steps: i) the researcher summarised the key points; ii) the participants were asked to clarify any points of ambiguity with the interview summary; iii) the interview was concluded by asking the participants if they could identify other end-users who they thought might be a valuable participant in the process. The questions developed and applied in this interview technique can be found in Appendix11.

Interview analysis

After each interview, the key issues brought up by the participants were logged. After each round of four interviews, the common issues across the four were identified. An issue was classed as a 'key issue' when it was raised by more than two participants; 'non-key' issues could be elevated to key issue status in subsequent rounds if raised by more participants. After each round of interviews, further sets of interview questions were developed to probe and converge on the key issues. Two categories of probing questions can be developed to converge on identified key issues: 'exception' and 'directionality' (Dick, 2000). An example of 'exception' probing might be where two participants agree that 'access to computers' is an issue, but there may be exceptions when teachers have access issues when problems occur during peak times of the day. 'Directionality' probing questions can be highlighted by a scenario where two participants agree that 'time taken to enter data' is an issue – however, for one participant, this might take much longer than for the other. The strength of directionality can be tested with probing questions.

Analysis of the issues

When all interviews had been completed, the key issues were categorised and grouped using techniques suggested by Dick (2000). An analysis of themes was facilitated by grouping the key issues according to their differences and similarities. This grouped data can be found in the results section.

In this section, the process of convergent interviewing has been described, as well as outlining the process and analysis of the data obtained from the interviews. In the next section, the data collection site is described.

3.8.2 Data collection sites

All surveys were distributed and applied within a single site. The quantitative surveys were applied pre- and post-instantiation of the artefact. The convergent interview process was conducted after the evaluation trial period of the artefact had concluded. All interviews were also contained to this site, which was characterised as a private Catholic Boys College that enrols students from years five to twelve, and totals 1320 students.

3.8.3 Population

Surveys were distributed to both teaching staff and teaching support staff at the college. The total population of teachers at the college was 94.

3.8.4 Sample

For the subject's responses to be valid, a single user was required to successfully complete both questionnaires pre and post instantiation of the artefact. The sample size for both the UTAUT and IS-impact questionnaires was 32, representing 38.09% of the total teaching staff at the college. A total of 12 respondents completed the convergent interviews post implementation of the artefact (14.28% of the total teaching staff).

3.8.5 Research period

Data was collected during the first and third terms of 2014, and correspond to the pre and post periods of artefact implementation. Given the frantic nature of schools at the beginning and end of terms, it was discerned that all measurements would be best applied between week three and seven of term to ensure no overlap with the marking/reporting period for teachers.

3.8.6 Data analysis techniques

The reliability and validity of the measuring instruments were first assessed for internal consistency and validity. Once this was completed, this study adopted five types of data evaluation techniques, which included four quantitative techniques: descriptive statistics; Pearson's *r* correlations; t-tests; and ANOVAs. All statistical analyses were performed using

SPSS. The fifth data technique evaluated the qualitative data through identifying, classifying, and counting the key terms and phrases collected from 12 interview passages. When all qualitative data had been collected, the key issues were categorised and grouped using the stated techniques. Themes were analysed by grouping the key issues according to differences and similarities. The results of this process are in sections 6.7.8 to 6.7.11. The various techniques used for each hypothesis can be found in the results chapter.

This section contains a summary of all the evaluation methods used within this study and the context of their application. It also contained statements about the measurement instruments, data collection methods, data collection sites, population, sample, and research period. The next section contains discussion on the central design repository (CDR); it is described and its use and importance in this study is detailed.

3.8.7 Central design repository

This section describes the central design repository (CDR) and its use in this study. It is a document repository that contains information about the DSR process, and also stores all knowledge and related issues discovered during that process. Alturki, Gable and Bandara (2011) describe the CDR as an information management system and repository, containing coded knowledge about ‘design processes’, ‘designed artefact’, and reflections on the ‘DSR methodology’.

The CDR is a necessary component of DSR that ensures new knowledge about the design process and products is recorded. Alturki, Gable and Bandara (2011) suggest that the minimum components of the CDR contain the CDR controller and the CDR document repository.

For the purposes of this thesis, the CDR was created using Microsoft SharePoint. A dedicated site, custom list, and a document library were created, and these served as the basis for the CDR. The custom list acted as the ‘controller’ for the CDR, and the document library contained all *information chunks* relating to the DSR.

The schema used for the controller in this study was modified from the one suggested by Alturki, Gable and Bandara (2011). The controller contained: data about the information chunk; information chunk ID; information chunk type categorised as ‘emerging’ or ‘communicated’; information chunk state categorised as a ‘new chunk’ or a ‘new version’; a link to the actual document in the CDR; the content of the information chunk; the version of the information chunk; and the source of the information chunk. A screenshot of the CDR controller is found in Figure 3.4, which shows the metadata captured by the CDR controller for each information chunk. The information chunk can be accessed through the CDR controller.

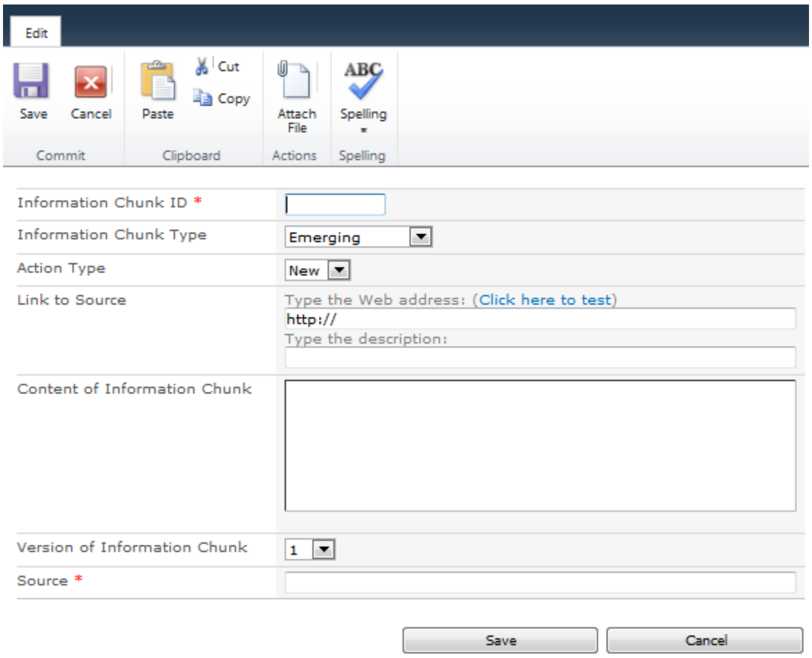


Figure 3.4: The central document repository (CDR) used for this study.

The second part of the CDR consisted of a document library, which stored all *information chunks* about the design (design information) of the artefact, and a screenshot of the CDR can be seen in Figure 3.5. This shows how the metadata and attachment files can be added for each information chunk stored in the CDR.

The design information added into the CDR had two sub-categories of design information: ‘design product’ information and ‘design process’ information. The design product information described knowledge about the artefact (such as its properties, functions, and structure), while the design process information described knowledge about the process of building and implementing the design and/or instantiation of an artefact. Within this study, an information chunk is entered into the CDR when the DSR reaches a *landmark point*, or when significant new knowledge emerges from the design process.

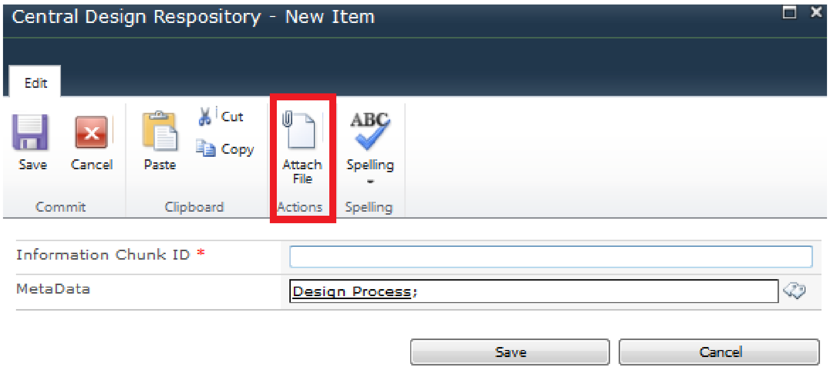


Figure 3.5: The process for adding files to the central design repository

Once the artefact had been instantiated, all information entered into the CDR was exported to an Excel spreadsheet, the contents of which can be found in Appendix 8.

This section has described the CDR and its use within this study; the next section discusses the important DSR outputs that must come from the CDR. Gregor and Jones (2007) described these as necessary to build 'design theory'. The elements needed to communicate 'design theory' are also described in the next section.

3.9 RIGOR CYCLE METHODS

In this section, the necessary outputs of DSR are stated – that is, those necessary to communicate, justify, and further develop IS design theory. These outputs were proposed by Gregor and Jones (2007). The rigor chapter provides in depth explanation of each of the design theory components within this study.

3.10 COMMENTS ON VALIDITY

In this section, definitions from Campbell and Stanley (1963) are used to discuss the threats to the internal and external validity of this study. 'Internal validity' refers to the extent to which one can accurately state that the treatment of the independent variable produced the observed effect in the dependent variable. ‘External validity’ refers to the ability to generalise the results to a larger population. It is essential that the research inherently contains both forms of validity, with the understanding that strong validity of one form can compromise the strength of validity of the other (Campbell & Stanley, 1963). Without at least an acceptable level of internal validity, research cannot have any substantive external value. Additionally, a highly controlled experiment may bear little resemblance to the real world and, thus, have limited external validity. Typically, internal and external validity threats relate to one of the following reasons:

- The study’s experimental method is not appropriate for the research objectives.
- The constructs used to measure the phenomenon are inappropriate or incomplete.
- The operationalisation of the method did not have appropriate rigor (operationalisation issues include the sampling process, measurement, data collection, and the data analysis process).

As this study uses a design science methodology (i.e. one that solves real-world problems), the threat of external validity is not usually a direct threat. There are some questions with regards to external validity given the small sample size, but it is generally believed that the random sample taken within the application domain is representative of the domain being studied. Given that the methodology used for this research is appropriate, the main focus for internal validity threats, therefore, centre on the appropriateness of the constructs and the operationalisation of these constructs.

Table 3.5 – Possible internal threats to validity (method and constructs)

Validity Threats	Definition	Identified
Nomological Validity	Defined by Cronbach and Meehl (1955), nomological validity occurs when the relationships between constructs are reflected in the relationships between measures or observations. Nomological Validity devolves from a well-developed a nomological network.	IS-impact UTAUT
Construct Validity	Construct validity occurs when the observed cause and effects in real world applications represents the theoretical basis for the cause and effect relationship.	IS-impact UTAUT
Predictive Validity	Predictive validity establishes the relationship between measures and constructs by demonstrating that a given set of measures posited for a particular construct correlate with or predict a given outcome variable.	IS-impact UTAUT
Content Validity	Content validity occurs when the questionnaire items used in a construct, fully represent the meaning or definition of a given construct?	IS-impact UTAUT
Discriminant Validity	If supposedly unrelated measures and constructs are considered alongside a variable, e.g. latent construct C, then there should be little or no cross loading on constructs A or B. In other words, the measures should "discriminate" among constructs.	IS-impact UTAUT
Convergent Validity	If, for instance, construct D, in the presence of other variables like the construct C, load on or are strongly associated with construct D, then we would say that they "converge" on this construct (convergent validity).	IS-impact UTAUT
Internal Consistency	Items in a questionnaire are often varied in wording and positioning to elicit fresh participant responses. If the scores from each of these items, for each participant, are consistent the construct has internal consistency.	IS-impact UTAUT

The possible internal validity threats that are related to the methods and constructs used in this study are summarised in Table 3.5. The potential internal validity threats related to the operationalisation of these constructs are summarised in Table 3.6.

Table 3.6 – Possible internal threats to validity (operationalisation of constructs)

Threat	Description	Construct
Instrument Validity	Validation of data gathering	Convergent Interviews
Inter-rater reliability	Mainly relevant to qualitative research where several raters or judges code the same data.	Convergent Interviews
Statistical Conclusion Validity	Assesses the mathematical relationships between variables, and makes inferences about whether this statistical formulation correctly expresses the true co-variation.	UTAUT / IS-impact

In this section, the possible validity concerns with the methodology of this study were expressed. Given that DSR is based on real-world problems, it was deemed that external validity would not be relevant unless there were major concerns with the internal validity of the study. It was also stated in this section that the focus of the internal validity concerns for would centre on the appropriateness of the constructs and the operationalisation of these constructs. In the final part of this section, the internal validity issues related to the appropriateness and operationalisation of constructs were discussed in detail. Section 9.3 in the final chapter discusses these threats to the study in detail. The last section of this thesis summarises all of the information presented in this chapter.

3.11 CHAPTER SUMMARY

This chapter collectively appraised the methodological approach used in this study, and consisted of twelve sections. The research problem was stated in section 3.1; the research goals and research questions were stated in section 3.2; the expected contribution to knowledge within the natural and design science realms was specified in section 3.3; the method adopted to investigate the research questions were detailed in section 3.4.

There are three major development cycles in this design science investigation: the relevance cycle was described in section 3.4; the design cycle was described in section 3.6, and the rigor cycle in section 3.7. The relevance cycle (section 3.6) consisted of five parts, which combined to triangulate the exact nature of the business problem. The anecdotal evidence collected from SQL reports, results from the three measurement instruments and the IT environmental considerations of the application domain laid the foundation for artefact development in the design cycle.

Within section 3.7, the design cycle was described using the eleven steps of artefact development suggested by Alturki, Gable, and Bandara (2008). The final stage of the DSR methodology described was the rigor cycle, which was described in five sections. Section 3.8 summarised this study’s evaluation methods and their application context. Section 3.9 contained a description of the functionality of the central design repository and its use in this study. Section 3.10 described the important outputs (justificatory knowledge) of a design science project. Finally, the potential validity concerns associated with the study’s methodology were made. The next chapter describes the relevance cycle.

CHAPTER 4: RELEVANCE CYCLE

4.1 INTRODUCTION

The contextual background for this study was proposed in Chapter 2. The central concept from this literature review was that education could be described as a 'system', and comprised of an organised set of service components (a system's perspective). The quality of each service component can be measured through performance metrics (PMs), which were defined in Chapter 2 as the change between the input and output measures as a result of the application of standardised practices.

Using the system's perspective, Chapter 2 contained arguments advocating the importance of PMs to improving service quality. Importantly, it was identified that PMs should be collected in an iterative and ongoing way so that continuous improvement to student outcomes can be achieved. Studies were cited in Chapter 2 listing example schools that extensively used data in decision-making processes. Examining these studies highlighted the broad problems with collecting and using data within these schools. A key issue identified with data collection related to the frequency of the data cycle – that is, the production of measures that define improvements from the input/benchmark to the output. Marsh (2006), in particular, cited "that many teachers prefer and rely on data sources that provide a greater frequency of updates to student's performances such as classroom tests, assignments and homework". Chapter 2 explicitly stated the relevance and importance of quality data in potentially improving outcomes for students.

The aim of the relevance cycle within DSR is twofold:

1. *To define the exact nature of the problem, in relation to the problem space*. As Rittel and Webber (1973) states, "defining the problem is the problem!" The wicked problem addressed by this study is defined, classified, documented and communicated using techniques specified by Hellmuth and Stewart (2014). Once the problem was defined to prove the 'relevance' of this study, it was determined that the wicked problem could be engineered with existing technology or solutions.

Using techniques from Hellmuth and Stewart (2014), a gap analysis was undertaken between the current and desired states of the EIA, with respect to the services being examined. It was determined that these gaps could not be addressed through existing technology and a novel artefact would need to be developed. Therefore, the relevance of the research problem is established.

2. *To determine the artefact's design requirements*. While design requirements from an enterprise perspective are identified within the EIA, design requirements from the user's perspective was not elicited from the EIA development. To attain user interaction issues with the legacy IS, anecdotal evidence was elicited. These design requirements were then directly incorporated as part of the artefact's instantiation.

This thesis uses TOGAF–v 9.1 standards to map the current and desired states of a problem domain. This mapping is completed as part of the relevance cycle. Once the gaps between these two states (across the EIA layers) were established, the EIA was used to facilitate artefact development by highlighting the gaps between the current and future states of the enterprise. The premise for determining artefact requirements is shown in Figure 4.0.

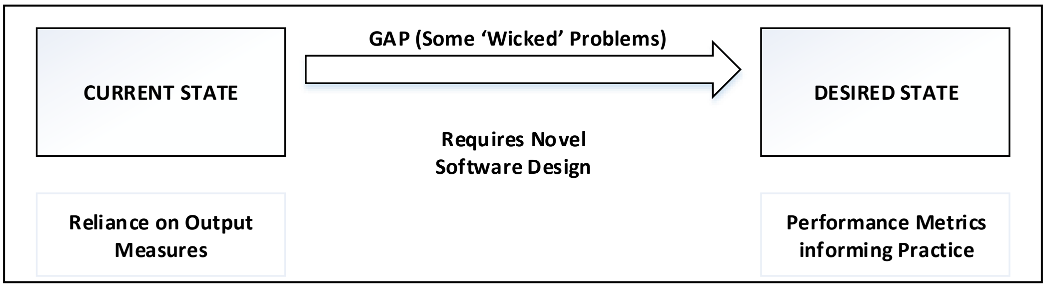


Figure 4.0: This figure highlights the basic scope and model for proving the relevancy of this design science research (DSR). The ideal state for data collection was highlighted in Chapter 2. This chapter reviews the current state of the application domain using a number of qualitative and quantitative data sources. These gaps form the basis for the next chapter of this thesis – the Design chapter.

Extending the premise shown in Figure 4.0, the full criteria for determining the requirements for the design of the artefact is shown in Figure 4.1.

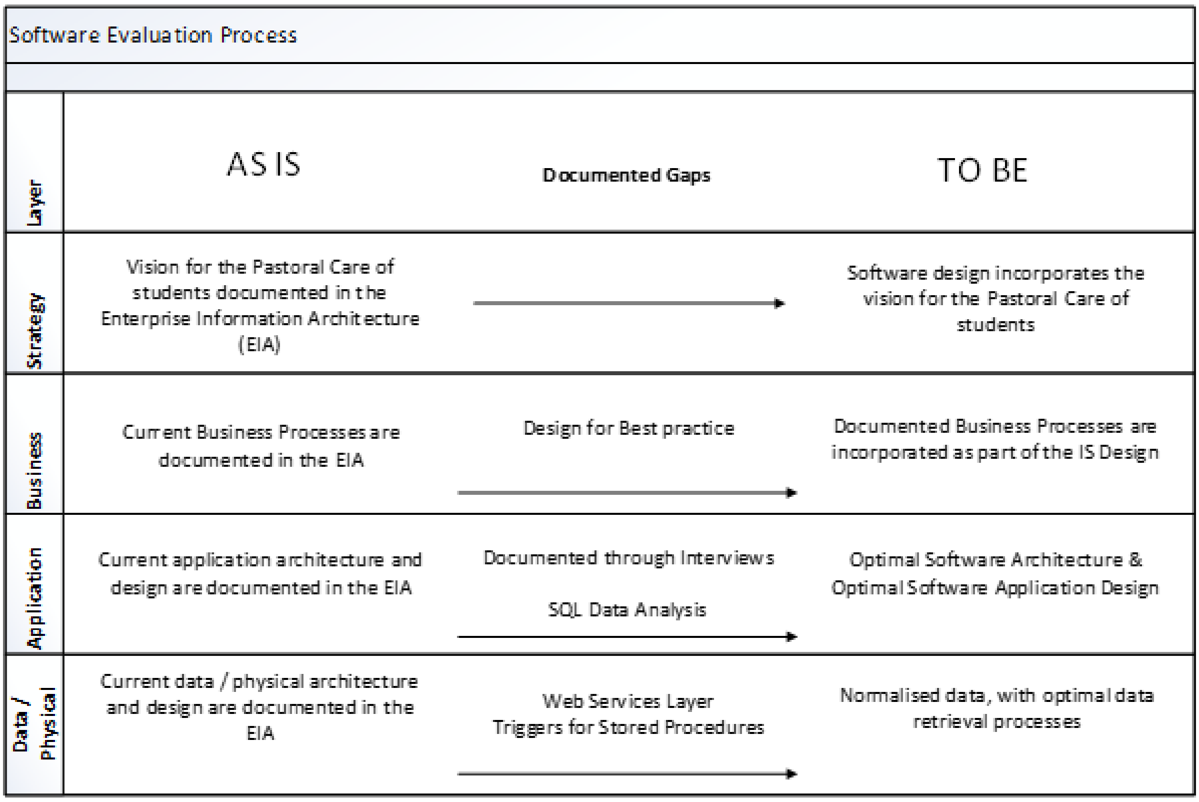


Figure 4.1: The criteria used to evaluate the appropriateness of design of the legacy IS.

Figure 4.1 shows the four dimensions considered in the design of the artefact, and these align to the four abstract layers of an enterprise as defined in The Open Group Architecture Framework (TOGAF – v.9.1).

The purpose of an EIA is to show the fundamental organisation of a system, embodied in its components and their relationships to each other. When there is a need for a component in an enterprise to change, the EIA document serves as a reference source to observe object dependencies. The principles governing the design of any components in this system are, therefore, dependent on aligning this component or components, with other dependent components of the system. These dependent components can reside and be classified into the four abstract EIA layers: strategy, business, application, and the data/physical layers.

The columns in Figure 4.1 are ‘as is’, ‘identified gaps’, and ‘to be’. The EIA documents both the ‘as is’ and the ‘to be’ state of the enterprise service component (pastoral care services). A comparison of the two states across the four dimensions (with respect to the pastoral care services unit) identifies possible gaps in the design of the information system used by that service component. As well as performing this gap analysis, this thesis directly collects evidence on potential software design issues. This is done through direct and indirect feedback from users, and an analysis of user behaviour, identified through SQL data record counts.

Chapter structure

Apart from this introduction, this chapter contains another five sections. The second section contains a fully documented EIA describing the application domain in eight parts. The first four describe the four abstract enterprise layers (strategic, business, application, and technology/data). The documentation of these layers is completed using the architecture development method (ADM), which aligns with the Open Group Architecture Framework TOGAF-v 9.1 (shown in Figure 4.4, section 4.4.3). The first four steps of the ADM require the documentation of these four abstract layers. The next four parts of this section describe the last four steps of the ADM: opportunities and solutions, migration planning, implementation governance, and the method for architecture change management.

Within the opportunities and solutions section, the 'to be' state is detailed, which is developed using the knowledge obtained from the first four sections of the EIA. In this section, the suggested changes made to the business, application and data layers to achieve the optimal 'to be' state are itemised. Effectively aligning a new IS across these layers of the organisation leads to benefits to both the service component and the organisation. Improved manageability, useability, agility to continuously improve the IS, and greater 'return on investment' (ROI) can be realised through standardising organisational components to the EIA (ANSI/IEEE Std 1471-2000). Achieving these design goals is necessary as part of any redesign of an IS used in a specific industry or organisations (TOGAF- v 9.1, 2014).

The migration planning section contains discussion on the steps undertaken to move from the legacy state to the new state. The final two steps of the architecture development method briefly discuss the process of implementation of the new IS into the enterprise: implementation governance, and architecture change management.

The purpose of the sections three and five of this chapter is to evaluate the design of the IS, referred to as the behaviour management system (BMS). This 'design evaluation' uses three measures: anecdotal evidence, SQL count data, and the software's functional capability to enact behavioural change, aligning it to best practice and the defined service strategy.

First, anecdotal evidence is collected from users on their perceived design issues with the legacy IS. Specifically, they are asked to point out major issues with it. The initial anecdotal evidence is presented in section three. In section four, the data quality resulting from the use of the legacy IS is analysed. The 'reporting frequency' of behaviours using the legacy IS are measured through SQL count data. The types of behaviours reported through the use of the legacy IS are also analysed using the existing SQL database. Section five contains discussion on behaviour modification theory, and key theories to improving student behaviour are promoted. At the end of this discussion, 'design considerations' on how these principles of behaviour management can be incorporated into the IS design are stated.

The final section contains an itemised list of the suggested design changes as stated in each section of this chapter. The itemised list highlights those changes that are considered addressed through the development of novel solutions. These design considerations form the basis for the design of the artefact presented in Chapter 5.

4.2 BACKGROUND TO THE BUSINESS PROBLEM

The research setting for this research project is an independent Catholic boys college (years 5 to 12) located in Brisbane, Australia. There are 1308 boys attending the college, which has a long tradition of providing the highest quality of pastoral care to its students. The college adopts a 'restorative justice' philosophy (Braithwaite, 2000) in the management of student behaviour. For eleven years, the accounting of student behaviour has been accomplished by assigning behaviour levels (1 highest; 7 lowest) to each student. The assignment of these behaviour levels has traditionally been completed at the end of each semester through a time-consuming consultative process between pastoral care staff and teachers. At the end of the year, students who attain level (1) behaviour are treated to an all-day trip to an amusement park. This function is lavish, and is arranged by the school Rector. Students who attain level (7) behaviour throughout the year are required to have ongoing meetings with their parents to discuss proactive behaviour modification strategies.

When students first enrol at the college, they are assigned a behaviour level of 4. By exhibiting positive behaviours (such as co-curricular, classroom or academic participation) students gain points towards achieving a better behaviour level. In contrast, negative behaviour moves the student towards a lower behaviour level. By the end of 2008, the manual accounting process for this system had become too time-consuming and inaccurate.

In 2009, the Vice Rector for pastoral care employed IT services to build a behaviour management system (BMS), which was to capture all data about student behaviour. In doing this, accurate behaviour levels could be assigned. A number of other advantages could also be attained through this data collection, such as the development of short- and long-term intervention strategies based on accurate data.

Currently, teachers are required to enter all instances of student behaviour via the BMS. The BMS link is embedded within a Microsoft SharePoint web page. Refer to the application view in section 4.17, for the application structure of the legacy IS. The BMS is accessed via a hyperlink. Clicking on this link opens up a business process management (BPM) tool that sits on the application server. Entering a *Behaviour Instance* triggers the first step in a *Behaviour Instance Workflow*. The UI for this application is shown in figure 4.2. A detailed architecture of the BMS and its dependent components, within the enterprise, are detailed in the next section of this chapter.

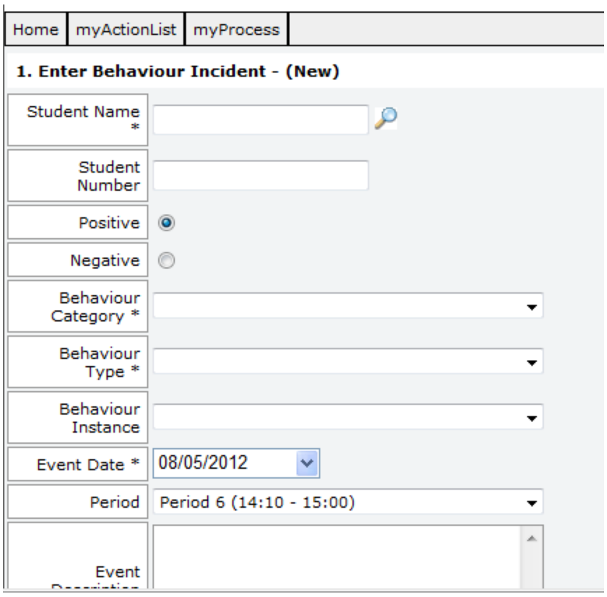


Figure 4.2: A behaviour instance is entered via a form created as part of a workflow.

4.3 ENTERPRISE INFORMATION ARCHITECTURE

4.3.1 Introduction

The documentation of the application domain is achieved through using an EIA framework. This thesis uses the framework and definitions provided by The Open Group Architecture Framework (TOGAF-v 9.1). Through completing an EIA, the optimal approach to developing the software artefact for this design science research (DSR) can be partly discerned. Other than this introduction, there are a further six parts to this section.

The first part of this section defines the EIA approach and elaborates on the framework and methods used to develop the EIA. This part also contains a summary description of the models and views used in the development of the EIA.

Part two contains information that describes the *Strategic Layer*, which predominantly describes the architectural vision for the host domain. Importantly, it also describes the strategic vision of the pastoral care services component. For the remainder of this thesis, the host domain will be referred to as the 'College'. Within this section, a number of views are provided to aid understanding of this vision (see section 4.3.4 for an explanation of the views used in this major section). These views include a *decomposition view*, which extracts the entities of the vision. The *customer process view* is also presented in this chapter, and it highlights the key services that the College provides to students throughout their enrolment period. A gap analysis of the delivery of key services for the pastoral care Unit is provided in this chapter. Possible information technology solutions are also suggested for these gaps where possible. The role of the artefact and its fit as part of the overall vision of the college is described in this part.

For the final three layers of the EIA (the business, application and data layers), the architectural focus will be on the pastoral care services component of the service chain only.

Part three contains description of the *business layer* for pastoral care services. Within this layer, the Archimate modelling tool is used to provide a high-level overview of pastoral care services. In particular, the business layer describes business units, positions, persons, roles and their (hierarchical) relationships. The *organisational domain* will be modelled using the *value network view,* and the *service view*. The *product domain* is represented using the *process control flow view*. Using business process modelling notation (BPMN), specific business processes will be represented in the *process domain*. These *business processes,* for the purpose of this document, will be limited to the pastoral care Service Unit. Finally, in the business layer, the *information domain* will be modelled using the *balanced scorecard view.*

Part four describes the *application layer*. Specific information objects and business functions relevant to business processes are identified and documented in this section. These objects and functions serve as a foundation for the development of a suitable application structure. The *application landscape view* documents all applications used in the organisation and their interdependencies. Using the Archimate modelling tool the *functional landscape view* model is developed to represent the *application domain.* The *functional landscape view,* as well as identifying all application structures, will inherently represent data access and data ownership.

Part five describes the *technology-data layer* structure used for pastoral care services. Using UML modelling, the following views would normally be included in the scope; *use case view*, *static structure view*, *component view*, *deployment view*, *sequence view*, and *state* *chart view*. Within this document, however, only the following views will be provided: *use case view, use case diagram view* and the *static structure view.*

The sixth section of this chapter contains four parts, which correspond to the final four phases of the architecture development method (ADM). This section addresses how the new 'as is' can be implemented effectively by leveraging the existing EIA. These sections include: opportunities and solutions for the new BMS, data migration planning, implementation governance, and the architecture change management.

The final part of this section makes recommendations for change to the existing EIA so that the newly designed IS aligns with the existing components of the enterprise. The next part of this section defines EIA, as well as TOGAF, the framework used in producing the EIA for the College. As part of this description, a framework of models/views used in developing the EIA is introduced.

4.3.2 Definition of enterprise information architecture

Enterprise architecture, as defined by ANSI/IEEE Std 1471-2000, is the "fundamental organisation of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution". An enterprise architecture model usually represents the current and or future architecture of the organisation. An EIA, as defined by TOGAF-v 9.1, is represented by four layers of abstraction: the strategic layer, business architecture, application architecture, and the data architecture.

4.3.3 Framework and methods used to develop this enterprise information architecture

The method used to develop the College's EIA parallels the architecture development method (ADM) from The Open Group Architecture Framework (TOGAF-v 9.1). The TOGAF ADM has 8 stages of architectural development, and are are highlighted in Figure 4.3.

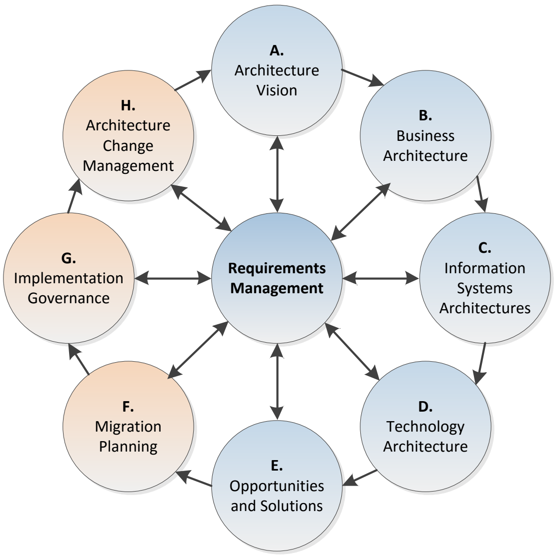


Figure 4.3: The ADM according to The Open Group Architecture Framework (TOGAF).

The first stage of the ADM is to develop the EIA vision for the organisation. The vision for the College's EIA is described within the *strategic layer* of this document. This purpose of the strategic layer is to position the organisational structure of the College and its respective organisational units in the *value network*, which is described as those products and services provided to the customer within their lifecycle – in this case, a student while enrolled at the College. Products, services and the college's goals are specified within this layer. The second stage of the ADM describes the business architecture of the College.

The aim of the business architecture layer is to describe how general design goals can be leveraged to increase the efficiency and effectiveness of the production, distribution and innovation of key educational services of the college. Highlighted in the specifications of this layer will be the organisational structure, which consists of the organisational units and their relationships, business processes, and key performance indicators (KPIs). The third stage of the ADM describes the information systems application architecture.

The goal of the information systems / application architecture layer is to link the College's business requirements to its supporting information system components. This objective is facilitated by specifying how the College's business requirements will be supported by one or more application structures/systems and their integration. The application structures that are represented in this layer are determined according to their fit in relation to the organisation's requirements. They are shown as a high-level conceptual construct to represent information flows, business processes, and information systems responsibilities. The fourth stage of the ADM describes the technology/data layer of the organisation, and its goal is to configure and design data structures and software artefacts that can be reused across a number of different service applications. In this document, the technology/data layer is modelled by using UML techniques.

The first of the final four stages of the ADM involves identifying potential opportunities and information solutions for the College – that is, how a business alignment with information technology can be leveraged to achieve the College's vision. The last three stages of the ADM are migration planning, implementation governance, and architecture change management, and these relate only to the College's pastoral care Service Unit.

4.3.4 Modelling

To effectively communicate EIA to the reader, a number of models are used within this document. The purpose of modelling is to provide the reader with an abstract representation and description of a particular aspect or view of the organisation. The models used in this document correspond to the domains presented in Customer Process section. The models represented in Figure 4.4 are bolded in red.

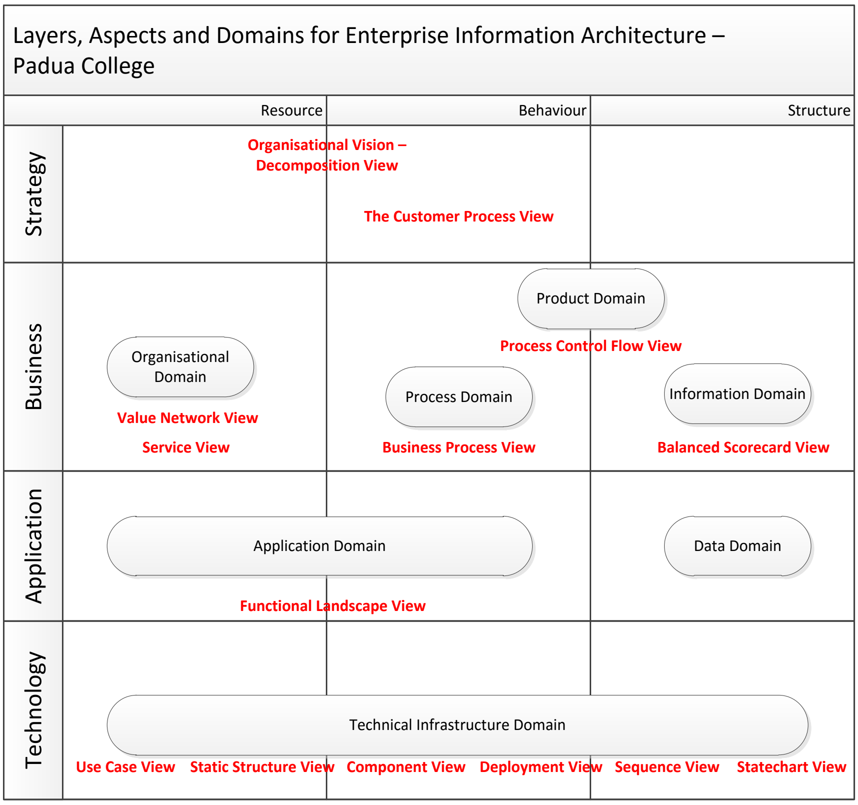


Figure 4.4: Layers, aspects, views and domains for EIA – the College.

4.3.5 Architecture – strategic layer

The design of the strategy layer requires the identification of the potential uses of information technology in the organisation, as well as their limitations. This is done in the context of the school vision. This chapter begins by explicitly deconstructing the College's vision statement. The College's services units, and the services they provide, are then modelled to facilitate analysis of how well these are strategically positioned. This assessment defines their ability to meet the defined organisational goals and their corresponding performance indicators. Gaps and potential solutions are identified at the end of this chapter.

About the College

The College received its name from the Franciscan Friar Saint Anthony (1195–1231), appointed by St Francis as the first Professor of Theology for the Friars. The College is the university city of northern Italy where St Anthony died.

The College began in 1956 when the Franciscan Sisters, who cared for the parish primary school of St Anthony's, were no longer able to cater for the large number of boys in their school. At the request of Sister Mary Bernadette O'Callaghan OSF, the Friars, who had taken charge of the Kedron Parish since 1929, agreed to begin a separate school for boys. Currently, the College is a progressive school of 1308 students.

College's aim

The school's main aim is to provide a Catholic education for the boys with a distinctive Franciscan influence. It therefore operates as a faith community rather than an institution, living out Gospel values and placing an emphasis on the Franciscan charisma. The value of each individual is emphasised, providing an education that is both relevant and personal to the student. The spirit of the College flows from the founder of the Franciscan Order, St Francis of Assisi (1182–1226), and it strives to be a Christian community and a place of affirmation and acceptance, where students are encouraged to endeavour to their personal level of excellence.

Organisational vision

The organisational vision is: "Inspired by our Franciscan values and beliefs, our students will engage in a dynamic and relevant curriculum, rich in diversity. It will focus on delivering experiences that cater for and extend the range of learning styles where students are challenged to attain standards that empower them to reach their potential. A whole school approach will promote the development of all dimensions of the individual giving him the opportunity to be a lifelong learner, a creative and critical thinker and a discerning participant in the world, now and in the future" (*College Vision Statement*, 2012).

Decomposing the organisational vision

The purpose of the decomposition diagram is to extract and analyse the entities from the organisational vision, and then to determine measures for those entities. Figure 4.5 highlights the entities extracted from the College's vision statement: i) diverse curriculum; ii) relevant curriculum; iii) dynamic curriculum; iv) creative, critical and discerning students; v) whole-school approach; vi) set standards. The entity 'life-long learning' has been omitted from the decomposition diagram, though the measures for all other entities have been included. A primary goal of the EIA will be to show how the service units in the College can achieve these targets through the delivery of services. This is the function of the customer process view.

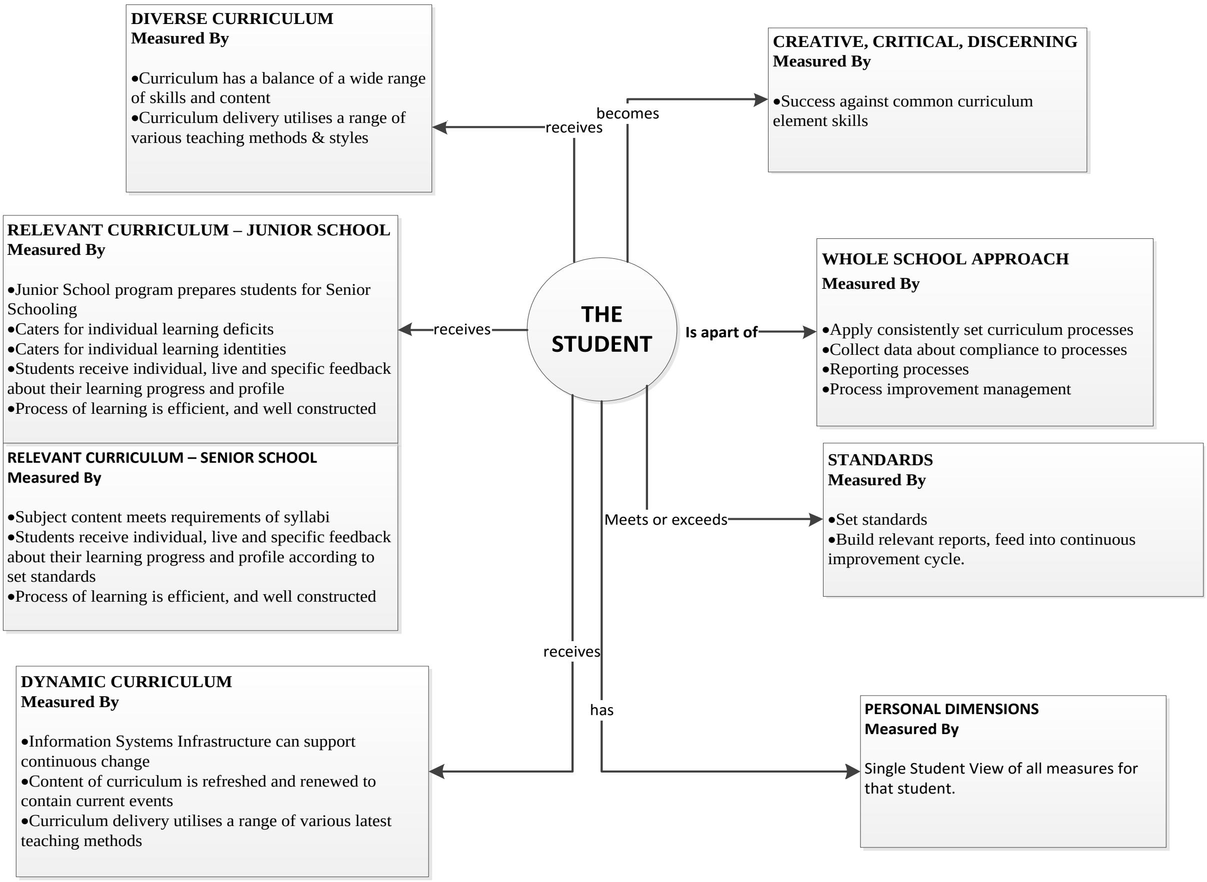


Figure 4.5: Decomposing the College's vision into dimensions and measures.

The customer process view

The customer process view highlights the services delivered by the College's service units. It structures the partial stages of the student's experience throughout the school cycle. Furthermore, it defines the partial services created to support this student's experience. Each partial service created for the student can be sourced internally or provided by an external service provider. This view serves as a foundation for defining the school's process design.

The student's first experience with the college is the 'enrolment process'. Once enrolled, the student is prepared access to a number of services within the College, and registers for either school-based or TAFE-based subjects, and the student's timetable is developed. For each subject at the College, the course structure, content, and delivery mechanisms are developed. In alignment with the student's academic development, pastoral care and student support services are an integral part of the student's personal development. All students complete subject-based assessments, as well as central examinations. Finally, student records and statutory reporting are prepared on behalf of the student. Figure 4.6 displays the *customer process view* for the College.

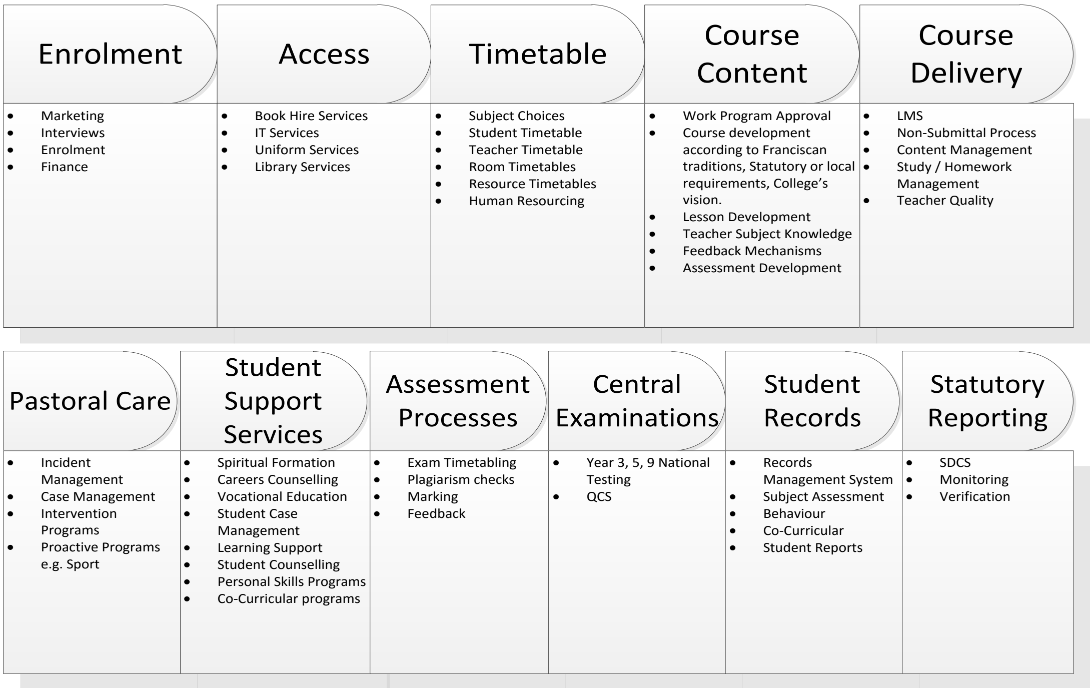


Figure 4.6: The customer process view highlights those services provided to a student throughout his term in the College

Gaps in the delivery of key student services

Table 4.0 shows the IS gaps in the delivery of student welfare services, including student support services and pastoral care services. From an IS perspective, significant gaps exist within the student support services. All activities for the pastoral care services are currently being catered for by the functionality contained within the BMS. Table 4.0 identifies the possible solutions/upgrades for each of these key services.

Table 4.0 – Solutions gap analysis

Student service component	Gaps	Proposed solution/upgrades
PASTORAL CARE		
Incident Management	X	Legacy IS to new artefact
Case Management	X	Legacy IS to new artefact
Intervention Programs	X	Legacy IS to new artefact
STUDENT SUPPORT SERVICES		
Careers Counselling		Student Information System SIS
Vocational Education		SIS
Student Case Management		SIS
Learning Support		SIS
Personal Skills Development		Not Applicable
Student Counselling		SharePoint Application

This section has briefly presented the strategy layer of the enterprise information architecture for the College, which decomposed the vision statement and provided measures for each of the entities in the vision statement. It also stated the key services the College provides its students throughout their enrolment. The activities required to support these services have also been stated. A gap analysis has been performed to identify where improvements can be made to these key services, and to suggest possible technology solutions. The information contained within the *strategy layer* provides the grounding for the *business layer*.

4.3.6 Architecture – business layer

This section focuses on the *business layer* of the pastoral care services component. Within this *business layer, the business services, functions*, and *processes* are positioned. A 'business service' is defined as the value the Business Unit delivers to the student. A 'business function' is defined as a grouping of similar business services (e.g. pastoral care). This chapter presents five different 'views' to aid conceptual understanding of the business layer: value network; service; process control; business process; and the balanced scorecard (TOGAF-v 9.1).

The *value network view* is initially used to show the relationship between the business functions and the business services. The *service view* describes the strategic alignment of a business function, business service, service units and business processes. The *process control view* provides a high level view of business processes and the applications that support them. The *business process view* details business processes by defining the sequence and combination of actions, performance indicators, and their triggers. Finally, the *balanced scorecard view* defines the performance indicators and/or success factors for specific business processes.

The value network view

The *value network view* describes the *service units* according to their role(s) in the *value network*. It provides a view of the service flow – that is, which *service units* provide what services. Analysis of this view facilitates the alignment of the *service units* to the *services* in the *value network*. It also highlights which *service units* are responsible for delivering the key services to students in the *value chain*.

Figure 4.7 shows that many services in the value network at the College are provided by multiple service units. In some cases, such as ‘personal skill development’, three separate service units coordinate to deliver the service. Although services provided to students will be provided by several service units, it is the goal of an organisation to ensure the accountability of these services to the students. Where possible, service units should be streamlined to ensure efficient delivery of key services. This section has provided the grounding for the next section of this chapter: the Service View.

	Leadership	Curriculum	Pastoral Care	Formation	Operations	Finance	I.T. Services	Support Services	Facilities
Pastoral Care Services									
Incident Management		1	2						
Case Management			1					2	
Intervention Programs	1		2					3	
Student Support Services									
Careers Counselling								1	
Vocational Education								1	
Student Case Management			1					2	
Learning Support								1	
Personal Skills Development		2	1						
Student Counselling								1	

1 Primary function; 2 Secondary function; 3 Ternary function

Figure 4.7: The Value Network View. The columns of the diagram show the various services units at the College. Each service may have more than one service unit that takes responsibility for its delivery.

The Service View

This section describes the *service view*, which describes the strategic alignment of the College's *business functions*, *business services*, *service units* and *business processes*. Only the pastoral care services are included within the scope of this section. The service view can be seen in Figure 4.8.

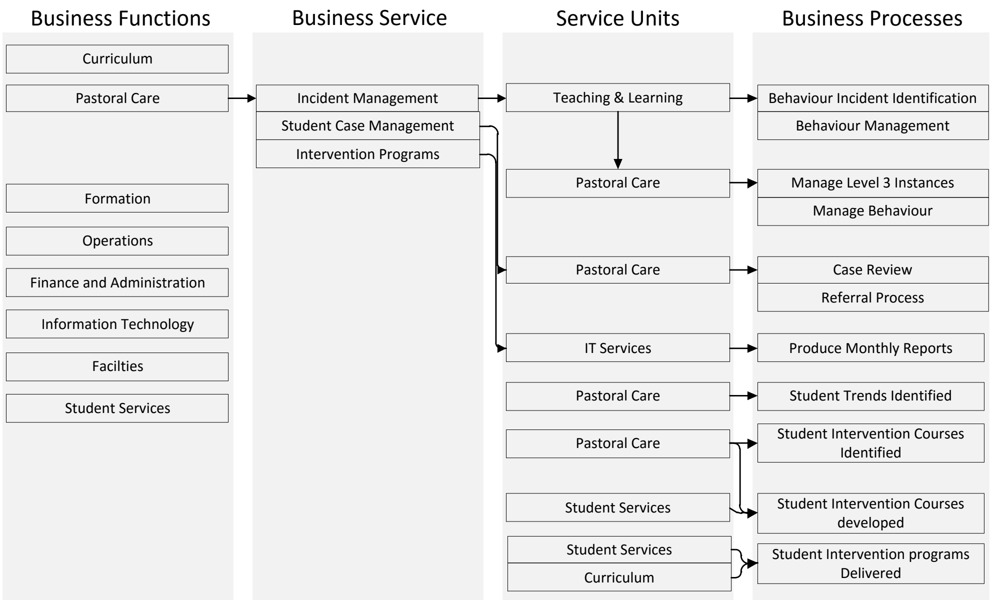


Figure 4.8: Service view, with pastoral care services highlighted

The *service view* shows the various business functions of the College: curriculum, pastoral care, formation, operations, finance & administration, information technology, facilities, and student services. Ideally, there should be close alignment between business functions, service units, and the business services they provide. Close alignment ensures accountability of KPIs of the key services provided to student. Figure 4.8 illustrates that the pastoral care business function delivers three key services to students. Key Services are delivered by a number of different service units – for example, the intervention programs are delivered by pastoral care services, curriculum services, and IT services. In the next section, the *service view* is consumed and the elementary activities associated with delivering these services are expanded. The *process control view* is used to illustrate a high level overview of the delivery of these services.

Process control flow – pastoral care

A *process control flow* defines the elementary activities, and their sequence and ownership, for particular *business processes*. Additionally, the *process control flow* determines applications and information objects consumed as part of the *business process*.

Within this section, three *process control flows* from pastoral care services are presented: management of a behaviour instance; student case management; and intervention programs management. Archimate is the modelling tool used for building the *process control flows*.

Process control flow: managing behaviour instances

Figure 4.9 shows the process control flow for the ‘incident management’ business process.

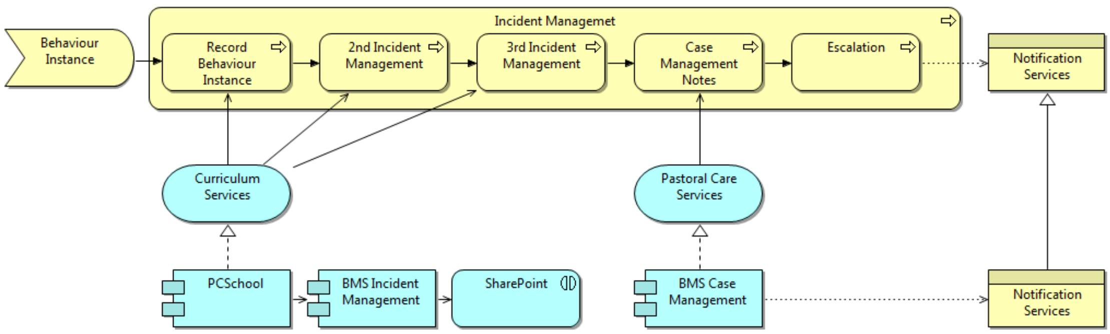


Figure 4.9: Incident management: application/process view

The business process is triggered when the students enact certain behaviours (either positive or negative). Teachers from curriculum services record the behaviour instances. Three data-level components provide the service for the teachers:, SIS; the legacy IS; and SharePoint. SharePoint is the interface for teachers, who follow standard processes for escalation to second and third incident management. At the third escalation, teachers make case notes in the legacy IS. An automated data summary of the behaviour instance is sent to the relevant house guardians from pastoral care services, who now manage this behaviour case. Depending on the case, further escalation may be warranted, and further notifications will be sent to student support services.

Process control flow: case management

Figure 4.10 shows the process control flow for the case management of student behaviour by pastoral care services. Students at the College all have an assigned behaviour level. The top band is 1, and the lowest is 7. There is 100 points per band. If the student is new to the BMS, then he is given a default 400 points.

If a teacher has made a behaviour instance entry into the BMS, the student's point balance is adjusted according to the valence and level of the behaviour instance. If the student's point balance crosses a band or behaviour level, then notification will be sent to the house guardian to review this student's case history. An aggregated summary of all entries made by either teachers or house guardians is generated by the BMS. The BMS case management review screen allows for the house guardians from pastoral care services to confirm, adjust, and make notes in this case review. Students may further be referred to Student Support Services.

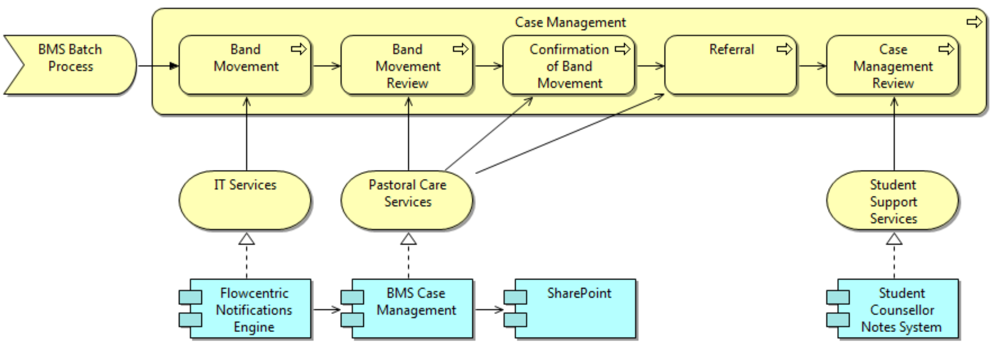


Figure 4.10: Case management: application/process view

Process control flow: intervention programs

Figure 4.11 shows the *process control flow* for developing and implementing intervention programs. On a monthly basis, the SQL analysis and reporting service sends eight behaviour-related reports to pastoral care services. These reports are managed by IT services, and are reviewed by both pastoral care and student support services. Intervention programs are developed by pastoral care services in conjunction with student support services. Curriculum services deliver these programs in the PALs subject. Every student participates in one PALs class per week.

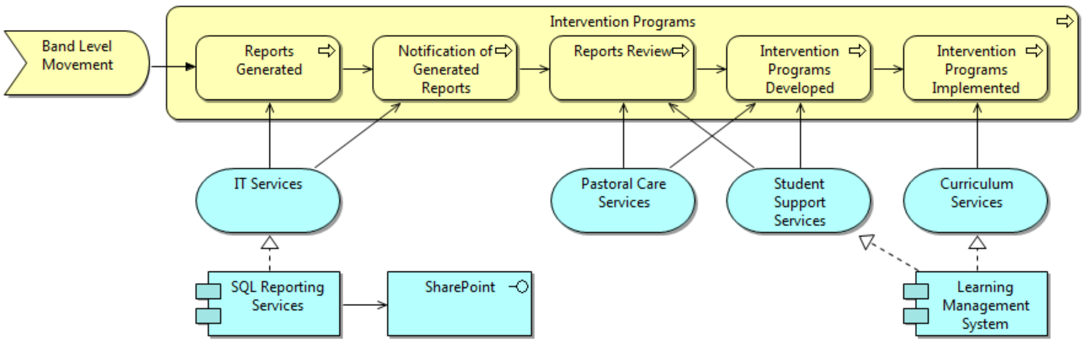


Figure 4.11: Intervention programs: application/process view

This section presents a high-level overview of the mechanisms associated with delivering services within the pastoral care function. The *process control flow* provides the foundation for detailing each of these business processes, which are modelled in the next section.

Business processes – pastoral care services

In this section, business process modelling notation (BPMN) is used to represent the three major business processes performed by pastoral care services: management of a behaviour instance; student case management; and intervention programs. A business process is a unit of internal behaviour or a collection of causal-related units of internal behaviour within an organisation. Business process modelling (BPM) involves building visual models to represent the business processes of an organisation. This visualisation facilitates current analysis and improvement of these processes.

Business process: managing behaviour instance

Figure 4.12 – shows the business process for managing a behaviour instance at the College. The figure shows six 'swimming pool lanes, which contains all the activities of the business process flow that relates to that particular stakeholder. For example, in Figure 4.12, the student has a single activity in this business process flow: the event instance.

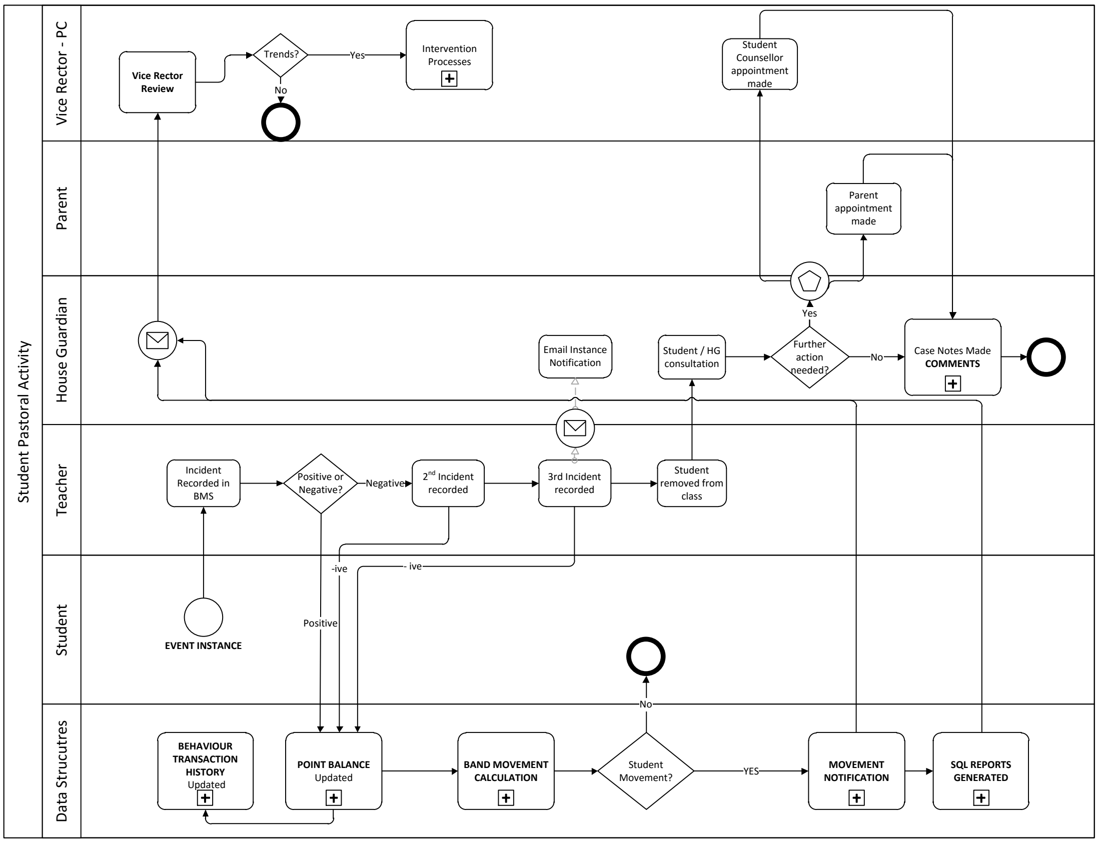


Figure 4.12: Management of behaviour instance

The teacher, however, is responsible for four activities in this business flow: to record the incident; second-incident management; third-incident management; and the student's removal from class. This *business process flow* identifies interactions with five different stakeholders in the organisation: the student, teacher, house guardian, parent, vice rector – pastoral care / student services. A sixth swimming pool lane identifies the interaction with the underlying data structures. Tasks are identified with rectangular objects, choices by diamonds, and the beginning and end of the business process flow are represented by circular objects.

In this example, the business process flow is triggered when a student enacts a particular standard of behaviour. The ‘incident management’ business process flow is terminated in three different scenarios.

Business process: student case management

Figure 4.13 shows the business process flow for the case management (pastoral care) of a student at the College. This process starts with either of two events: a level-3 behaviour incident, or a student moves across a band level during the preceding day. The business process for these two events is the same, regardless of the trigger. Similar to Figure 4.13, six swimming pool lanes demonstrate this business process flow.

Business process: intervention programs

The final business process flow of this section is the provision of behaviour intervention programs. This business process flow is represented in Figure 4.14, which shows it is triggered by the production of batch reports sent to the house guardians and Vice Rector of the Pastoral Care Service Unit. The process only ends if it is perceived that no behavioural intervention programs are required.

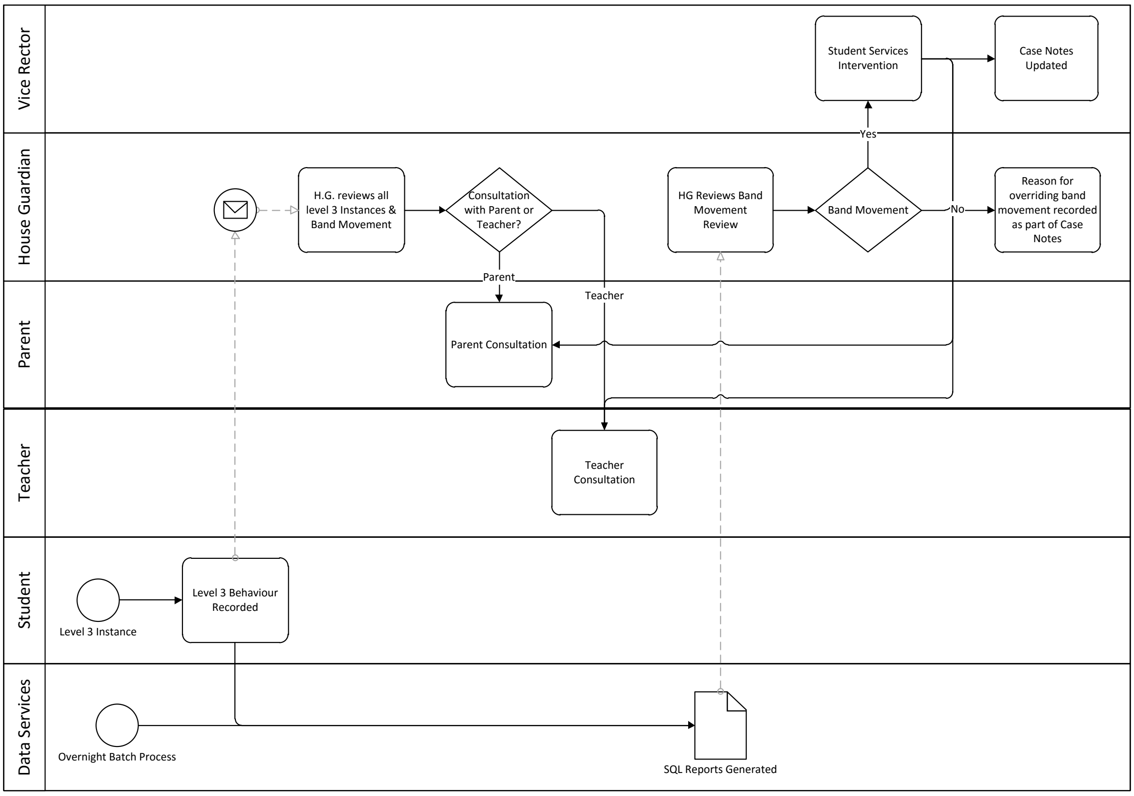


Figure 4.13: Student case management

This section has detailed the three major business processes that form part of the pastoral care function. Information presented in this section allows the business line owners to identify weaknesses in the business processes and make improvements to them. To be able to make those judgements, however, KPIs must be available for those business processes, so business decisions can be based on real data. The next section presents a view for identifying and developing KPIs for the business function.

Balanced scorecard view

The final view for this chapter is the *balanced scorecard view* (BSC), which is used to specify performance indicators and applications that might be used to derive performance indicators. These performance indicators should serve as a foundation for the design and performance management of business processes. A BSC is only provided for pastoral care services, and the BSC for student support services is not documented for this EIA.

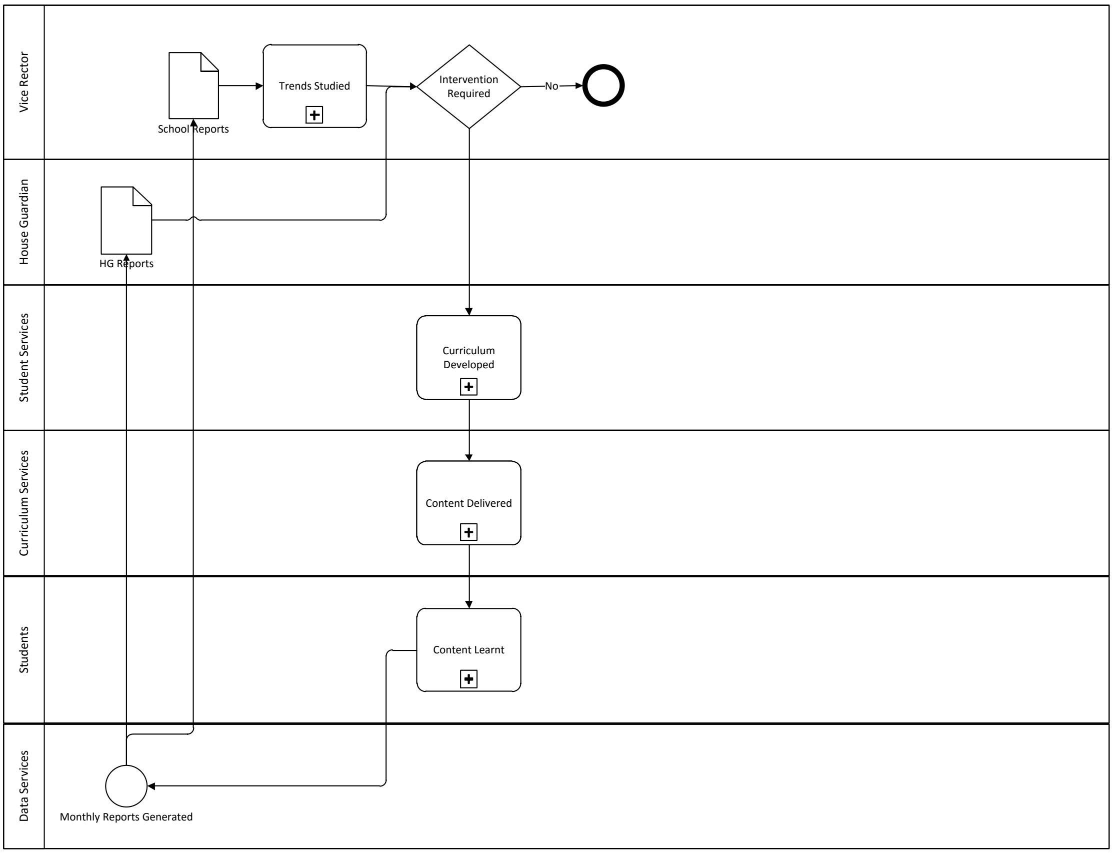


Figure 4.14: Intervention management

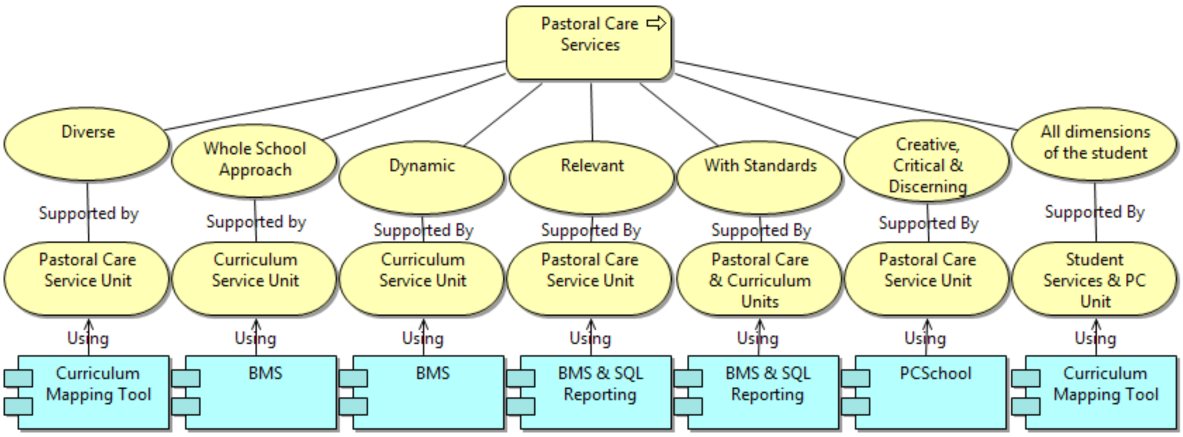


Figure 4.15: Balanced score card view: pastoral care services

Figure 4.15 shows the BSC for pastoral care services, the key entities from the vision statement, and which service unit is responsible for delivering it. Finally, this view also shows which applications will be used to collect that entity's data for the KPI. As shown in Figure 4.15, the KPIs for pastoral care services will be determined as follows:

1. The diversity of pastoral care services is measured using a curriculum-mapping tool. The diversity of the lessons for the development of personal skills can be measured using this software tool.
2. The whole-school approach to pastoral care services can be measured by the number of participating teachers, and by making positive/negative comments in the Behaviour Management System (BMS). SQL Reports are generated highlighting this information.
3. The dynamic nature of pastoral care services is measured using the BMS. Teacher case notes can be analysed to ensure they are dealing with students in an effective and meaningful way. This will be a qualitative measure.
4. The relevancy of pastoral care services can be measured pre and post intervention. Trend mapping of behaviour is delivered using SQL reports from the BMS.
5. The Pastoral Care Services Unit will set acceptable standards and tolerance levels associated with certain student behaviours. The BMS and SQL reports allow for analysis of various student bodies by various student behaviours.
6. A student's participation in, and results, for their personal and learning skills (PALS) class will determine the student's engagement in learning new personal skills. This will show whether the student is a creative, critical and discerning thinker in this aspect of their life.
7. The diverse nature of the curriculum of PALS, and the student's participation in this subject, determines the KPI for 'all dimensions of the student'.

This chapter positioned *business services*, *business functions*, and *business processes* within the context of the business layer. The business services of the College were defined, and which business service units delivered them (i.e. what services, and who delivers them). The scope of this chapter also included a granular view of those business processes contained within the pastoral care services. Finally, information was presented that discussed how KPIs could be produced for the pastoral care services. The next chapter focuses on the *application layer* of the EIA for the College.

4.3.7 Architecture – application layer

The purpose of the *application layer* is to define what kinds of software applications are relevant to the College – that is, what applications are needed to present and manage data for each key service that the College provides for students? These software applications are described in terms of how they support both the information objects in the data layer and business functions and processes in the corresponding business layer. The application layer is modelled using *landscape view*. Using the Archimate modelling tool, the *landscape view* documents all of the applications needed, and their relationships, to deliver the *service* to the stakeholder. Through the functional landscape view, data ownership, functional reuse is recognised.

The landscape view

In this section of the EIA Document, a *landscape view* is provided for the Pastoral Care Services Unit.

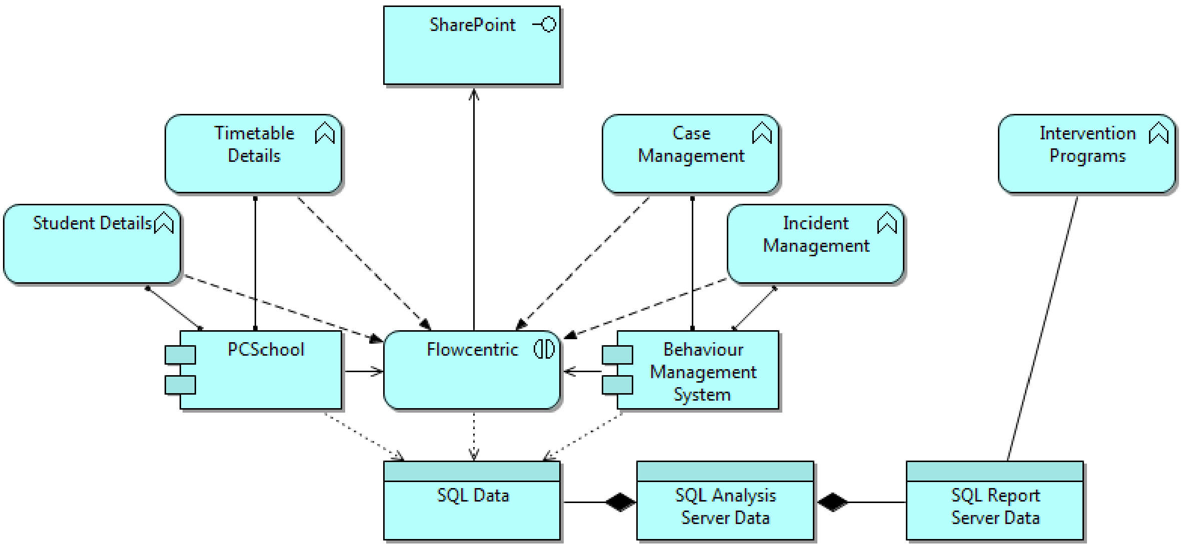


Figure 4.16: Application landscape view for pastoral care services. This view highlights all of the applications and their relationships in supporting this business service.

Figure 4.16 shows the complex relationships between the various applications. At an information object level, data for the pastoral care services is stored within a SQL server database. All data for all applications at the College are stored in SQL databases. This is significant, as many other service units at the college that use other applications will access common sources of SQL data. This allows an effective case management approach – for example the student counsellor case notes system accesses information from the legacy IS allowing for a fuller view of the student within the school.

At the centre of this service is an application called FlowCentric, which is a business process management tool. A key strength of this tool is its ability to take information from multiple applications and manipulate it within a business process flow. In this case, FlowCentric accesses and uses information from two further applications: PCSchool (SIS) and the legacy IS. PCSchool holds the authoritative source of information about a student and his classes. The legacy IS holds the business logic and rules regarding 'student behaviour', specifically incident management and case management. The legacy IS is a bespoke .NET application. Both applications use SQL as their database. FlowCentric provides the automation and routing of data to each of the stakeholders following the business process flow, while Microsoft SharePoint provides the presentation layer for all services and applications at the College. Leveraging SQL, SQL analysis server, and SQL reporting server provide the data, information and, thus, justification for behavioural intervention programs within the College.

This part contains a brief overview of those applications needed to support the three main pastoral care services provided by the Pastoral Care Unit. The *application landscape view* highlights the complexity of relationships between each of the applications. The next part presents the data layer for the pastoral care services, and various views are presented within a UML modelling context.

4.3.8 Architecture – data layer

This part presents the *data architecture* for the College enterprise. Its goal is to define the entities for each key service of the enterprise. Only pastoral care entities will be identified for the initial scope of this document. Three views will be provided in modelling the data architecture: use case view; use case description; and a static structure view.

Use case view

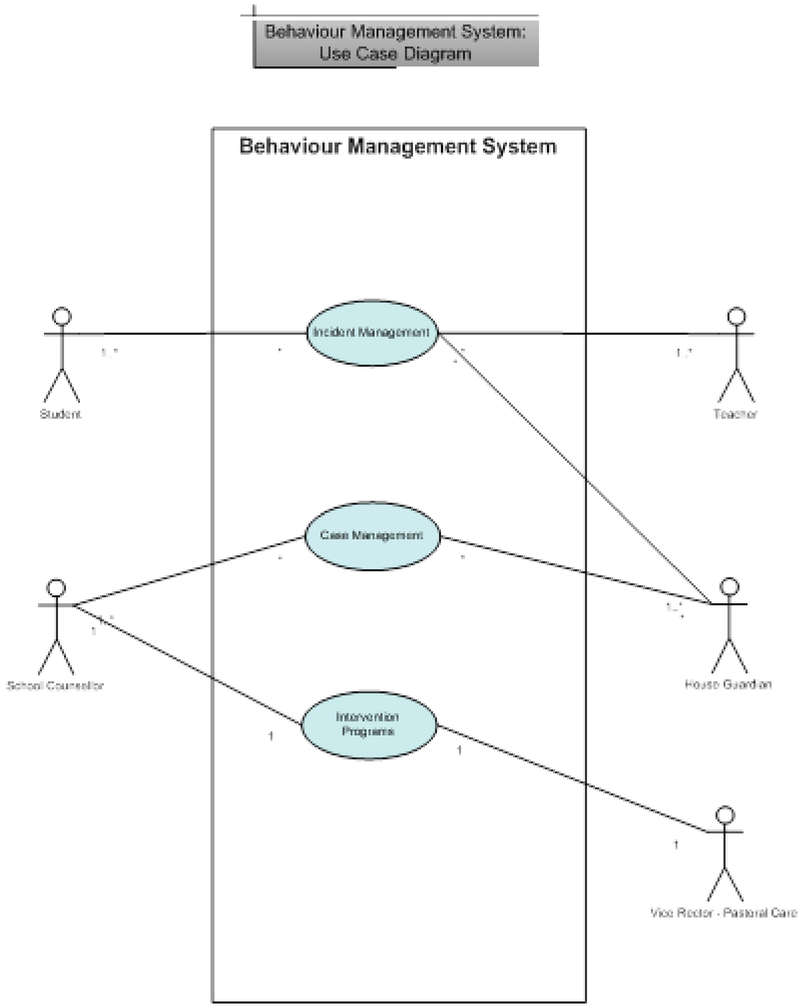


Figure 4.17: Use case view: pastoral care services.

At its most basic level, the *use case* diagram shows the three business services, and the stakeholder's interaction with them. This view illustrates a basic diagrammatic concept, which is used in the next section to detail the use case scenarios. The *use case view* shows that users from five role types across four different service groups participate in the delivery of three business functions for a single service.

Use case description

The following view gives detailed descriptions of the *use cases* for the behaviour management system (BMS), and include: managing behavioural incidents, and case management.

Use case description: Managing behavioural incidents.

EVENT INSTANCE

Precondition: The student has an instance of a positive or negative behaviour that meets a specific standard.

Main flow of events: The use case starts when a teacher registers a new behaviour instance into the behaviour management system using the ‘enter new behaviour’ instance screen. The student’s ID, name, valence, behaviour category, behaviour type, behaviour instance, behaviour level, date, school period, and behaviour description are recorded. When the behaviour instance is submitted, data the FCEventInstanceBLL is executed.

The FCEventInstanceBLL determines whether the behaviour is level 2, 3, or 4. If the event instance is level 4, then an email is sent to that student’s relevant house guardian. Once the FCEventInstanceBLL has completed, the following activities at the database level are executed.

Student points balance adjustment

If the student is new to the BMS, then he is given a default number of points. If a teacher has made a behaviour instance entry into the BMS, the student’s points balance is adjusted according to the valence and level of the behaviour instance. Students have 100 points per band, and there are seven bands or behaviour levels. If the student’s point balance crosses a band or behaviour level, then notification is sent to the house guardian to review the student’s case history. The lFCBehaviourLevelMovementBLL handles this logic.

Student points transaction history amended

Using the logic from the FCPointsTransactionBLL, a new instance of the behaviour is recorded in the student's transaction history. Information from the FCEventInstanceBLL is captured and stored in the FCPointsTransactionBLL against that student.

Teacher comments on behaviour updated in the case notes system

Using the logic from FCCommentBLL any comments that have been captured in the FCEventInstanceBLL for that student is extracted and entered into the CommentEntity

Use case description: student case management

Precondition – The student has crossed a band level, and a notification is sent to the house guardian to review the student's case history. Specifically, a batch file is sent to the house guardian at 12.00am that lists all students within the house whose cases need to be reviewed that day.

Main flow of events – The following information is kept regarding the students band movements: ID, student number, student name, new suggested band level, current points, current behaviour level, movement date, IsOverWritten, allocated points, and reason. This information is kept in the BandMovementEntity Class.

When the house guardian reviews the case, they are presented with a screen that contains fields from both the BandMovementEntityClass and the CommentEntityClass. The house guardian can review the comment history of teachers and, at this point, add comments to the comment history of that student. The house guardian also reviews and allocates points, and the new behaviour level based on that student's history.

Intervention agents, such as the student counsellor, make contact with the students and enter their case management notes through the counsellor notes management system. The student counsellor, and Vice Rector have access to all comments made for a student –

that is, a full case history containing comments by counsellor, house guardian, and teachers. The house guardians have access to both comments they have made, and those by teachers. Teachers have access to only comments that they have made in relation to a particular student.

Static structure view

The static structure view provides the entities associated with pastoral care services. Within this view, the entities for pastoral care services are identified, and each class has a relationship with another class and their entities. In the example shown in Figure 4.18, the *EventInstanceEntity* class has a relationship with the *CommentEntity* class, *PointsBalanceEntity* class, and the *BehaviourTransactionHistoryEntity* class. In simple terms, when a student enacts a certain behaviour type, the student's point's balance is adjusted, comments can be made about this behaviour, and the behavioural event is logged as part of the student's behavioural history. Figure 4.18 shows the classes and related entities for the BMS .NET application in the business logic layer. These are included to ensure that all classes and entities related to the pastoral care function are included as part of this document. No further reference to these classes will be made.

This section has presented the data layer for the pastoral care services. Various views were presented within a UML modelling context. The previous four parts of this section make up the 'as is' information architecture for the College. The next four sections address issues pertaining to the future state of the EIA, and the next part begins to model the future state by examining opportunities and solutions for this future architecture.

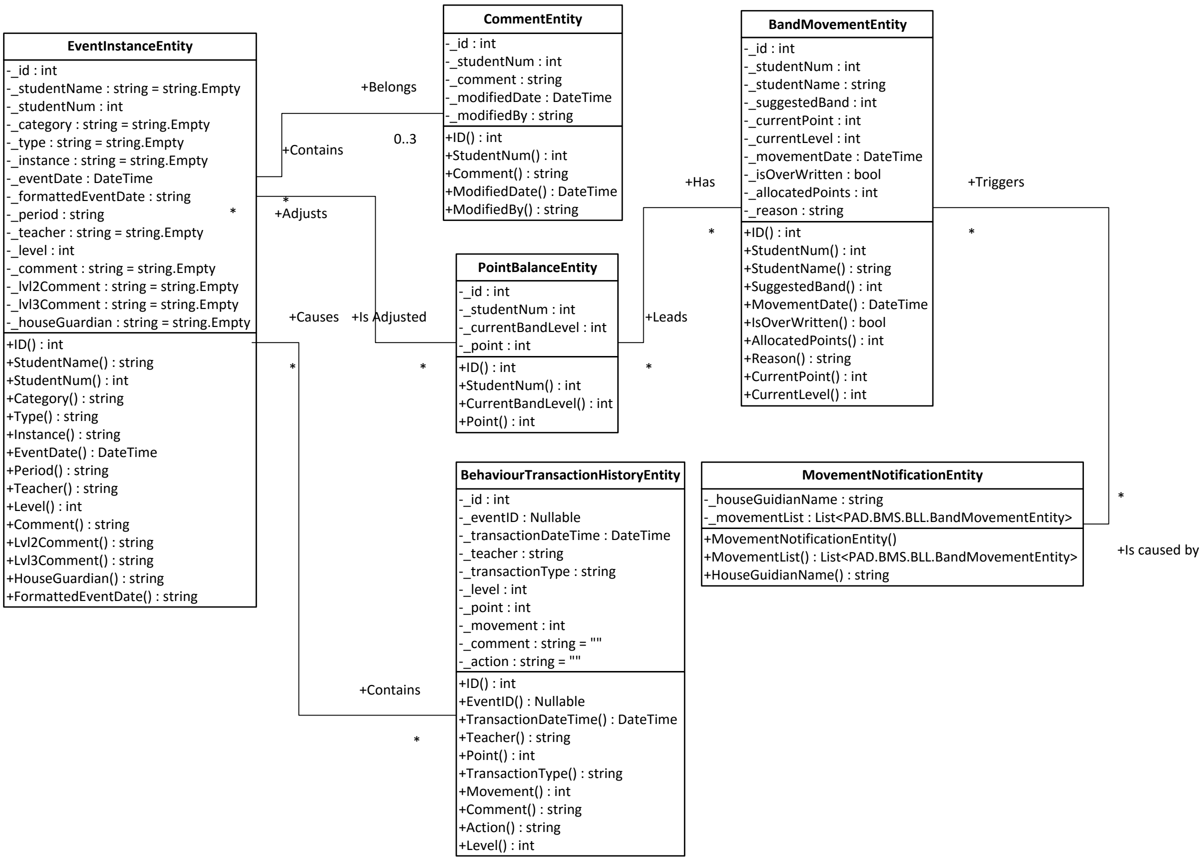


Figure 4.18: Static structure view

4.3.9 Opportunities and solutions

The purpose of parts 4.4.5, 4.4.6, 4.4.7, and 4.4.8 was to describe the first four steps of the ADM: to document the strategic, business, application and data architectures of the Pastoral Care Services Unit.

The next four parts of this section align with the final four steps of the architecture development method, and require development the documentation for the ‘to be’ state. This new EIA state is documented so that the most appropriate application architecture can be built using the existing IS infrastructure at the College.

Changes to the existing EIA at the College

The following section shows the EIA layers that will potentially be altered within the pastoral care services unit (Figure 4.19). These changes will be required, to accommodate a new pastoral care services application. Changes have been made at the business layer. At this layer, improved business flow and streamlined business processes have been developed and proposed for the new application. There have also been design changes made at the application layer to accommodate a new proposed application design. A web-services layer has been added between the data and application layer and, finally, at the data layer, changes have been proposed to the data structure accommodating the potential new web-services.

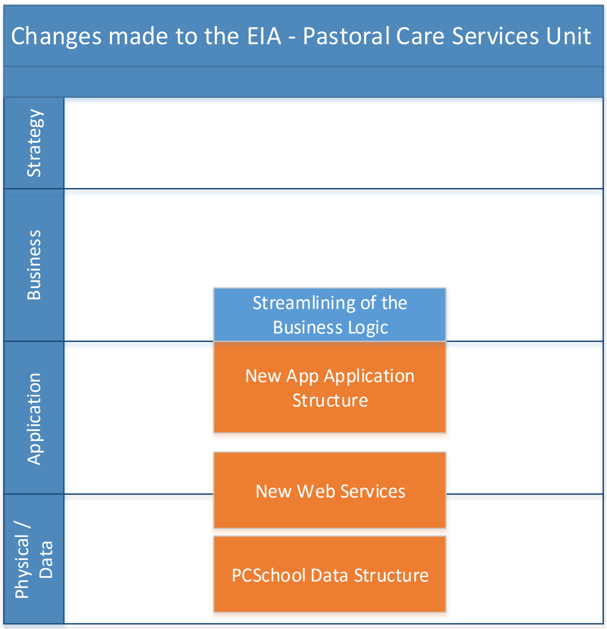


Figure 4.19: Changes made to each of the enterprise information architecture layers.

Changes at the business layer

Proposed changes at the business layer include changes made to the three business processes used in the Pastoral Care Services Unit. These include incident management, case management, and intervention programs. These proposed changes are shown in Figures 4.20, 4.21, and 4.22 respectively.

Incident management – proposed changes

In Figure 4.9, the business flow for the management of a behavioural incident is shown. This business flow shows a teacher making a record of a behaviour instance, and having the ability to escalate this to level 2 and level 3 type behaviours. With the new proposed business flow, the functionality for teachers to escalate student behaviours has been removed and simplified. This functionality has been recreated in the back end programming logic. Changes to the original business flow can be seen in Figure 4.20 below. To accommodate the new business flow changes have also been made at the application layer. The 'business process flow tool' (FlowCentric) has been decommissioned, with data being called directly from the PCSchool SIS, via web-services.

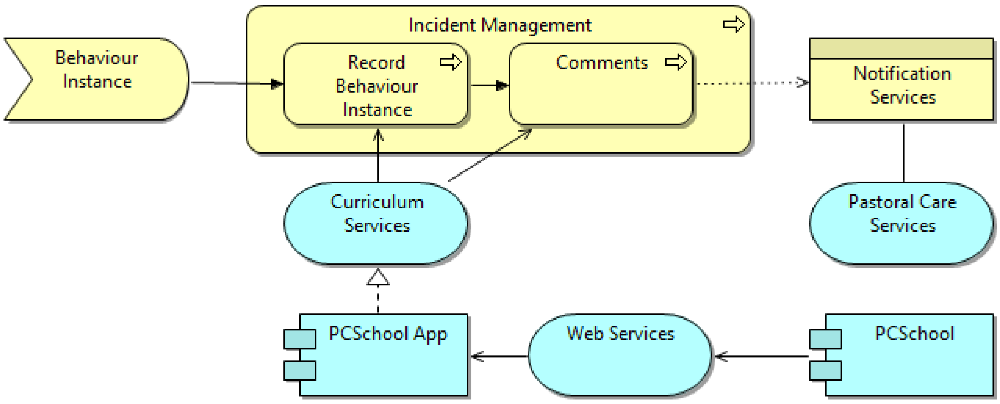


Figure 4.20: Business flow – behaviour instance

Case management – proposed changes

Figure 4.11 showed the business flow for case management. The new changes made for the case management workflow encompasses the omission of the behaviour level (confirmation of band movement) management step. This functionality has been recreated in the back-end programming logic. The new business flow can be seen in Figure 4.21. Further changes are made at the application level, with the FlowCentric engine decommissioned. Band movement information is retrieved directly from the SQL reporting and analysis server.

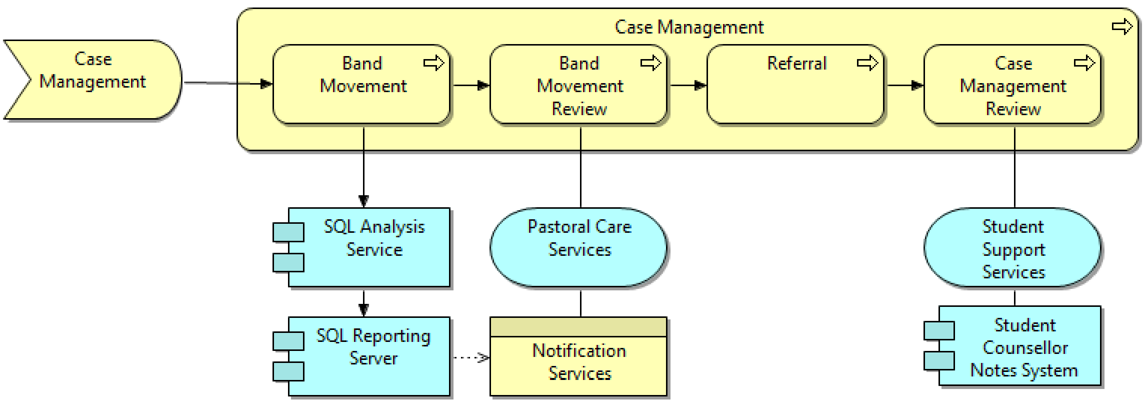


Figure 4.21: Business flow – case management

Intervention programs

Figure 4.22 shows the business flow for the management of intervention programs. It remains the same, however, data is now retrieved directly from the SQL server, and retrieved using web-services. A set of web-services has been developed especially for this study, and an overview can be seen in Table 4.1. A detailed description of these web-services and the testing regime for these web-services are detailed in Appendix 6.0.

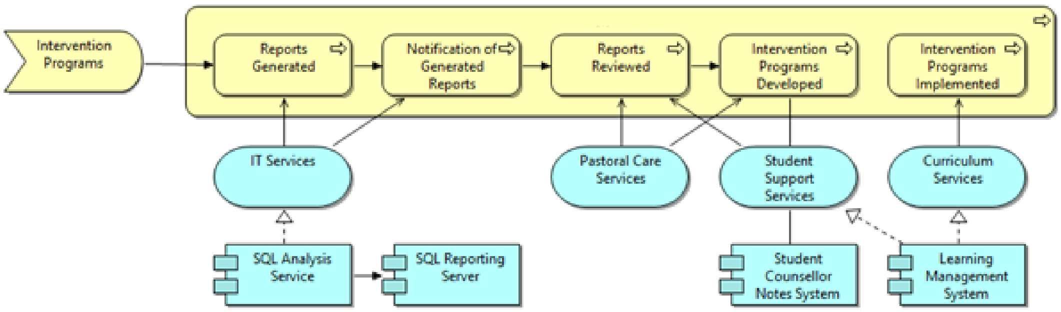


Figure 4.22: Business flow – intervention programs

Changes at the application layer

Figure 4.23 shows the summary of changes at the application layer. As the figure shows, the main interface for access to the two services, incident management and case management will be conducted through an iOS app. Data is pulled directly from a series of web-services, and these are listed in Table 4.1. Programmed functionality at the data and application levels facilitates the call of data to and from these web-services. To facilitate the management of intervention programs, the SQL analysis and reporting server will deliver automated reports to the appropriate staff.

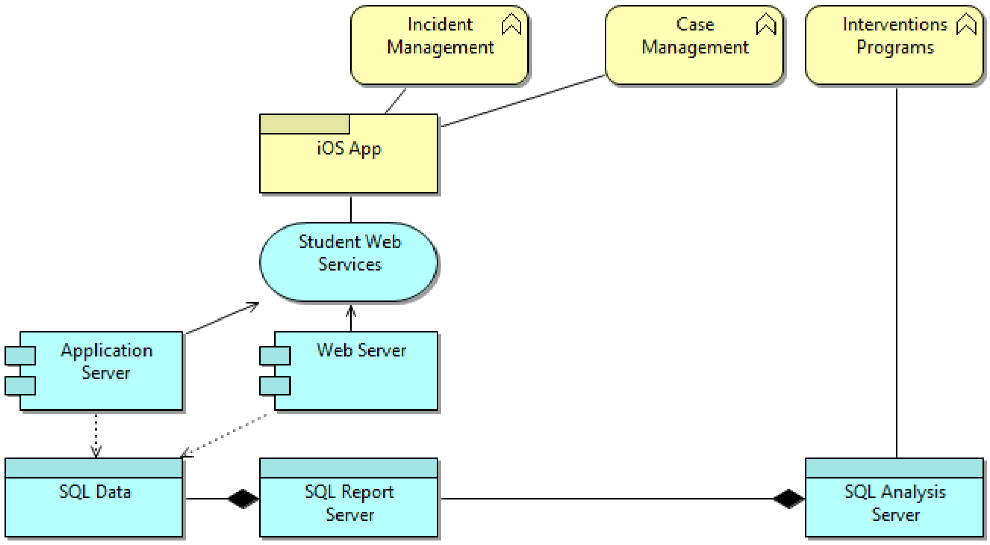


Figure 4.23: Data/application layer

Web- services

Table 4.1 – Potential web-services to be developed for the artefact

Order	Type Web-Service Name
1.	GET api/Schools/GetSchools
2.	GET api/Authentication/GetAuthenticatedUserDetails
3.	PUT api/Students/StudentUDIDUpdate/{Id}
4.	GET api/Students/GetStudents
5.	GET api/Students/ClosestStudentData
6.	GET api/Students/GetStudentImageByName/{Id}
7.	GET api/StudentClass/GetStudentsInCurrentPeriod
8.	GET api/Students/GetStudents
9.	GET api/Students/GetStudentDetails
10.	GET api/StudentAttendance/GetStudentAttendanceCodes
11.	GET api/StudentAbsence/GetStudentAbsences
12.	GET api/StudentDiscipline/GetMeritsDemerits
13.	POST api/StudentDiscipline/PostDiscipline
14.	GET api/StudentClass/GetStudentsClasses
15.	GET api/StudentSubject/GetStudentSubjectsByParams
16.	GET api/StudentEmail/GetStudentBasedEmail
17.	GET api/StudentDiscipline/GetDisciplineWorkFlows/{Id}
18.	GET api/StudentAttendance/GetStudentAttendance

The following web-services, shown in Table 4.1 have been identified for development, and their purpose is to ensure that the data consumed in the FlowCentric application can be called by the new iOS app. Further details about these web-services can be found in Appendix 6. To ensure they were updating and reading data from SQL databases correctly, changes were made to the underlying SQL data table structure. Details of these changes can be found in the next section.

Changes at the physical/data layer

The underlying SQL table structure has been modelled to accommodate the new data requirements, and data fields have been included in the SQL database to hold information such as UDID, merits and disciplines. This table structure can be seen in Figure 4.24, and a full detailed data dictionary can be found in Appendix 7.0.

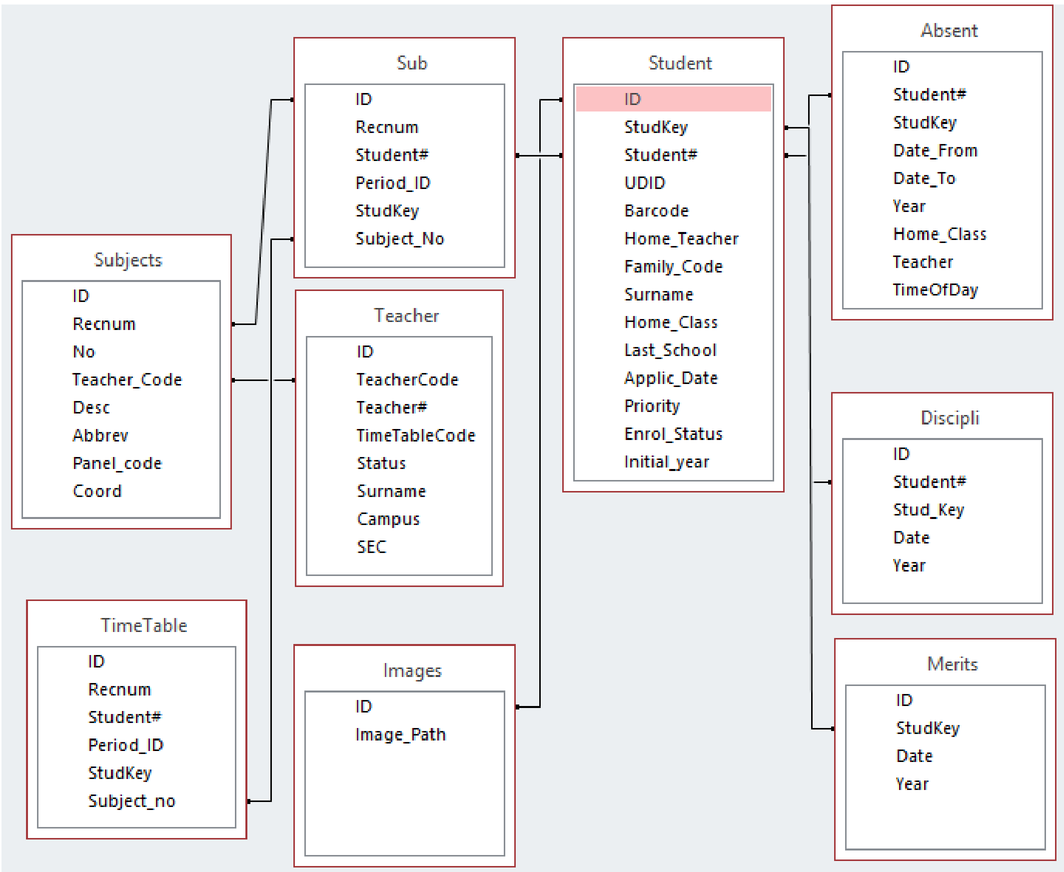


Figure 4.24: Underlying SQL normalised table structure

This section has identified those changes required at the business, application, and data layers. The design of the iOS app itself is forwarded in the design cycle chapter. The next part of this chapter briefly discusses the migration planning stage, and the implementation governance strategy for this change.

4.3.10 Migration planning

The purpose of this section, according to the TOGAF- v 9.1 methodology, is to summarise and order the development steps required to achieve the new architecture state. It highlights the work needed during this development period, and seeks to develop a plan to minimise disruptions to the business. It creates a timeline of work, with clearly stated dependencies. Table 4.2, shows the simple schedule of works required for the new IS.

Table 4.2 – Summary of the schedule of works for the new artefact

Order	Dependencies	Development Tasks
1	-	New state EIA modelling (pastoral care services)
2	-	Changes to the underlying data structures (see Appendix 7)
3	2	Development of the web-services
4	3	Web-services testing
5	1	Development of data dictionary to fit with design document
6	1-5	BMS app development
7	6	White and black box testing of BMS app
8	6	Development of SQL analysis cubes and reports
9	8	Decommissioning of FlowCentric engine
10	-	Change management

The schedule of works listed in Table 4.2, can be undertaken without any disruptions to the operations of the enterprise, as the work is conducted in parallel to the current operations. Given, that not all users in the enterprise will be trialling the new IS, the decommissioning of the FlowCentric engine will not occur until after the review of the trial period.

This part has briefly described the tasks, their order, and dependencies in transitioning to the new EIA state for pastoral care service. The next part of this section contains the plan for the governance for the future implementation.

4.3.11 Implementation governance

The first phase of this document was presented to the College as part of the 2010 curriculum review. The first part of developing a governance strategy for the College was to introduce the concept of service oriented architecture (SOA). Currently the College’s organisational units are not closely tied to the key *services* it provides. If this alignment could be facilitated, then the foundations for an effective EIA would exist. Managers for these services will be able to closely work with the enterprise information architect in documenting the various architectures and *services* they are responsible for. These documents would be presented at both a leadership and board level for scrutiny and ongoing governance. As the College matures in this respect, an EIA governance board may be established.

At this time, projects are managed by IT services, which is responsible for formulating recommendations for each implementation project at the College. IT services for each project, including this pilot project, will construct an ‘architecture contract’ that governs the overall implementation and deployment processes. Throughout this pilot project, the researcher was responsible for the governance of the various project lifecycles, and reports to IT services for any changes to the ‘architecture contract’.

4.3.12 Architecture change management

In line with comments made in section 4.5.8, it is proposed that a formal a*rchitecture change management* program be adopted. The type of change management strategy depends on the nature of the IT project, and the schedule for each project is structured and managed by IT services. Typically, change management programs will have a communication strategy, learning strategy, access strategy, and support strategies. For this project, these strategies are developed, but not included as part of the documentation of this thesis. This part concludes the documentation of the EIA for the College, having highlighted and stated, in part, design recommendations for the new BMS app. These recommendations are listed in the next section.

Itemised scope for change

The previous section described both the ‘as is’ and ‘to be’ state of the EIA, and thereby in part sets a scope of works for the new BMS design. Not included in this scope are the design considerations and requirements for the future IS itself. This is investigated in sections 4.5 to 4.8 of this chapter. An itemised list of requirements that make up the scope of works is listed in Table 4.3.

Table 4.3 – Itemised requirements for the new artefact as determined by documenting an EIA

Order	Dependencies	BMS App requirements
1	-	Ensure that the new state aligns with other EIA service components
2		Incorporating the strategic vision of PC services unit
3		Functionality and business process for incident management
4		Functionality and business process for case management
5		Functionality and business process intervention programs management
6	-	Changes to the underlying data structures
7	2	Development of the web-services
8	1	Development of data dictionary to fit with design document
9	1-5	BMS app development
10	6	Development of SQL analysis cubes and reports
11	8	Decommissioning of FlowCentric engine

The next section examines and documents the design issues with the legacy IS itself, and begins by collecting anecdotal evidence from teachers on their experiences with the software. Once these issues were documented, a further investigation was conducted to determine how these perceived design issues affect data quality.

4.4 PROBLEM AWARENESS – ANECDOTAL EVIDENCE

After completing project testing, the legacy IS (referred to as the BMS) went ‘live’ in August 2010. The application domain took a staged approach in the implementation of the BMS. Initially, teachers could only enter data pertaining to students’ co-curricular activities. This activity was not seen as business critical and, therefore, a logical introduction of the BMS for end-users. After one semester of the IS running in production, no bugs or problems were reported with the use of the software. In February 2011, teachers were encouraged to use the full functionality of the system – that is, enter negative comments about students within the classroom. At this time, teachers began to raise concerns about the practicality of data entry within the classroom. This initial anecdotal evidence suggested three classes of problems associated with use: computer access, web page navigation time, and data entry time.

4.4.1 Key problems identified with the legacy IS

The first issue identified with using the BMS was that teachers needed to move to a central teacher computer to enter student behaviour data. This computer is often located away from where student behaviours are occurring – "proximity is important in managing negative behaviours".

A second issue was related to the time taken to navigate to the pertinent fields within the IS. In a traditional IS, a teacher is required to open up the application, navigate to the module, find the student, and then make an entry against that student. This was seen as a time-consuming process in a classroom environment.

The third issue was the time it took to enter a record, related to student behaviour, in the legacy IS. Many teachers complained that, while teaching, entering any information into an IS detracts from the teaching and learning process.

4.5 IS USE – SQL DATA

Given the initial feedback on the BMS, as outlined above, a further investigation on teachers' use of this software was undertaken that involved data mining the current SQL data server. Information was collected that described the total use of the BMS over an eighteen-month period, including how and when teachers were using the BMS, and the quality of data being entered into it. This is described in the next section.

4.5.1 BMS use by teachers

Figure 4.25 highlights the growth in BMS use since its implementation in January 2011.

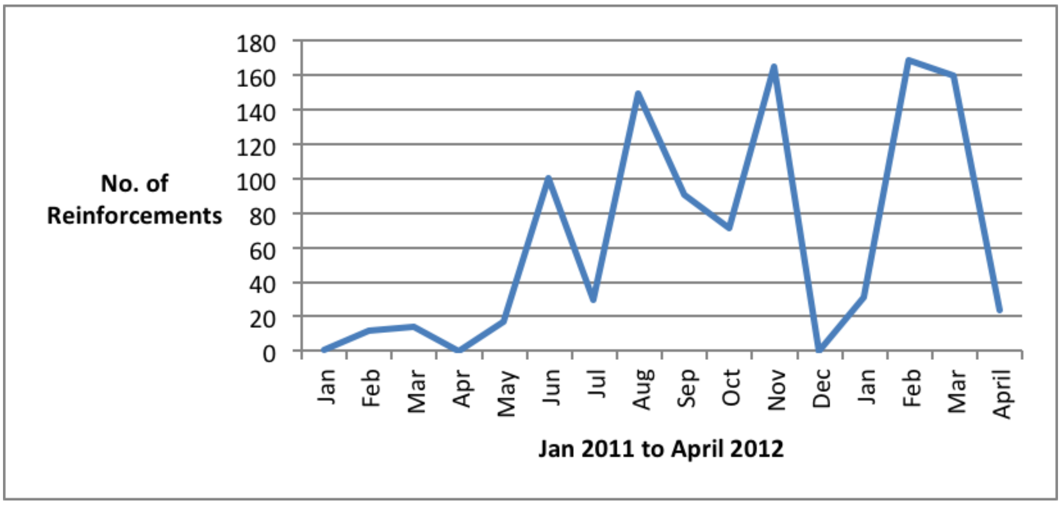


Figure 4.25: Total number of reinforcements made by teachers, January 2011 to April 2012.

This figure shows that there has been continual growth in the use of the BMS since it was brought into production. The drop in use of the BMS during the July, September, December–January, and April periods corresponds to the Australian school vacation periods. Figure 4.26 illustrates the number of student reinforcements vs reinforcement valence made in the BMS within the classroom.

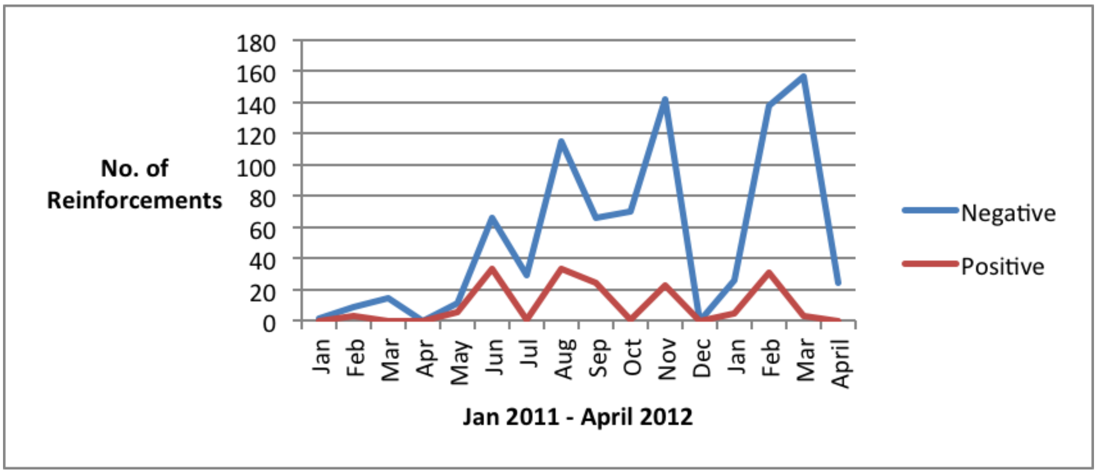


Figure 4.26: Classroom use of the BMS. Negative and positive comments represented separately.

Figures 4.25 and 4.26 shows consistent growth in BMS use for both classroom and co-curricular reinforcements. Within the classroom, however, there has been a consistently low use of the BMS when allocating positive reinforcements for students within the classroom. Figures 4.27 and 4.28 illustrate the low use within the classroom environment, and Figure

4.28 clearly shows that the major use of the BMS within the classroom was to allocate negative behaviours.

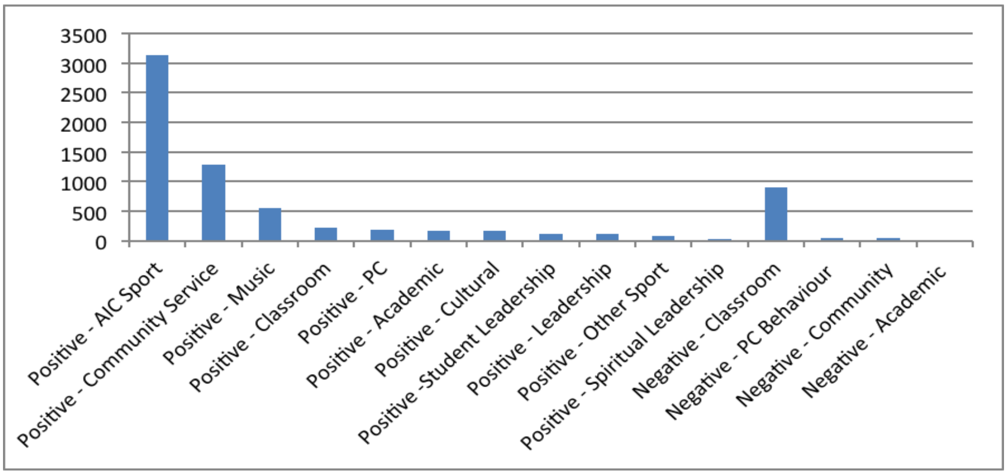


Figure 4.27: Categories of reinforcements made by teachers since the introduction of the BMS.

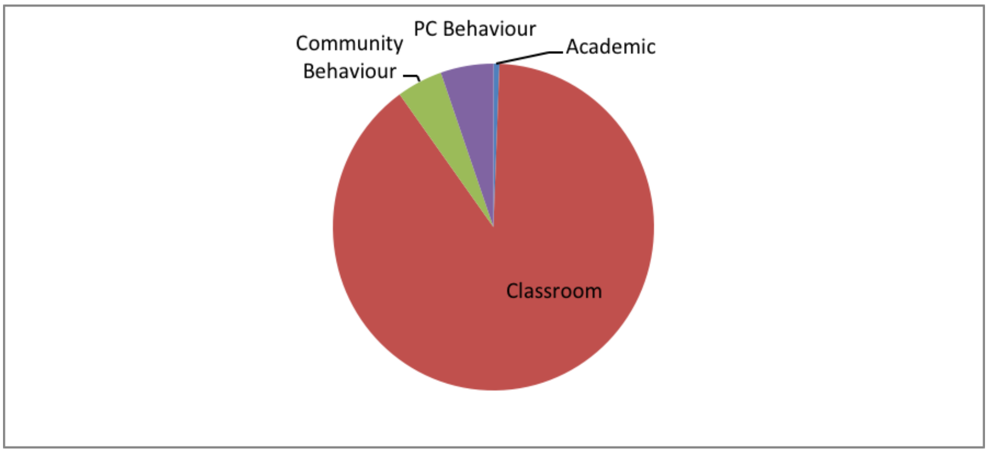


Figure 4.28: Negative reinforcement categories.

The overall categories of student reinforcements can be seen in Figure 4.29, and it shows 84.23% of all reinforcements made by teachers are related to co-curricular activity. The two largest categories are AIC sport and community service reinforcements, which together make up 62.8% of the total.

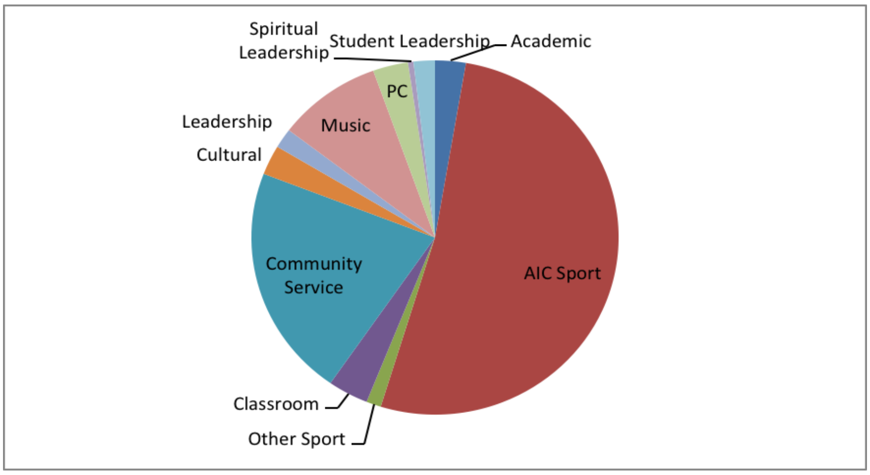


Figure 4.29: Categories and allocations of positive reinforcement made since the introduction of the BMS.

Classroom reinforcements

Classroom reinforcements make up 15.77% of total reinforcements. Figure 4.28 shows the reinforcement categories for all negative comments entered into the BMS, and most of these are made within the classroom environment. Figure 4.29 shows the categories of all positive reinforcements made within the College, and only 4% of these are made via the BMS. The ratio of positive to negative reinforcements within the classroom is approximately 4:12. This represents a mismatch between behaviour management practice and behaviour management theory.

4.5.2 Discussion on BMS use by teachers

The quantitative data in this section characterises the teachers' use of the BMS within the College. It shows that teachers have generally increased their use of the BMS, but mainly used it to record co-curricular participation. The SQL data showed an approximate 4:12 ratio of positive to negative reinforcements made within the classroom. Triangulations of these two issues suggest that teachers are reluctant to use the BMS within the classroom. The SQL data also suggests that teachers are not using the software in ways that represents best practice for managing student behaviour.

The evidence, shown by the SQL data, supports the initial anecdotal evidence from teachers about their perceived useability issues with the legacy IS. The IS design issues reported by them, therefore, will be taken into consideration in the design and development of the new artefact. These design considerations are shown in Table 4.4, and the recommendations requiring novel solutions are marked.

Table 4.4 – Design recommendations from anecdotal teacher feedback

#	Recommendations
1	*** Mobile technology – allow for data entry proximal to students.
1	*** Reduction in the time requirements for data entry.
2	*** Change the way that data transactions are completed, so to reduce attention Debt on teachers within the classroom.

*** Considered to be design problems requiring novel solutions.

The previous five sections discussed design considerations from two perspectives: the integration of the application domain with the EIA; and that of the user. A third perspective, considered in the next section, is that of using design to facilitate best practice – that is, what is best practice when managing the behaviour of students, and how can this be incorporated into the design of the new IS?

4.6 BEHAVIOUR MODIFICATION THEORY

4.61 Introduction

When designing and building an IS, its strategic and business outcomes must be considered. If it is built for personal use, then the new IS must effectively achieve the goals established for that personal use. Similarly, if it is built for business purposes, it must achieve those business outcomes. The IS developed for this study is a student behaviour management IS. The overarching goal of this IS, therefore, must be to improve the behaviour of students. Given this goal, best practice principles associated with behaviour modification should be incorporated as part of the behaviour management IS design.

Behaviour modification can be studied from a number of perspectives: biological, cognitive, social or behavioural (Gleitman, Fridlund & Reisberg, 1986). Incorporating principles from the biological and cognitive perspectives are impractical as part of any IS or app design. There are diverse and numerous theories associated with behaviour modification. From a practical perspective, not all theories can be incorporated as part of the design. The design scope for the new IS, therefore, is limited to the five tenets of operant conditioning theory (Ferster & Skinner, 1957): specificity of feedback; balance/schedule of feedback; immediacy of feedback; consistency of feedback; and the cost-benefits of performing behaviours. These tenets of operant conditioning theory are briefly discussed in the next five parts of this section.

4.6.2 Specificity of feedback

Feedback works best when it relates to a specific goal. When teachers establish clear learning goals within the classroom, feedback relating to those learning goals is more likely to become tangible, objective, and consistent. For example, telling a student that they are doing well because they completed the ‘maths extension exercises 5–12’ is more effective than simply saying “you’re doing a good job”. It is effective on two levels: the achievement becomes tangible for the student; and it ensures consistency of feedback for all students within the classroom.

The first business goal of the new IS, therefore, should be to provide the facility for teachers to quickly provide specific feedback to the students on specific behaviours.

4.6.3 Balance of feedback

According to operant conditioning theory (Ferster & Skinner, 1957), how and when behaviour is reinforced has a large impact on the strength and rate of a particular behaviour. Reinforcement schedules, therefore, are a key component of the learning process, and these can vary in their frequency. Behaviour may be reinforced every time, none of the time, or within a range of varying frequencies. The goal is to either strengthen or diminish behaviour through the use of positive or negative reinforcement.

In school settings, behaviours are unlikely to be reinforced each and every time they occur. As such, a partial reinforcement schedule is preferred in this environment over the continuous reinforcement schedule model. In partial reinforcement, behaviours are reinforced only part of the time. Although this method of reinforcement means learned behaviours are acquired more slowly, behaviours tend to be more resistant to extinction.

There are four schedules of partial reinforcement: fixed-ratio; variable-ratio; fixed-interval; and variable-interval. This study subscribes to the fixed-ratio schedule for school environments. For a fixed-ratio schedule to be possible at an operational level, teachers must receive feedback on the number and types of feedback they are providing students.

The second business goal of the new IS, therefore, is to provide teachers with feedback on the number and types of reinforcements they are providing to students. This is needed so reinforcement schedules can be adjusted to meet the goals of that schedule.

4.6.4 Immediacy of the feedback

The third factor in determining the effectiveness of feedback is the period of time between the behaviour and the feedback to that behaviour. The more immediate the feedback, the more effective it is.

The third goal of the new IS, therefore, is to facilitate the provision of feedback to the students immediately after the positive or negative behaviour. This means that teachers, within the classroom, need the ability to enter data entry on the new IS without detracting from the teaching and learning process.

4.6.5 Consistency of feedback

The fourth factor affecting feedback effectiveness, discussed in this chapter, is its consistency. If the consequence or feedback to a behaviour does not contingently (reliably, or consistently) follow a specific behaviour, its effectiveness is reduced. If, however, a consequence follows the response consistently after successive instances, the ability to modify a response will increase.

Consistency of feedback is a problem within schools. Students have different teachers with different expectations regarding behaviour. To address this problem in some way, the new IS should address the issue of feedback consistency from and between teachers. The fourth goal of the new IS, therefore, is to provide a way to moderate the inconsistent feedback from a single teacher as well as between all teachers within a school.

4.6.6 Cost benefit of performing the behaviour

The final variable that influences the effectiveness of feedback is the perceived cost benefit of performing a particular behaviour. Operant conditioning theory states that if the size or amount of the consequence is large enough to be worth the effort, the consequence will be more effective upon the behaviour. In reality, the new IS has no control over the size of the reward; however, the knowledge of the reward can be facilitated as part of the functionality. The fifth goal of the new IS, therefore, is to provide functionality that facilitates communication to the teacher and student about the reward/consequence of the student's behaviour. These elements are summarised in Table 4.5. In this table a 'design response' for each of the 'design considerations' is also proposed.

Table 4.5 – Design considerations incorporating behaviour modification theory

Behaviour Element	Design Consideration	Design Response
Specificity of Feedback	Provide the facility for teachers to quickly provide specific feedback to the students on specific behaviours.	A specific behaviour can be searched prior to lesson and applied easily within the classroom setting. Behaviours can be proactively targeted.
Schedule of Feedback	Provide teachers with feedback on the number and types of reinforcements they are providing to the students.	For each student, teachers can easily see a graph (pictorial view) of their interactions with that student.
Immediacy of Feedback	The BMS IS should be designed so that feedback can be provided to the student without disrupting the teaching and learning process.	The new IS architecture allows for quick mobile access. Drag and drop function is used. Minimalist functionality approach to the design.
Consistency of Feedback	A mechanism for maintaining consistency of feedback from a single teacher, and between teachers should be facilitated.	Teachers can easily see a graph (pictorial view) of all teachers' interactions with the particular student they are viewing. This allows a teacher to 'moderate' their feedback for that student.
Cost-benefit of behaviour	How can the cost benefit for teachers be increased?	Teachers are aware that the electronic recording of such behaviours leads to a whole of community approach.
	How can the cost benefit for students be increased?	The consequence/reward for behaviours are communicated to the student, and their learning community.

Sections 4.7.1 to 4.7.5 discuss the major elements of operant conditioning theory. For each major element, a design and functionality consideration has been proposed, and, ideally, any behaviour management IS would contain this functionality

This section discussed the major elements of operant conditioning and behaviour reinforcement. For each tenet of operant conditioning theory, a function and design consideration has been proposed for the ideal behaviour management IS. This section also proposed briefly how this functionality can be included as part of any new IS design, and presented all the design considerations for the next chapter.

4.7 CONCLUSION

The first purpose of this chapter was to prove the relevance of this design science research; the second was to highlight the design factors that must be considered for a new IS. To prove the relevance of this research, this chapter explicitly investigated whether IT was a limiting factor to the production of PMs. By proving that IT limited the production of PMs, the relevance of this thesis was, in part, established. Additionally, it established that to address these identified limitations, a novel IS solution would need to be developed.

A full EIA document was created to determine how any new IT components would need to be aligned to the existing information technology architecture of the enterprise. Design considerations from the EIA perspective were presented in Table 4.4. Perceived user issues with the current legacy IS were gathered from anecdotal evidence and validated by the SQL data measuring the frequency and types of behaviours reported with the legacy IS. The design considerations presented in Table 4.6 contain three items considered to be wicked problems (Hevner, March, Park & Ram, 2004).

TABLE 4.6 – Design chapter requirements

Order	Information systems requirements	Wicked Problem
2	Incorporating the strategic vision of PC services unit	
3	Functionality and business processes for incident management	
4	Functionality and business processes for case management	
5	Functionality and business processes for intervention programs management	
6	Changes to the underlying data structures	
7	Development of the web-services	
8	Development of data dictionary to fit with design document	
9	Artefact development	
10	Development of SQL analysis cubes and reports	
11	Decommissioning of FlowCentric engine	
12	Mobile Technology – allow for data entry proximal to students.	X
13	Reduction in time requirement for data entry.	X
14	Change the way that data transactions are completed.	X
15	Facilitate best practice – specificity of feedback	
16	Facilitate best practice – schedule of feedback	
17	Facilitate best practice – immediacy of feedback	
18	Facilitate best practice – consistency of feedback	
19	Facilitate best practice – cost-benefit of behaviour	

Finally, as part of investigating the ideal design for the new artefact, functionality that facilitates best practice behaviour management was forwarded, and the tenets of behaviour management were stated. How these might be incorporated into any new IS was also stated (see Table 4.5). Table 4.6, finalises this chapter and lists the full set of design considerations for the next chapter of this thesis. The key IS design considerations for the design phase form the basis for the next chapter.

CHAPTER 5: DESIGN CYCLE

5.1 INTRODUCTION

This chapter outlines those steps completed in the design, development and instantiation of the IS artefact. For the purpose of this research, these steps are referred to as the design cycle. As previously stated, the design cycle method outlined in this chapter closely aligns with the one suggested by Alturki, Gable and Bandara (2011).

Although, Hevner's (2004) DSR methodology is most commonly cited in DSR research, there is a common concern with the lack of specificity associated with these guidelines. Veneable (2010), for example, when investigating academic views on Hevner et al.'s (2004) DSR guidelines concluded that the existing guidelines were unclear with too high a level of abstraction. Winter's (2008) views align with those of Veneable (2010), stating "there is little consensus on accepted models for DSR".

Alturki, Gable and Bandara (2010) recently introduced a comprehensive DSR roadmap through systematic analyses of all DSR related literature. As a result, this DSR roadmap is distinctly comprehensive in comparison to other DSR methodologies. This method is not meant to be prescriptive; however, it does provide comprehensive guidelines for DSR development. The Alturki, Gable and Bandara (2010) guidelines are characterised by three cycles: relevance, design, and rigor. The design cycle within this method consists of eleven steps and is adopted for the purposes of this thesis.

This chapter contains thirteen sections. Other than this introduction and the chapter conclusion, the remaining eleven sections align with the eleven steps of the design cycle methodology: i) solution/research goals; ii) evaluating the solution's viability; iii) defining the research scope; iv) resolving if it is within the design science paradigm; v) establishing the research type – IS design science, or IS science research; vi) resolve themes – construction, evaluation, or both; vii) define requirements; viii) define alternative solutions; ix) explorer knowledge – base support of alternatives; x) develop construction; xi) design testing and evaluation.

The next section, aligning with the DSR methodology adopted for this study, states the goals of the research, as well as the design and functionality requirements of the artefact – and, thus, the scope of this project is inferred.

5.2 DEFINING THE RESEARCH SCOPE

5.2.1 Introduction

The following section contains three broad parts: i) it describes the research scope, which encompasses all activities associated with this thesis; ii) describes the scope of activities associated with the design and development of the artefact itself; and iii) describes the scope for the development of the artefact's novel element.

5.2.2 Research scope

The scope of this research encompasses the design, development, instantiation and evaluation of an IS based artefact. The artefact is designed to meet the research, business, and technical problems stated in Figure 5.0. The model encompasses all the design requirements specified in Tables 4.3, 4.4 and 4.5. Once the artefact has been instantiated, this research then tests the effect it had on the individual and the organisation. The top tier of the matrix defines the research problems (the research questions formed for this thesis are stated in section 3.3).

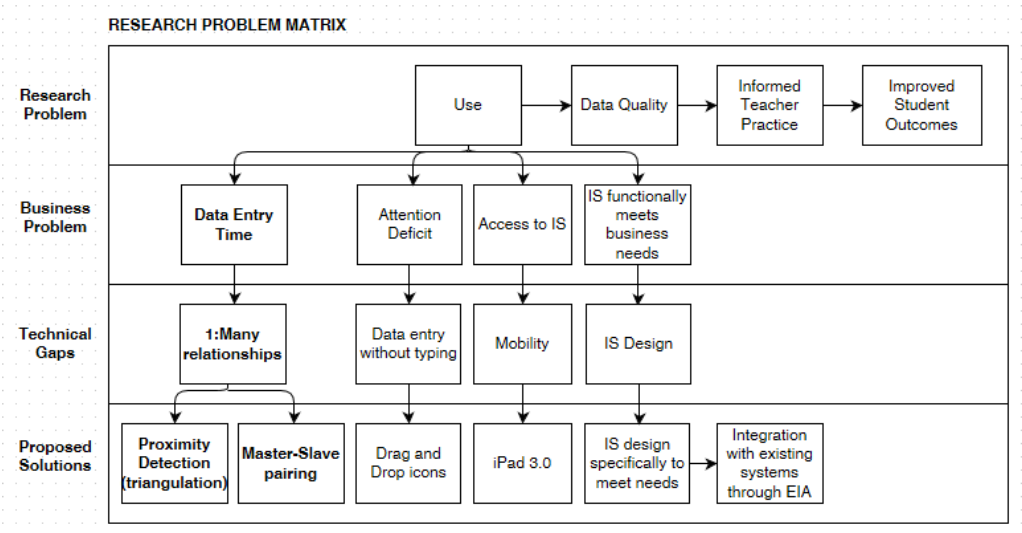


Figure 5.0 Research, business and technical problems associated with this research. The problems are represented as a multi-tiered problem matrix.

The research questions address the research problems stated in the top layer of Figure 5.0. The second tier of the matrix highlights the business problems on which the research questions were based. Details of these business problems were discussed in section 4.1. The third tier represents the identified IS technical gaps that must be addressed to ensure the proposed artefact and solution are viable. The bolded boxes highlight the novel element of the artefact. As part of this study, a pilot project tested the viability of the 'proximity detector', and this is discussed in the next section.

Following is a discussion on the artefact design scope, and potential technical solutions are briefly described for each business problem highlighted in the second tier of Figure 5.0. Table 5.0 restates each of these business problems and provides potential solution options for them. The second row of Table 5.0 (business problem layer) outlines the need for the redesign of existing profiling software to significantly reduce the number of user transactions for a given data set. Part 4 of this section further elaborates the scope of this required novel functionality.

5.2.3 – Artefact design scope

The scope of the design and development of the artefact is required to meet all of the requirements identified in Figure 5.0. Figure 5.1 (below) shows the various architectural layers of the proposed artefact. Each of the design considerations identified within the relevancy and design chapters are shown in alignment with each architectural layer of the proposed artefact.

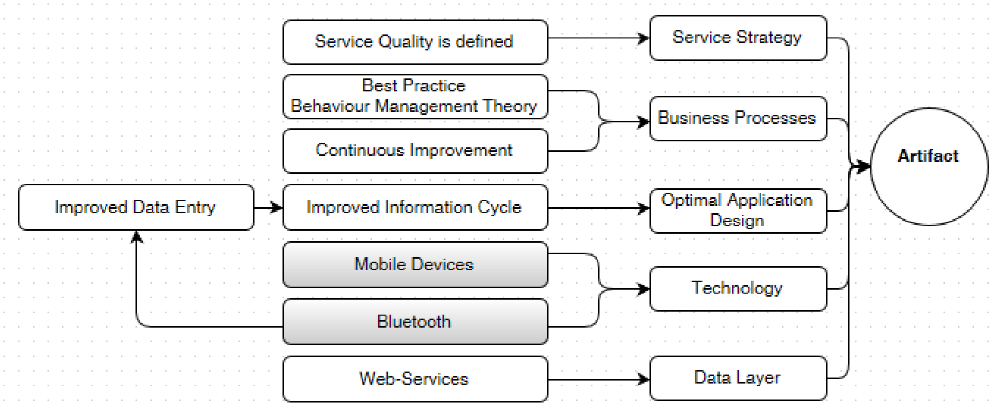


Figure 5.1: Shows the artefact design scope. The grey boxes represent artefact requirements of the novel solution.

Figure 5.1 shows that the artefact design scope for this research consists of the redesign of the five abstract artefact layers. The first layer ensures that the overall remaining abstract layers of the software align to the defined *service strategy*. The *business layer* is redesigned to incorporate best practice behaviour management techniques. The business processes are also redesigned to ensure that the continuous flow of information as part of the continuous improvement cycle. The *application layer* is designed to include optimal HCI design, incorporating business processes and new technology that facilitates data entry within the classroom. The *technology layer* uses mobile technology and Bluetooth sensors (more information about this can be seen in the next section). The *data layer* requires a redesign of web-services to easily access information within and from the application.

5.2.4 – Design scope – novel component of the artefact

The novel functional element, which needs to be developed as part of the artefact, is shown in Table 5.0.

Table 5.0 – Identified artefact requirements and potential solutions

Identified requirements	Potential solution options
Novel requirement – the data entry process cannot interfere with the teaching and learning process.	Propose a new IS design that reduces the number of user transactions needed to commit a given data set to the IS, and requires minimal attention and time. This could be achieved through the automation of 'key field' lookup. This automation can be achieved through using either a temporal, event or proximal trigger.
Adjunct requirement 1 – address the issues of 'attention deficit'	Addressed through the use of iconography, prepared behaviour targets, drag and drop functions, voice activated data entry.
Adjunct requirement 2 – access to the 'information system'	Use of mobile technology; Windows 8, iOS or Android.
Adjunct requirement 3 – the IS contains the specific functionality required by the business unit.	Specific documented functionality Feedback mechanisms that are identified in the research that will improve teacher's subjective evaluations. EIA identifies needs from an enterprise perspective.

Table 5.0 also shows the three adjunct requirements that ensure the effectiveness of this novel element. As is stated in the table, a potential solution for requirement 1 is the revision and development of an IS model that minimises the number of user interactions when entering data. It is proposed that the reduction in end-user transactions will be achieved through the automation and lookup of profile information. The technical scope for this

automated lookup function can be seen in the next part of this section, which also describes the how the number of user interactions for a given data set can be significantly reduced by automating the key field look-up in parent tables and, thereby, infers the scope for the novel part of the artefact. Requirements 2, 3, and 4 in Table 5.0 are specifically addressed in this chapter.

This section presents two scenarios for evaluating the number of user interactions required to enter a data set for a class of students: one that documents the current user interactions needed for adding student behaviour records; and a second proposes a more efficient means of adding and retrieving data when using information systems in the classroom.

Scenario 1 (current)

When using a database with a normalised relational schema, the data can have three entity relationships – one:one; one:many; and many:many. When retrieving data from an IS where the entity is in a one:many data relationship, the data entry and retrieval process requires that the parent field is retrieved before the related information in the many tables can be manipulated (Haplin & Morgan, 2010).

The process of applying a behaviour instance to the student requires a minimum of three user interactions per data transaction: i) the student is identified in the student master table; ii) the target behaviour is then found in the behaviour master table; and iii) the two fields are then combined to make a record in a third table. This is represented in Figure 5.2, which shows that adding a single behaviour to 30 students in the classroom requires a minimum of 90 user interactions.

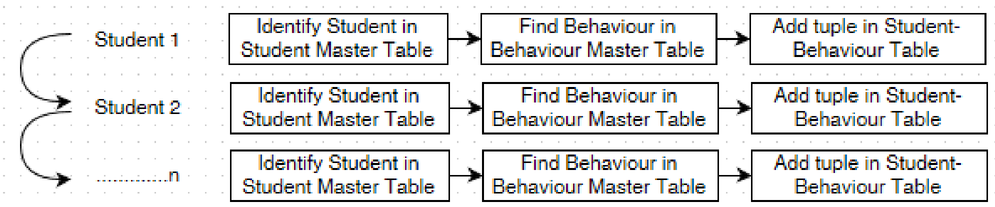


Figure 5.2: The process of adding information to a student's profile. The student ID is first retrieved. The related table is then navigated to and a behaviour instance is selected. Once the user has opened the related table, data can be added to the 'many table' defining the student-behaviour records.

Scenario 2 (proposed method for reducing interaction with IS)

The process of profiling in classroom settings requires standard information chunks applied to many students. In this scenario, the applied behaviour is obtained first. By automating the parent field lookup this standard behaviour can be applied to each student. The number of user interactions can be reduced to 31 (i.e. the lookup of the standard behaviour applied to 30 students). This is shown in Figure 5.3.

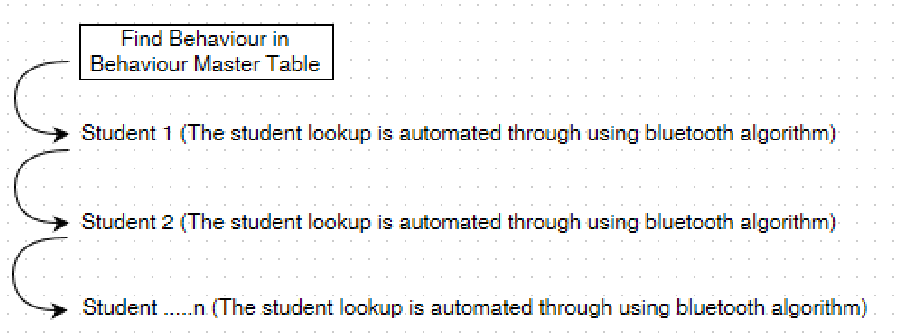


Figure 5.3: Shows the simple process of applying one chunk of information, multiple times.

This automation lookup process can be achieved using a number of potential mechanisms, such as a specific event trigger, a temporal trigger, or a trigger based on proximity.

The two scenarios above show the current and proposed mechanism for reducing the number of user interactions with the IS. Although relational data modelling itself does not limit the design of IS, they are typically designed with interfaces where retrieval and adding data follows the process highlighted in Figure 5.1. This thesis contests that classrooms are least suited to this kind of design and, therefore, that poor data quality in schools is a result of IS with this design type.

The previous three sections provide an outline of the research scope, the scope for artefact development, and the scope of development for the novel element of the artefact. The next section discusses the viability for the novel functionality discussed in section 5.2.4.

5.3 SOLUTION VIABILITY

This section contains nine parts. Other than this introduction, the next seven parts each describe a stage in the decision-making process to determine the optimal solution for the design and development of the novel part of the artefact. This decision process was undertaken to determine a viable solution for pilot testing, and is illustrated in Figure 5.4 in section 5.3.2, where each stage in the decision matrix is explained in detail. Section 9 forwards recommendations for the artefact development.

5.3.1 Pilot Project

To test the feasibility of a solution that automates the ‘key field look’ up in relational databases, a pilot project was conducted in the early phases of the study. The goal was to investigate possible solutions that would automate the process of looking up data in a table using a predetermined trigger. The pilot project was required to pass seven major requirements before its viability could be determined:

1. Determining a trigger for the automation process (section 5.3.2).
2. Determining the signal medium for signal communication and triangulation (section 5.3.3).
3. Determining the correct mobile device to transmit the signal medium (section 5.3.4).
4. Ensuring the mobile device had the code framework to support the exchange of signal information between devices (section 5.3.5).
5. Resolving an authentication/security model so the artefact could be instantiated in a live environment (section 5.3.6).
6. Web-services could be supported on the mobile platform (section 5.3.7).
7. The signal detection, accuracy and information exchange is examinable and determined to be reliable (section 5.3.8).

These steps are shown in Figure 5.4 in the next section.

5.3.2 Automation triggers

The first step to determine the viability of the novel element of the artefact was deciding on the optimal trigger for the automation process. Three types of trigger were investigated: event, temporal, and proximal.

The most probable choice for a trigger was determined according to the automation activity, which is described as a “teacher looking up the details of a student and applying data to that student”. The trigger deemed most characteristic for this scenario was the *proximal trigger* –that is, when a teacher approaches a student to examine a behaviour, the artefact is able to automatically look up that student’s identifying key in the ‘parent table’. The proximal trigger would require several conditions to be met for the solution to work, and these are discussed in the remainder of this section. Figure 5.4 shows the solution viability pathway for choosing a solution that automates the lookup of student details.

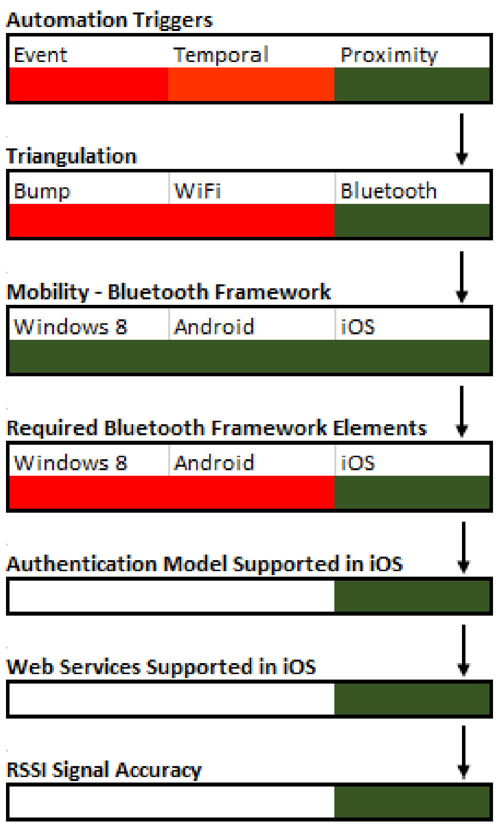


Figure 5.4: Solution viability pathway

The next most viable automation trigger was determined to be the *temporal trigger*. Since most students are timetabled to a particular class with a particular teacher, all students within a particular class can be identified. These students can then be populated in a list and made available to a teacher. This process is not fully automated, as the teacher still requires manual intervention to choose a single student. This solution also does not work well when teachers are not in their normal classes; for example, period swaps. It is likely that the temporal trigger will be incorporated into the solution for when anomalies to the first solution do not allow a teacher to find a student via a proximal trigger. This solution, however, is considered routine design.

The least attractive solution for automation is the *event trigger*, which can be applied in unlimited ways (e.g. when a student finishes a task, an automatic lookup process can be triggered). Two major problems arise with this approach. The first is, that the instantiation of this trigger requires a software redesign and the integration of other IS that fall outside the scope of this research. Also, this type of trigger would be considered routine design, and, again, outside of the scope of this research.

With the *proximal trigger* chosen as the most viable solution for the IS artefact, the next decision facing the researcher was to choose the signal medium in which to exchange information between the student/teacher mobile devices. Three possible solutions were forwarded: i) exchange of information using WiFi; ii) modifying the principles, concepts and algorithms of Bump™ technologies for the exchange data; and iii) data exchange via Bluetooth signal.

5.3.3 Data exchange and signal triangulation

WiFi

WiFi, or wireless local area network (LAN), uses high frequency radio signals to transmit and receive data. WiFi uses standard Ethernet protocol. In research and discussions on the use of WiFi and its ability to triangulate device location within the schools context, the following issues were identified:

- 802.1X is not a common authentication method for all schools; therefore, authentication to school networks using mobile devices may be problematic.
- Problems with accuracy – in a classroom environment, distances of 20cm need to be distinguished.

- Mobility of WiFi could be problematic – routers have to be wired and networked, whereas devices like a Bluetooth transponder can be made and shifted with relative ease. This makes Bluetooth triangulation better over smaller distances.

Bump technologies

Bump technologies works using a two-part algorithm: one contained within the app running on the 'paired' device, the other on a server hosted in the Cloud. The algorithm uses the phone sensors to 'feel' the bump on the two devices. Data about the sensor disruption, location and temporal data are sent to the Cloud from both mobile devices. The server on the Cloud receives the information and, using a matching algorithm, sends data back to the paired phones. This solution does not work particularly well in dense areas (e.g. classrooms or conferences). The makers of Bump suggest multiple 'bumps' to help resolve matching in these areas. There is a potential to use this type of solution; however, making multiple bumps between student and teacher mobile devices was determined undesirable.

5.3.4 Bluetooth signal

With the later versions of smart mobile devices that support Bluetooth LE (BTLE 4.0), a programmer can obtain the radio (received) signal strength indicator (RSSI) between the device and sensor stations, as well as a UDID for identifying the device. The MAC address of the mobile device can also be obtained if using the right software on the sensor side. For the purposes of this thesis, it was determined that Bluetooth data exchange and triangulation had the most potential to meet the technical needs for this solution, and was therefore investigated further. All mobile device types (iOS, Windows, and Android) contain a Bluetooth framework as part of the operating system; however, currently the most sophisticated framework was inherent in the Apple operating system (iOS).

5.3.5 Pilot problem – direction for using the Bluetooth framework

If the BTLE 4.0 framework solution is used, then Bluetooth signal triangulation can be achieved two ways: i) through monitoring the iPhone from a series of set sensor locations; ii) on the iPhone itself by reading the signal strength between it and devices that are advertising from known points. The latter is applicable given the nature of the problem. Triangulation can be achieved by placing a series of low energy peripherals (slaves) and having them advertise at regular intervals. Within the advertised information, the location of that peripheral can be determined in the room. The app on the master device can read these advertisements, and retrieve the RSSI information using the delegate method. A particular device can then be triangulated, and functionality is demonstrated in the code block below.

```
centralManager:didDiscoverPeripheral:advertisementData:RSSI:
```

Figure 5.5: Code block for the discovery of peripheral devices.

The latter solution requires that the slave devices be placed in an advertising mode using the BTLE 4.0 framework. The master device senses the RSSI from the slave via the advertisement packets, which also send UDID for the slave devices. A central server then needs to combine these readings to triangulate the location of the slave devices.

5.3.6 Required Bluetooth framework elements

The following section briefly describes the object model for the BTLE 4.0 framework in iOS, and the four stages to establish a master-slave relationship using Bluetooth signal. The master-slave object model is a key requirement for a viable solution for the problem set.

Bluetooth Object Model

The following code block describes the object model for the BTLE 4.0 framework. Objects are classified as Main, Data, and Helper objects.

Main objects: CBCentralManager, CGPeriphealal,CBPeripheralManager, CBCentral

Data objects: CBService, CBCharacteristic, CBMutableService, CBMutableCharacteristic

Helper objects: CBUUID,CBATTRequest

Figure 5.6: Bluetooth object model

Bluetooth master-slave relationship

Four steps are necessary for the exchange of information between a master and slave app using Bluetooth signal as a medium:

1. Setup the CBCentral manager.

```
CBCentralManager *manager = [[CBCentralManager alloc] initWithDelegate:self queue:nil];
```

Figure 5.7: Code block for the setting up of the CBCentral manager

2. The CBCentral manager then scans for devices.

```
NSDictionary *dictionary = [NSDictionary dictionaryWithObject:[NSNumber numberWithBool:YES]

forKey:CBCentralManagerScanOptionAllowDuplicatesKey];

[manager scanForPeripheralsWithServices:nil options:dictionary];
```

Figure 5.8: Code block that allows the CBCentral Manager to scan for devices

3. The detected slave devices are processed.

```
- (void)centralManager:(CBCentralManager *)central didRetrievePeripherals:(NSArray *)peripherals{

//Choose peripheral and connect

[manager connectPeripheral:[perpherals objectAtIndex:0]options:[NSDictionary dictionary]];
```

Figure 5.9: Code block to facilitate detection of slave devices

4. The master app is notified when connection to the peripheral is complete.

```
- (void)centralManager:(CBCentralManager *)central didConnectPeripheral:(CBPeripheral *)peripheral{

//Write value to a characteristic

int i = 1

[peripheral writeValue:[NSData dataWithBytes:&i length:sizeof(i)] forCharacteristic:[[service
characteristics ] objectAtIndex:0] type:CBCharacteristicWriteWithoutResponse];
```

Figure 5.10: Code block shows the master device is notified once the slave device is connected to it

After a thorough investigation, it was determined that the exchange of information could be achieved using the iOS BTLE 4.0 framework via Bluetooth signal.

5.3.7 Authentication model

The next step to ensure the viability of the new solution was to determine if users could read and write information to a database using the iOS master app. The integration with the web-services was developed and tested in conjunction with the authentication process for the pilot project. It required six individual steps and four web services, and next part outlines the method for testing these web-services and the authentication process.

5.3.8 Web-services, support, development and testing

Four web services were initially developed to test both the authentication model as well as the web-service calls itself. Figure 5.11 shows the workflow for the web-service calls in the authentication process.

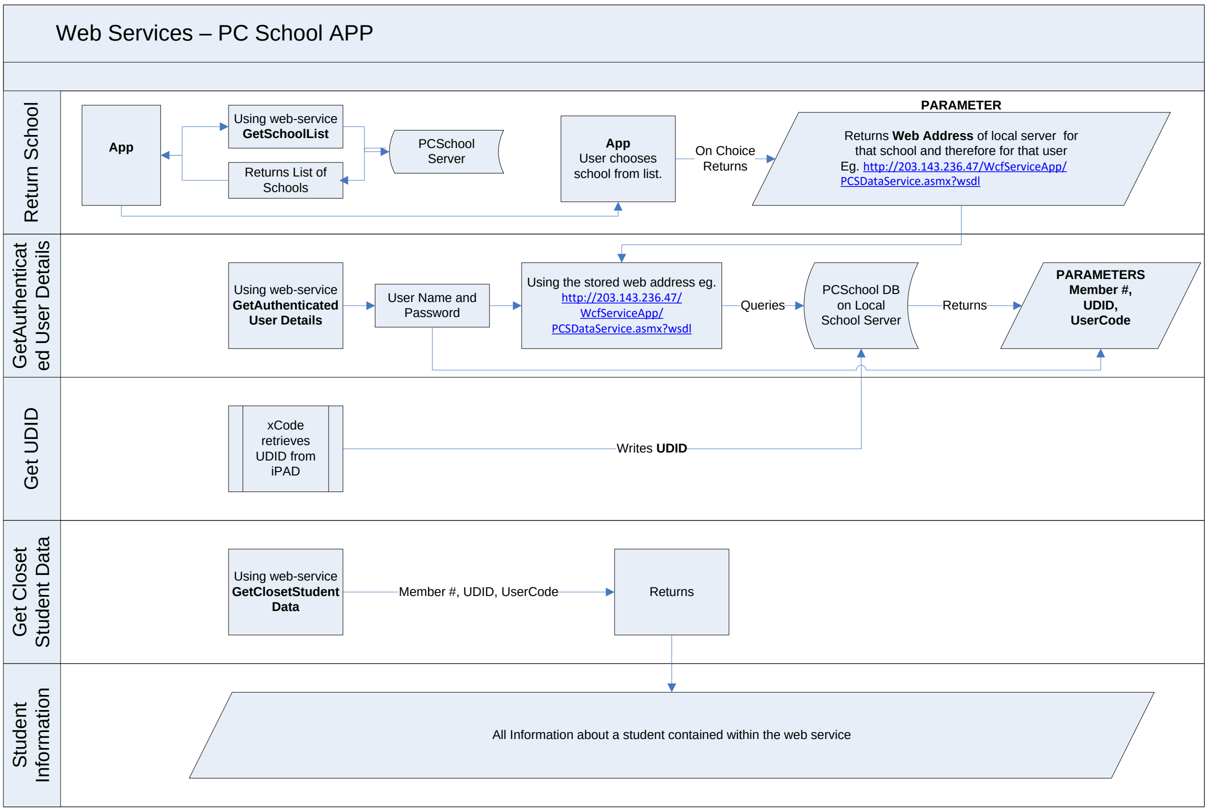


Figure 5.11: Pilot web-services workflow showing the authentication process

In this workflow, the app first consumes a web-service located on the pcschool.net website. This web-service returns a list of schools and their spider URLs, and when students first download the app and run it, it provides them with this list of schools (a generic hardcoded one). Once completed, the app stores the URL for the web server where the web-services for each individual school are located. The student/teacher then navigates to another interface where they can enter a username and password. When the student/teacher submits this information, the app will pass the ‘app generated UDID’, which is stored in the database against the student/teacher’s name. Based on the dynamic web service URL, the user is authenticated using the credentials SSUSERID (UDID), MEMBER#, USER CODE. Whenever any future web-service calls are made, the MEMBER#, USERODE and SSUSERID are part of the authentication. The web-services were tested using the testing client <http://validwsdl.com/>0. The results of these web-service calls can be found in the CDR (Appendix 7).

5.3.9 RSSI signal testing

The following section provides an overview of testing results for the pilot project, which specifically focused on the Bluetooth functionality. The testing scripts can be found in Appendix 6. A video for the basic test of Bluetooth functionality can be found on YouTube at:

http://www.youtube.com/watch?v=lIio-q4Wf7U

The results in Table 5.1 show that only one evaluation criterion failed testing during the pilot phase. Recommendations to remedy this problem can be found in the next part of this section. Another significant result from the testing was the variability in RSSI signal strength between two static devices, which was found to be relatively ‘noisy’, even at the low transmission levels found in iOS peripherals. Although this variability was present, consistent discrimination could be determined between two devices 20cm apart.

Table 5.1

Test ID	Description	Pass	Behaviour if not passed.
RS1	Master device is established.	**Y**	
RS2	Master device can scan for multiple peripheral devices.	**Y**	
RS3	Slave devices are detected and processed.	**Y**	
RS4	Master device is notified when connection is completed with the slave devices.	**Y**	
RS5	The UDID of the slave devices are retrieved.	**N**	Apple, in version 6.01, has made changes to the framework to prevent access to the UDID of the slave devices. The UDID will have to be generated by the app.
RS6	RSSI from multiple devices are recorded and discriminated.	**Y**	
RS7	Variability of RSSI signal is low enough to discriminate between devices 20cm apart.	**Y**	

5.3.10 Recommendations for future design and development

The following recommendations are made so that a unique identifier for the slave app can be obtained and referenced by the master app:

1. The slave app requires have the capability to generate a unique identifier;
2. This unique identifier needs to be transmitted from the master to the slave app via Bluetooth signal;
3. Design considerations for the slave app will need to be forwarded as part of the design document.

This section has described each stage in the decision-making process that determined the optimal solution for the design and development of the artefact, and briefly provided the results of the evaluation of the pilot project. Subsequently, it made recommendations for future design and development of the artefact. The next section addresses how this research complies with the output components required of a design science research.

5.4 RESEARCH PARADIGM

Over the last two decades, researchers such as Walls et. al (1990), Nunamaker et al. (1991), Hevner, March, Park and Ram (2004), March and Smith (2005) and Chatterjee and Hevner (2006) have significantly contributed to establishing a research framework within the design science research paradigm. In particular, these contributions have centred on the question: "What key attributes should a design science research encompass, to make valid contributions to knowledge?"

The first purpose of this section is to state the essential requirements for rigorous design science research – and these key elements can be categorised as either artefact design requirements, or design theory requirements. This section relies heavily on work from Hevner, March, Park and Ram (2004) to identify the necessary artefact design requirements, and Gregor and Jones (2007) to identify the necessary design theory components.

Within the design science paradigm, research can be further classified into design science and design research, with the required outputs of these varying slightly. Therefore, the second purpose of this section is to correctly classify this research and explicitly state its necessary outputs – thus, ensuring its rigor and contribution to knowledge.

This section has four major parts: i) a definition of design science; ii) a statement of those key attributes needed to ensure a contribution to DT knowledge; and iii) a discussion on the differences between design science and design research. This research is classified as design research, and this classification is justified in the final part of this section.

5.4.1 Defining the design science paradigm

The origins of design science come from the field of engineering and science of the artificial (Simon, 1996). Its purpose is to design and develop knowledge and solutions to specific problems through the creation and application of innovative artefacts. "It is fundamentally a problem solving paradigm. It seeks to create innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, management, and use of information systems can be effectively and efficiently accomplished" (Hevner, March, Park & Ram; 2004, p. 76).

5.4.2 Design science outputs

Artefact design output

As stated in section 5.4.1, the major output of design science is the design, development and instantiation of an artefact. A vital requirement that must be addressed when developing this artefact is that of innovation. The artefact must be considered an original and innovative solution to a particular problem space. The artefact developed for any DS research cannot be classed as a routine design, – that is, a simple application of best practice methodologies or applications to an existing organisational problem. It must be built to solve essential unsolved problems in unique and pioneering ways. By doing this, the knowledge gained from designing, developing and instantiating the artefact has the potential to make a clear contribution to knowledge.

For any DS research to be replicable, each design science research must clearly establish a replicable output – how is knowledge and theory about the design process, identified, recorded and communicated (Simon, 1996)? In other words, how is the design theory produced? Seminal work by Dubins (1978) describes the necessary components of theory in the natural and social sciences. Dubins suggests that to have theory, one must clearly state: the basic units of the theory; the relationships and behaviour between those units; the conditions to which the relationships and behaviour are expected to remain consistent; anomalies to the expected relationships and behaviours; and finally truth statements about the theory.

Using the foundations of Dubins' work, Hevner, March, Park and Ram (2004) state that to communicate knowledge about the design, development and instantiation of the artefact, it must be described in terms of four outputs: "constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems, p.77)”. The outputs of the artefact design, and how this thesis has addressed each of those, are summarised in Table 5.2.

5.4.3 Design theory outputs

Using the work of Gregor and Jones (2007), the design theory outputs for design science research are shown in Table 5.3. As with Table 5.2, a response on how this thesis fulfils these requirements is made. The design theory chapter (Chapter 8) spends considerable time discussing each of the components of design theory in order to communicate the new knowledge gained through this study. The responses in Table 5.3 are outlined according to the components described in the rigor chapter.

Having fulfilled the requirements stated in Table 5.2 and Table 5.3, this thesis can justify its research type within the design science paradigm.

Table 5.2 – Design science components

Requirement	Description	Research Instantiation
An artefact is designed, developed and instantiated.	The researcher designs, develops, and instantiates an artefact that meets a defined business problem. The purpose and scope of the artefact is clearly articulated.	An artefact is instantiated to meet the documented business problems stated in Chapter 3. The purpose and scope of the artefact is clearly articulated here.
The artefact makes a contribution to knowledge.	Through the design, development and instantiation of the artefact, a clear contribution to knowledge is made. The artefact addresses a problem that requires an innovative solution.	The artefact can solve an existing business problem using new and innovative technology. The innovative design makes a contribution to knowledge.
The artefact is made up of constructs, models, methods, and an instantiation.	The research clearly defines the artefact through the use of constructs, models, methods and instantiation.	Artefact is defined through the use of constructs, models, methods, and instantiation.
	Constructs are the basic language units in which problems and solutions are defined and communicated (Schön, 1983).	The constructs of the artefact are defined in Table 8.3.
	Models communicate the relationships and boundaries of the solution and provide an understanding of the relationships between the problem and solution components.	The model of the solution and its component interaction are communicated in Chapter 6.
	Methods define the processes inherent in the solution, and provide a framework on how to solve the problem (i.e. how to navigate through the solution space).	The method of development is communicated in Chapter 4.
	Instantiation provides a real-world test of the artefact in the problem domain.	The artefact is instantiated in a school.
Artefact evaluation	The artefact is comprehensively tested using artificial and naturalistic evaluations.	The artefact is evaluated using: (black-box) testing, UTAUT, IS-impact and convergent interviews.

Table 5.3 – Design theory components reference guide

Design theory element	Article
Purpose and scope What are the goals of the artefact? What are the scope, boundaries, limitations, and exceptions that can be made to the theory?	The scope and purpose of this research (identified in the relevance section) is to specifically improve four identified information flow paths that, although critical to quality outcomes in education, were not well designed in previous education-based IS. This prevented the ability to implement continuous improvement to education services.
Constructs The basic components of the artefact that can be used to describe theory.	The units of interaction, the laws of interaction between these units, and the conditions in which the laws are upheld are defined in section 8.3. This study concerns itself with those constructs related to improving information flow throughout a continuous improvement cycle.

Principle of form and function What is the abstract architecture of the IS artefact?	The principles of form and function are defined in Table 8.0 of the rigor section. Van Aken's (2003) classification model is used to define the form and function of the artefact.
Artefact mutability The changes in state of the artefact anticipated in the theory – that is, what degree of artefact change is encompassed by the theory?	There are two likely areas of change to the artefact: i) the way and type of automation in the retrieval of information objects; and ii) the design software to engage end-users to the data to inform practice.
Testable propositions Truth statements about the design theory.	Factors related to improved information flow throughout a continuous improvement cycle. These are defined in section 8.6.
Justificatory knowledge The underlying knowledge or theory from the natural, social or design sciences that gives a basis and explanation for the design (kernel theories).	The kernel theories are provided: 1. total quality management 2. behaviour management theory 3. relational modelling
Principles of implementation A physical implementation of the artefact that assists in representing the theory as an expository device and for testing.	The details of the each step of the implementation is outlined in the central design repository (CDR)
Expository instantiation	The artefact is instantiated within a school.

5.4.4 Design science vs design research

Hevner et al., (2004) identifies two types of research contribution within the design science paradigm: *design science* and *design research*. Design science is characterised as the construction and evaluation of artefacts at a generic level, and its purpose is to examine the design research process and generate standards for its rigor. The purpose of design research, in contrast, is to create solutions to defined problems that are much more specific in nature than those associated with design science research. Tables 5.2 and 5.3 contain a list of the output components necessary for design science research. While Table 5.2 defines the necessary artefact outputs, Table 5.3 defines the necessary theory outputs. This section has shown how this thesis has fulfilled the requirements of a design science research.

This section clearly articulates how this research has fulfilled the requirements for artefact design and design theory. This entails the research to claim rigor of, and classification within, the design science research paradigm. This section also articulates how this research was further sub-classified as design research. The next section of this research resolves the themes of this research.

5.5 RESOLVING THEMES

A design science research project usually consists of two major elements in artefact development: construction of the artefact; and the evaluation of the artefact (Hevner, 2007). In some circumstances, however, only the construction or the evaluation may be necessary as part of the design science research project. For example, in circumstances where the artefact is particularly novel, the evaluation phase of design science may not be necessary (March & Smith, 1995; Winter, 2008). As shown in the methodology section (Chapter 3), this thesis undertakes both major elements of the design science research project.

5.6 DEFINING THE REQUIREMENTS

This section provides an overview of the artefact design requirements. The requirements for the design and development of the artefact are drawn from four other sections of this thesis, and are broadly categorised as architectural requirements, business requirements, technical requirements, and design requirements. The requirements for the artefact are shown in Figure 5.12.

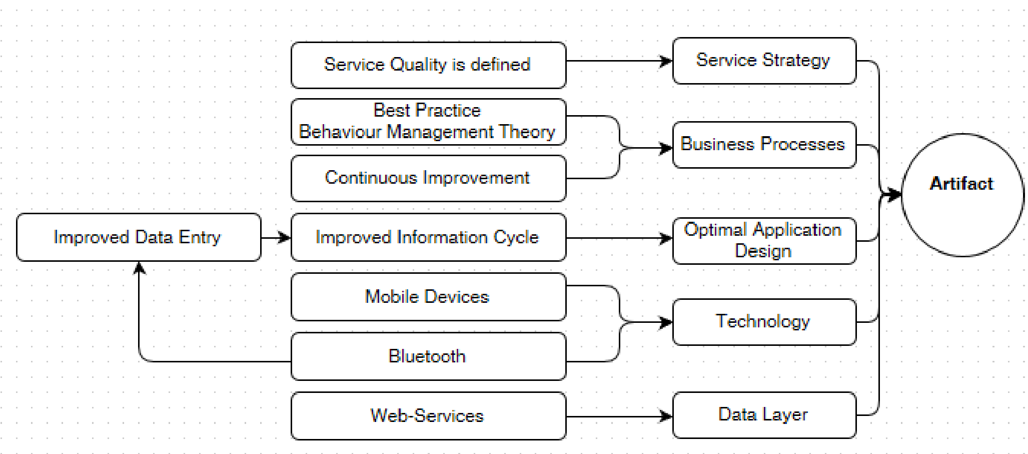


Figure 5.12 Broad categories of requirements for the design and development of the artefact.

As indicated in Figure 5.12, the architecture of the artefact depends on the enterprise information architecture (EIA) of the application domain. The first requirement for the design and development of the artefact, therefore, is to ensure that the architecture of the artefact can coexist within the IS architecture of the application domain. In Chapter 3, an EIA was written for the application domain that consisted of four main layers: strategy, business, application, and physical/data layer.

The strategy layer identified the goals of the organisation and, by doing so, oriented the purpose and business need of the artefact. In the business layer, the services that a customer (student) will experience from enrolment through to graduation were documented through the use of a 'value network view', which identified each of the service units (enrolments, finance, student services, pastoral care services, academic services, etc.). The service department that sponsored the design of the artefact was pastoral care services.

Table 5.4 – New design considerations incorporating behaviour modification theory

Behaviour element	Design consideration	Design response
Specificity of feedback	*Facilitate teachers to quickly provide specific feedback to the students on specific behaviours.*	A specific behaviour can be searched prior to a lesson and applied easily within the classroom setting. Behaviours can be proactively targeted.
Schedule of feedback	*Provide teachers with feedback on the number and types of reinforcements they provide to the students.*	Teachers can easily see a graph (pictorial view) of their interactions each student.
Immediacy of feedback	*The BMSApp should be designed so that feedback can be provided to the student without disrupting the teaching and learning process.*	The app architecture allows for quick mobile access. Drag and drop function is used. Minimalist functionality approach to the design.
Consistency of feedback	*A mechanism for maintaining consistency of feedback from a single teacher and between teachers should be facilitated.*	Teachers can easily see a graph (pictorial view) of all teachers' interactions with the particular student they are viewing. This allows teachers to 'moderate' their feedback for a student.
Cost-benefit of behaviour	How can the cost benefit for teachers be increased?	Teachers are aware that the electronic recording of such behaviours leads to a whole-of-community approach.
	How can the cost benefit for students be increased?	The consequence/reward for behaviours are communicated to the student and their learning community.

Within the business layer, a list of services that the Pastoral Care Services Unit provides was documented. These three main services were identified as 'managing behaviour instances', 'case management' and 'intervention programs'. The process control flow and business processes were mapped for each of these three pastoral care services. The application layer of the EIA contained the identification of the various applications used by the Pastoral Care Service Unit to deliver services. Finally, the data structures of the identified services were mapped using a ‘use case view’, and UML modelling. Through the documentation of the EIA, the architectural, business functions, business processes and data requirements for the existing artefact were identified. The next part of this section discusses the developing new business requirements for the artefact.

5.6.2 New functional requirements

As well as incorporating the business needs of the existing IS, further business requirements are drawn from behaviour management theory. A key design requirement of the artefact is the incorporation of best-practice behaviour management processes and, through this, the artefact is theoretically improved. These requirements are documented in Table 5.4 (above): i) specificity of feedback; ii) schedule of feedback; iii) immediacy of feedback; iv) consistency of feedback; and v) cost-benefit of the behaviour. By incorporating these elements into the artefact’s design, it is anticipated that a closer approximation to the desired behaviours can be achieved.

These requirements represent a subset of the business logic and functionality required for the artefact. The remainder of the business logic and functional requirements were drawn from the existing legacy IS and identified within the EIA document.

5.6.3 Design requirements

Through conducting a case study (see Chapter 3), several design issues with the legacy IS were identified. The case study gathered direct design requirements based on the users experience with the legacy IS, and these stated in Table 5.0 and labelled ‘adjunct requirements 1, 2, 3’. Further design requirements are made based on the architectural, business and technical requirements stated in this section.

5.6.4 Technical requirements

The technical requirements for the artefact are described as items 6 to 14 in Table 4.6. Section 5.3 discussed this study's pilot project. It ensured that the technical requirements could be met as part of the design, development and instantiation of the artefact. A representation of the pilot projects in shown in Figure 5.13.

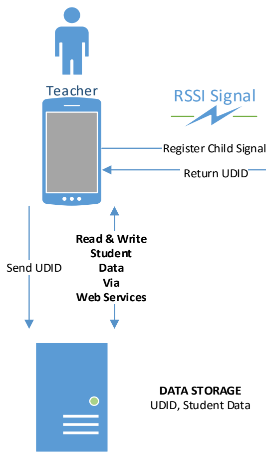


Figure 5.13: A possible solution to automate user interactions when entering data in classroom profiling software.

This section summarised the requirements for the design and development of the artefact to be built for this thesis. The architectural requirements were highlighted within the EIA document in Chapter 3, and the functional requirements for the artefact were also highlighted in the EIA. Additional functional requirements were stated in section 5.6.2. The design requirements were discussed and documented in section 5.6.3 and, finally, the technical requirements for the artefact were discussed and stated in section 5.6.4. The next section contains statements that espouse 'defining alternative solutions' and 'exploring the knowledge base support of alternatives'.

5.7 DEFINING ALTERNATIVE SOLUTIONS

Design is a creative process that entails the exploration of number of viable options/solution sets, and seeks to test their applicability to a specific problem. They are tested for their suitability, and the gaps and errors that arise from the application of the test solutions are identified (Hevner, 2004). Through this identification process, further refinements can be made to the viable solutions that could solve the business/research problem. A gap analysis was conducted for each viable solution proposed and tested. These evaluations can be found in the CDR.

5.8 EXPLORER KNOWLEDGE BASE SUPPORT OF ALTERNATIVES

An alternative solution to the business/research problem will be based on theoretical underpinning(s) – that is, the final solution design will encompass research principles based on some natural or social science kernel theory (Walls, Widmeyer, & El Sawy; 1992). The kernel theories that the design encompasses can inform design theory. Conclusion from the design science project may also contribute to the nomological knowledge base of the kernel theory (Goldkuhl & Lind; 2010). This step of the design cycle investigates the kernel theories that support and inform artefact design, and their use is discussed at length in the discussion chapter. The kernel theories used in this research were identified in Table 5.3. The next section provides the design documentation used to develop the artefact.

5.9 DESIGN DOCUMENTATION

The following section outlines the design documentation used as the basis to develop the artefact. This section has ten parts. Other than this section, the remaining nine parts align to the nine screens that make up the app: the splash; login; student details; student subjects; student absences; attendance codes; student timetable; add appraisal; and configure and send email feedback screens. For each screen, its name, key features and web services are stated. Once the artefact development was completed, the Apple Store was used to distribute the apps to the participants. Figure 5.14 shows the artefact and its availability from the 'Apple App store'.

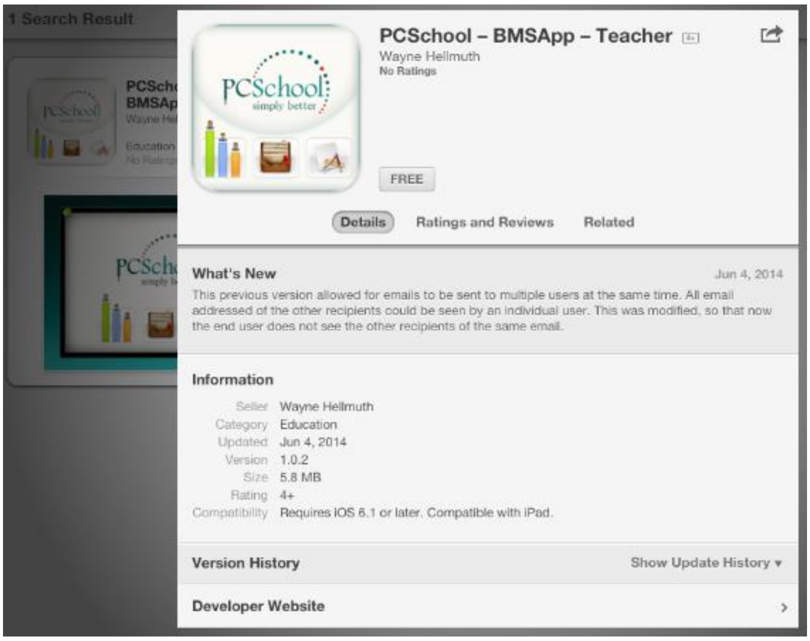


Figure 5.14: The artefact was available for trial via the Apple App store

5.9.1 Screen name – splash

Figure 5.15 Shows the 'splash screen' for the teacher app.

The *splash screen* is a requirement within iOS; it only remains on screen for a few seconds before the app defaults to the login screen. No web-services were required for this screen.

Features – splash

- The app will load the necessary features in this screen.
- After a few seconds, the app will default to the login screen.

Web services – splash

- There are no web services required for this screen

5.9.2 Screen name – login

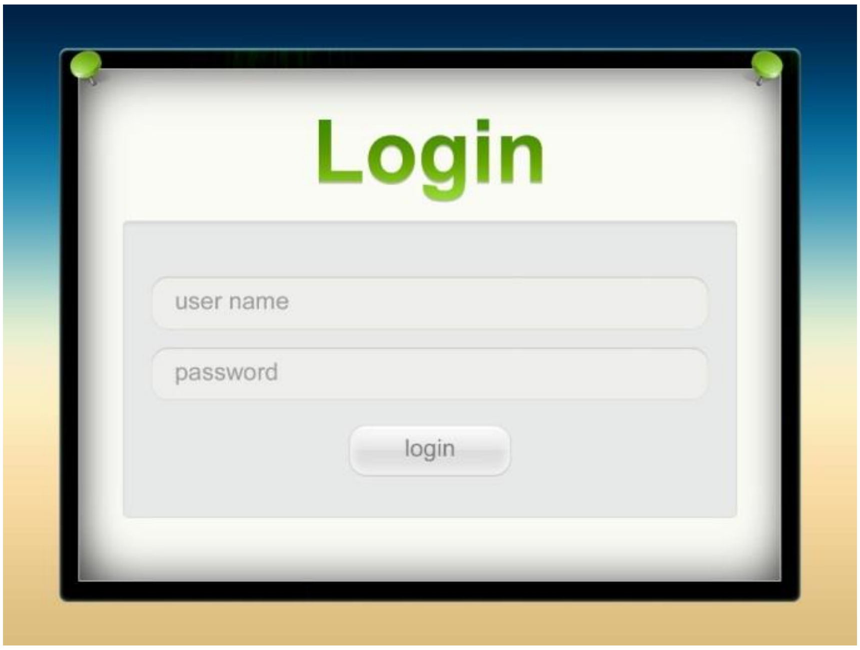


Figure 5.16 Login screen for the app. Once the authentication process is complete, a number of web-services are triggered (see Appendix 6.0 and WS-1 to WS-6 of the CDR).

Screen features – login

- The end-users (teachers and students) need to login by specifying the user name and password in this screen.
- When the login method is successful, the app generates a unique identifier (ID) for the device.
- This unique ID will be referenced for the accessing the database info.

Table 5.5 – Web services, login screen (A)

No.	Web Service Name	Input List	Output List
A1	GetSchoolList		
A2	GetAuthenticatedUserDetails	*UDID* *UserName, Password* *Member#, UDID*	
A3	UserUDIDUpdate	*UDID, Member#,* *UserCode*	
A4	GetClosetStudentData		• *Member #* • *Name* • *PCClass* • *PCTeacher* • *Year* • *Home room* • *Address* • *Phone*

5.9.3 Screen name – student details

Figure 5.17 Shows the app's first screen after the splash screen.

Screen features – student details

Figure 5.17 is the student details screen, which shows a number of web-services that are successfully called in parallel. The functionality of this screen is as follows:

- The student parameter is fulfilled when a student is selected in a list / **or**
  the student's name is returned via a search / **or**
  the student is the closest to the proximity detector.
- Student parameter order of preference is –
  i) bluetooth proximity (if on)
  ii) search (if active)
  iii) chosen in class list
- The student's personal details are returned.
- A count of the number of positive and negative interactions the current teacher has with the student is displayed graphically.
- A count of the number of positive and negative interactions of all teachers with that student is displayed graphically.

Table 5.6 – Web services, student detail screen (B)

No.	Web Service Name	Description	Input List	Output List
B1.	All Students	When the RSSI signal is not present for a student, i.e., we need to identify a student who is not currently in a teacher's timetabled class, we need to be able to return back any current student enrolled at Padua. The search function will allow the teacher to search the name, and from here we return the UDID, Member #, and Student Code. This information can be plugged into another web service.	*Text in search box*	*Student name matching search parameter*
B2	Current Class of Students	Return the names of students in the current class for a given teacher in the current period. We will need to return the UDID, Member #, and Student Code, as well as the Student Name. (Parameter current Period?? How is this being done now? Does PCSchool Spider current have a field that identifies current period? Is this a parameter or not?)	*Teacher Current period*	*First name and surname for all class members*
B3	Behaviour feedback	Return count for current teacher positive and negative comment count for a student. Return count for all positive and negative comments on students. Is represented in graphical form	*Current Student*	*Teacher +ive count* *Teacher –ive count* *All Teach. +ive count* *All Teach. –ive count*
B4	Student Picture	Return Student Picture based on UDID, Member #, and Student Code	*Current Student*	*.jpeg picture*
B5	Student Details		*Current Student*	*All student details*

5.9.4 Screen name – student subjects

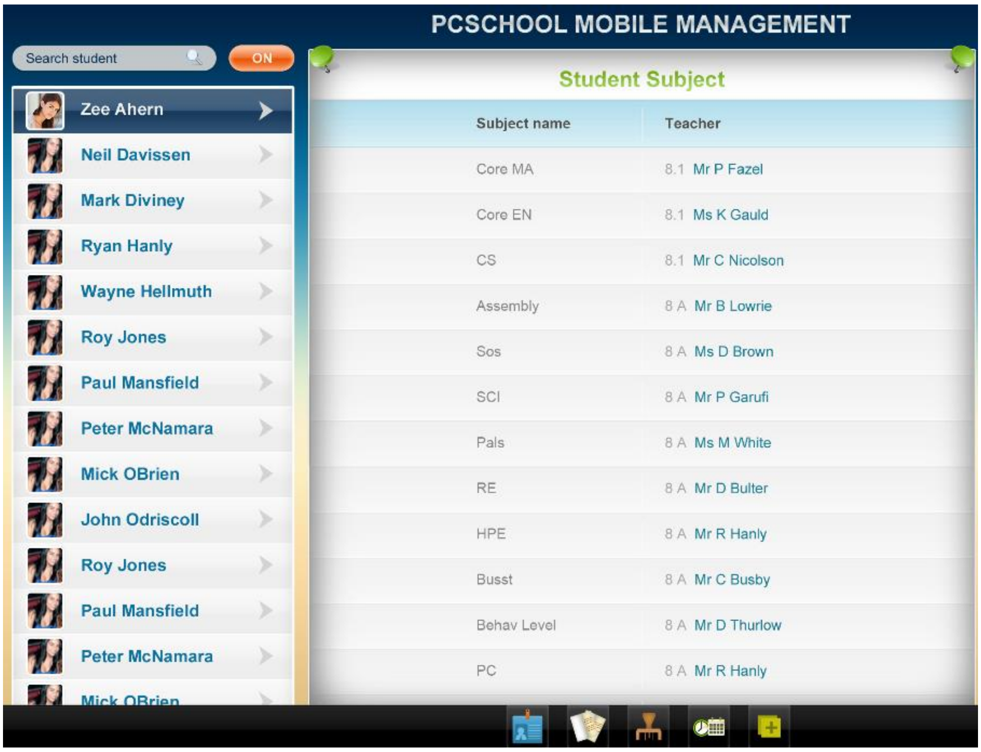


Figure 5.18: This screen displays all subjects a student is studying and the relevant teacher.

Screen features – student subjects

Figure 5.18 shows the *student subjects screen*, which adds utility to the app. When a student is selected in a list – **or** the student's name is returned via a search – **or** the student is the closest to the proximity detector, all subjects that the student is enrolled in will be displayed.

Table 5.7 – Web services, student detail screen (C)

No.	Web service name	Input list	Output list
C1.	Subject information	Selected student parameter	• *Subject name* • *Class* • *Teacher name*

5.9.5 – Screen name – student absences

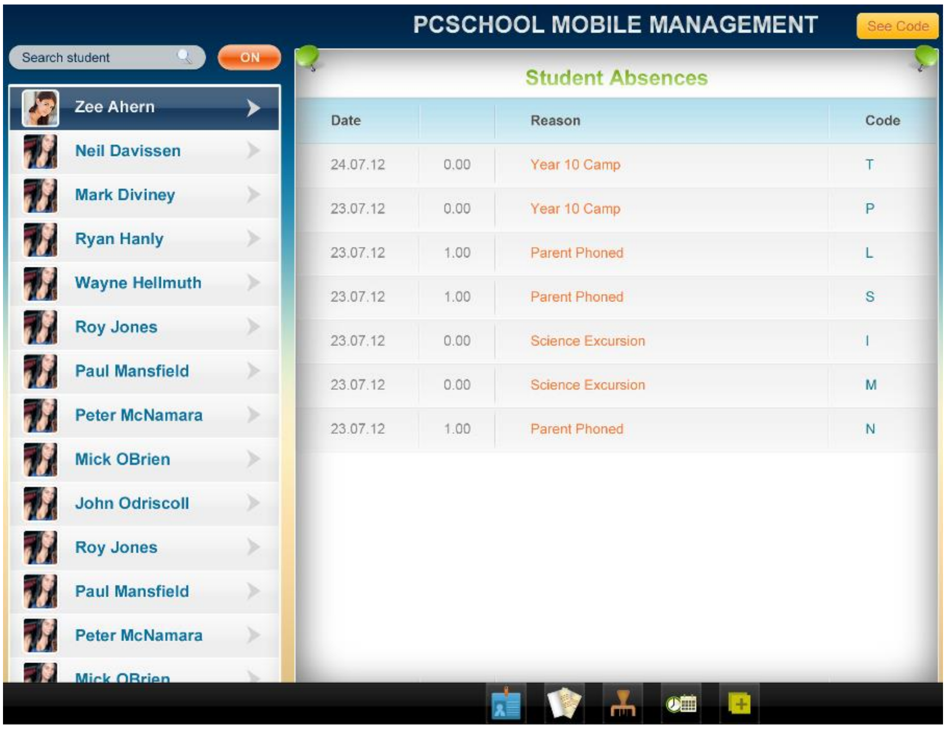


Figure 5.19: This screen displays the absence history of a student

Screen features – student absences

Figure 5.19 shows the *student absence screen*. The absence history of a student was discussed as a highly desirable feature in managing and making subjective evaluations about a student's behaviour.

Table 5.8 – Web services, student absences screen (D)

No.	Web Service Name	Input List	Output List
D1.	Absence Codes	Selected student parameter	• *Date* • *Time of absence* • *Reason* • *Code*

5.9.6 Screen name – attendance codes

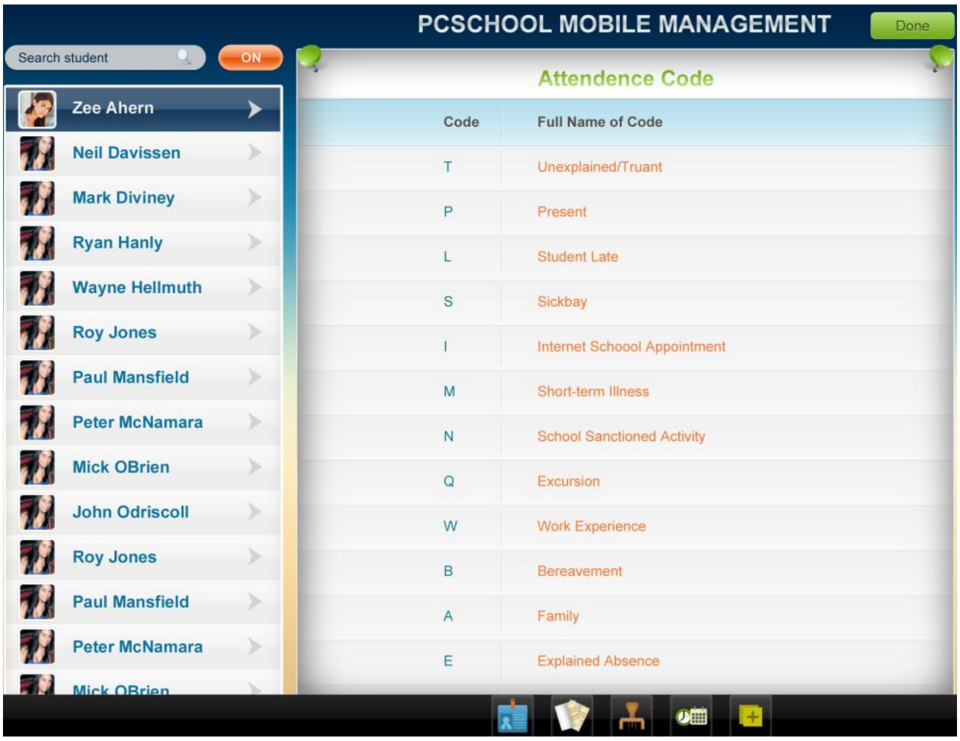


Figure 5.20: Information codes to explain absences

Screen features – attendance codes

Figure 5.20 shows the simple attendance codes screen, which displays the codes for each absence type.

Table 5.9 – Web services, student attendance codes screen (E)

No.	Web Service Name	Input List	Output List
E1.	Student Absence Codes	None	• *Code* • *Code description*

5.9.7 Screen name – student timetable

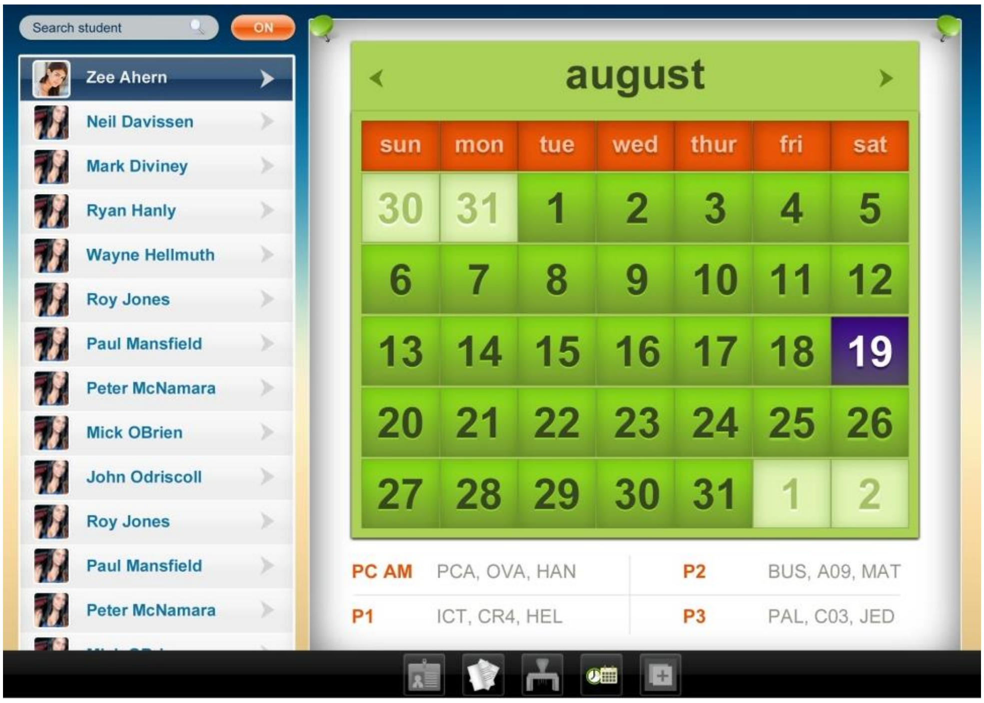


Figure 5.21: On this screen, teachers select any calendar date to locate a student.

Screen features – student timetable

Figure 5.21 highlights the functionality of the student timetable lookup screen, which displays the timetable of the student in focus. The screen has a standard calendar control that, when pressed, provides information for the missing parameter of ‘date’. With the date and student information, the student’s timetable is returned.

Table 5.10 – Web services, student timetable screen (F)

No.	Web Service Name	Input List	Output List
F1	Student Timetable	Member # Date (Missing Parameter retrieved when date is pressed on the calendar control)	• *Period* • *Subject code* • *Room code* • *Teacher code*

5.9.8 Screen name – add appraisal

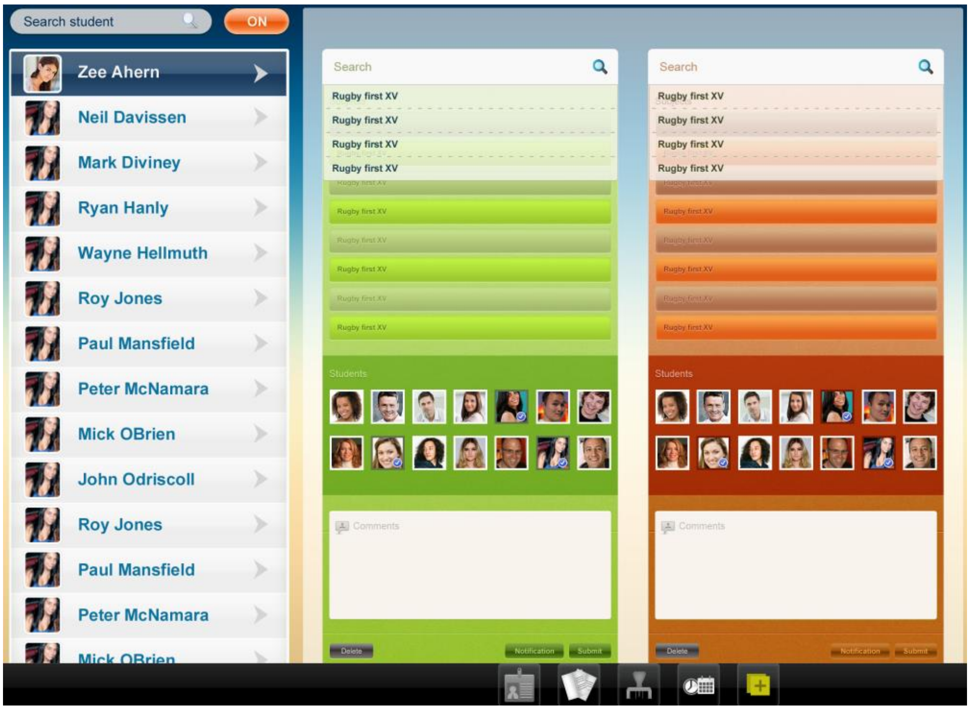


Figure 5.22: This shows the screen where a teacher can easily log appraisals of a student.

Screen features – add appraisal

Figure 5.22 shows the *add appraisals screen*, in which multiple appraisals can be searched and applied to multiple students. To make an appraisal, the student's picture is dragged to the green/red space area and 'dropped' into the bucket.

Table 5.11 – Web services, student add appraisal screen (G)

No.	Web Service Name	Input List	Output List
G1	Behaviour Type Search		
G2	Add Behaviour Instance	Missing Parameter	• *Behaviour type* • *Behaviour instance* • *Behaviour type* • *Student #* • *Teacher reporting* • *Period* • *Subject* • *Comment*

5.9.9 Screen name – emailing comments

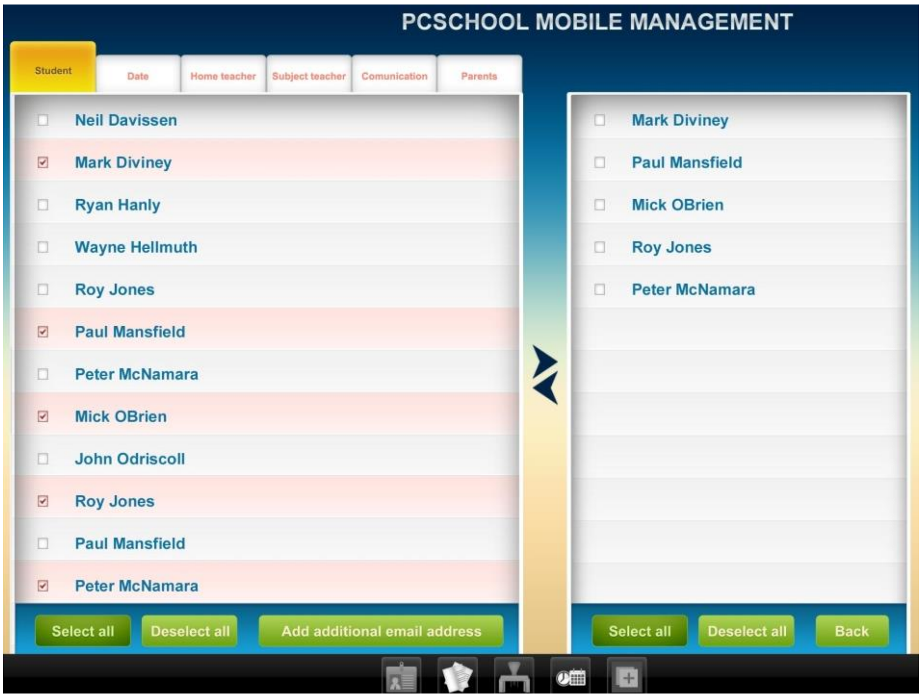


Figure 5.23 This shows the email module, where anyone related to the student can be notified easily of the student's behaviour.

Screen features – emailing comments

Figure 5.23 shows the email notification screen where a user can select the list of people to send the emails to about the behaviour appraisal applied to the student. Comments made in the appraisal screen are automatically added in the body of emails sent.

Table 5.12 – Web services, student emailing comments screen (H)

No.	Web Service Name	Input List	Output List
H1.	Home teacher	Tab choice	• *home teacher*
H2.	Subject teachers	Tab choice	• *subject teachers*
H3.	House guardian	Tab choice	• *house guardian*
H4.	Parents	Tab choice	• *relevant parents*
H5.	Make email list	Text, emails	

5.9.10 Screen name – student app interface

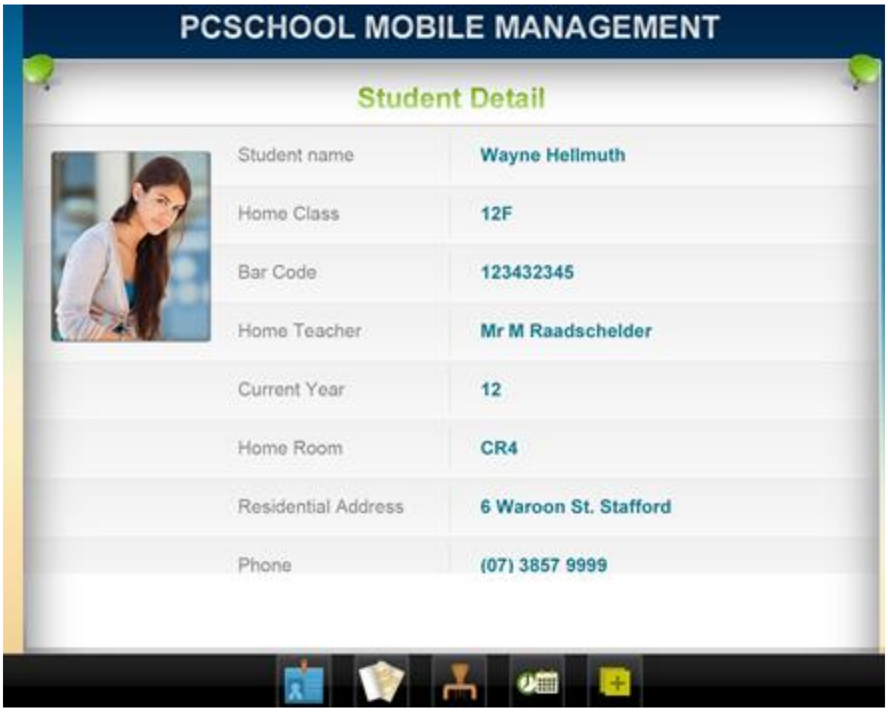


Figure 5.24 shows the interface for the student app.

Screen features – student APP – student details

Figure 5.24 is the *student details screen*, which shows a number of web-services that are successfully called in parallel. The student app runs in the background (suspended state). Bluetooth is automatically turned on through the opening of the app. This app has no other functionality.

Table 5.13 – Web services, student detail screen (B)

No.	Web Service Name	Description	Input List	Output List
B4	Student picture	Return student picture based on UDID, member #, and student code.	Current student	*.jpeg picture*
B5	Student details		Current student	*All student details*

This section has provided the design documentation for the artefact development. Within this design all of the architectural, functional, and design requirements have been incorporated. The next section of this chapter makes a brief statement about the construction of the artefact.

5.10 CONSTRUCTION OF THE ARTEFACT

An instantiation of a novel artefact is developed during this stage of the design cycle, and the artefacts design requirements are incorporated during the build process (Nunamaker, Minder & Titus, 1991; Peffers, Tuunanen, Rothenberger & Chatterjee, 2007; Hevner & Chatterjee; 2010). Knowledge obtained from the construction process is added to the CDR.

5.11 DESIGN TESTING AND EVALUATION

Hevner et.al (2004) states that the goal of behavioural science is to seek truth, while the goal of design science is to seek utility – and that these two goals are inseparable. "Truth informs design and utility informs theory" (Hevner, March, Park & Ram, 2004, p. 80). Both artificial and naturalistic evaluation methods are applied in this research to evaluate the truth and utility gained from it,.

The aim of the evaluation stage is to determine how well the instantiation of the artefact meets the needs specified by the business/research problem. The artificial evaluation methods will determine whether the artefact is working without errors or 'bugs', and whether it meets the functional specification. The naturalistic evaluation methods will determine whether the solution works according to "naturalistic" metrics, which include the administration of a second IS-impact and UTAUT questionnaire to evaluate behavioural changes resulting from the artefact's instantiation. As a result, knowledge about design products and processes is produced. The second measure of specific behavioural outcomes will facilitate analyses of the relationships between the changes to the artefact and changes to behavioural outcomes. Finally, information about the nature of student/teacher behavioural interactions/outcomes can be discerned in this cycle. This next part of this section describes the artificial and naturalistic methods applied to evaluate the artefact.

5.11.1 Artificial evaluation methods

The artificial testing methods used to evaluate the artefact can be viewed in Table 5.13, where both 'black box' and 'white box' testing are completed. Black box testing is defined as functional testing, as it focuses on ensuring that the outputs of the artefact comply with documented and expected outputs. This testing ignores the internal components and mechanisms of the artefact. Functional, system, acceptance and beta testing (identified in Table 5.4), are considered black box testing. White box testing examines the structural components and internal mechanism of the IS. Predominantly, white box testing is concerned with the individual units of coding (classes) and their interaction with other code classes.

The complete list of all of artificial testing methods used in this study can be found in Table 5.13 (above). The test scripts for each of the web-services methods (white box) can be found in Appendix 5, while end-user acceptance testing scripts can be found in Appendix 6 (black box).

5.11.2 Naturalistic evaluation methods

The naturalistic testing methods can be seen in Figures 3.1 and 3.2, and a detailed description of them can be found in the methodology chapter. The results for the UTAUT, IS-impact, and convergent interviews can be found in the results chapter.

Table 5.14 – Artificial software evaluation types

Type	Purpose	General Scope	Opacity	Responsible to test
Unit	Code structure.	Small unit of code no larger than a class	White box	Programmer
Integration	Code structure working in multiple classes of code.	Multiple classes	White box	Programmers
Functional	Functional requirements using test case scenarios.	Total artefact	Black box	Independent tester
System	Requirements analysis – system as a whole.	Total artefact in representative environments	Black box	Independent tester
Acceptance	Requirements analysis to customer satisfaction.	Total artefact in customer's environment	Black box	Relevant stakeholders
Beta	Ad hoc.	Total artefact in customer's environment	Black box	Relevant stakeholders
Regression	Testing for unintended changes during a change control process.	Any of the above	White box	Programmers / independent testers

This section has described both the artificial and naturalistic testing methods used for this thesis. The results for the UTAUT, IS-impact Scale, and Convergent Interviews can be found in chapter 6 – the Rigor Cycle chapter.

5.12 CONCLUSION

This chapter discussed those steps completed in the design, development, instantiation and evaluation of the IS artefact. For the purpose of this research, these steps were referred to as the design cycle. The design cycle methodology used in this chapter closely aligned with that suggested by Alturki, Gable and Bandara (2011), and was chosen because it is distinctly comprehensive in comparison to other DSR methodologies.

This chapter contained thirteen sections. Outside of the introduction and conclusion, each part of this section closely aligned with the eleven steps of the design cycle methodology. In these parts: the research goals were stated; an evaluation on the viability of a number of solution pathways was completed; and the research scope was defined. These parts resolved whether this research fitted within the design science paradigm, and established the exact research type as a ‘design research’. The themes of this research, both construction and evaluation, were resolved, and the requirements for the design and development of the artefact were communicated in the context of alternative solutions. Finally, this section made statements about the development of the artefact and how it was evaluated using artificial and naturalistic methods.

The next chapter is the Rigor Cycle chapter, where the detailed results from the naturalistic testing are presented. The analysis of these results and what they mean for design theory are discussed in the final two chapters of this thesis.

CHAPTER 6: RESULTS

6.1 INTRODUCTION

Chapter 3 reported on the development and validation of the data collection instruments used for this study. The purpose of this chapter is to report the results for each hypothesis by using the instruments described in Chapter 3 to a sample of teachers, parents and students within one test site. The sample size for this research was 94 teachers and 1238 students. Of the teachers, 38.09% responded to both surveys. The same survey was applied pre- and post-implementation of the artefact and the time between both surveys was six months, reflecting the length of the artefact trial period. After the quantitative surveys were collected, twelve staff members were selected for interviews. A technique called convergent interviewing was used to illicit information from the interviewees about their experiences and beliefs related to three topics: the trial artefact; the use of data and IS to inform practice; and on data use in the context of their organisation. For this research, both quantitative and qualitative results were obtained to triangulate the effects of the instantiated artefact to end-users and its impact on the organisation.

This chapter has eight main sections other than this section. The second section states the research questions that are addressed in this chapter. Section 3 states the data analysis techniques used for each of the research questions investigated. Section 4 states the data preparation activities undertaken. Section 5 provides details about the survey sample. Section 6 discusses the construct reliability for the UTAUT and IS-impact scales. Sections 6 and 7 provides the results for each of the research questions, and the final section concludes this chapter.

6.2 RESEARCH QUESTIONS ANSWERED IN THIS CHAPTER

Three questions were formulated for this research: one investigated the teacher’s engagement with the newly instantiated; a second investigated the impact of instantiated artefact; and the third investigated how data was perceived and used as a tool for improving teacher practice. These research questions were:

6.2.1 Research questions – design science

Table 6.0 – Hypotheses investigated in this study	
H1	**Did stakeholders engage with the artefact?**
h1	The new artefact will positively influence teacher's intention to use it.
h2	PE, EE, SI, FC will mediate teacher's intention to use the new artefact.
h3	The new artefact design will have an impact on the individual.
h4	The new artefact design will lead to increased use.
H2	**What was the impact of the artefact?**
h5	The new artefact will improve perceptions about the System and Information Quality.
h6	The new artefact will have a positive Impact on the Individual and the Organisation.
h7	The new artefact will improve the quality of data measuring student behaviours.
H3	**How was data perceived and used as a tool for improving student pastoral care?**
h8	Teachers will perceive the artefact has having utility for their role.
h9	Teachers will use the artefact uninhibited by exogenous factors to the artefact.
h10	Stakeholders will perceive a positive relationship between artefact quality and their reporting behaviours.
h11	Teachers will perceive a positive relationship between their reporting behaviours and student outcomes.

PE – Performance Expectancy, EE – Effort Expectancy, SI – Social Influence, FC – Facilitating Conditions

6.3 DATA ANALYSIS TECHNIQUES FOR THIS STUDY

This section begins by explicitly describing the data analysis techniques used in this study. The second section describes how these data analysis techniques were employed for each research questions in this thesis.

6.3.1 Data analysis techniques in detail

The five quantitative techniques used in this study included: descriptive statistics; Pearson's r correlations; t-tests; Wilcoxin (non-parametrix tests); and ANOVAs. Additionally, a qualitative technique evaluated the data by identifying, classifying, and counting key terms and phrases collected from twelve (12) interview passages.

Descriptive statistics

Descriptive statistics is a process of describing the features and characteristics of a collection of information, usually quantitative in nature. They differ from inferential statistics (or inductive statistics) in that they summarise a sample and its activities. The purpose of inferential statistics, using probability theory, is to learn about the population that the data sample is thought to represent. Descriptive statistics, however, simply describe the collected data. In this study, SQL data mining and the resultant data is used to describe the teacher's engagement (use) with the legacy information system and the new artefact.

Pearson's r Correlation

Correlation analyses are used to define the direction and strength of a linear relationship between two variables. Pearson *r* is designed to examine multiple continuous variables. The correlation coefficients (*r*) will have a value range between –1 and +1. The valence of the value indicates a negative or positive relationship. An *r* value of –1 or +1 indicates a perfect correlation.

Paired sample t-tests (repeated measures)

A *t*-test is a statistical examination of two population means. A two-sample *t*-test examines whether two samples are different. A *t*-test is commonly used when the variances of two normal distributions are unknown and when the sample sizes are small. The test statistic in the *t*-test is known as the *t*-statistic. The *t*-test looks at the *t*-statistic, *t*-distribution and degrees of freedom to determine a *p* value (probability) that can be used to determine whether the population means differ (<http://www.investopedia.com/terms/t/t-test.asp>). In this research, the paired sample *t*-test uses one categorical independent variable (i.e. pre- and post-test time), as well as one continuous dependent variable (i.e, each construct within the IS-impact and UTAUT scales).

Wilcoxin test

The Wilcoxin test is a non-parametric test used when the sample size is relatively small. It performs the same function as a *t*-test, however, it takes into account uneven distributions when comparing two groups from the sample. In small sample sizes there is a greater chance that the distribution is not normal. The Wilcoxon statistical test is used to measure differences between the two repeated, but related, samples taking into account that the distribution may not be normal. For this sample, the results for both *t*-tests and Wilcoxin tests were the same for each hypothesis tested.

Mixed between-within analysis of variance (ANOVA)

Mixed between-within subjects ANOVA (sometimes known as a split-plot ANOVA) utilises two types of one-way ANOVA into one analysis. It uses a 'between-group' ANOVA and a 'within-subjects' ANOVA. This model requires 'one-between-groups' independent variable (e.g. type of intervention), one 'within-groups' independent variable (pre and post scores), and one 'continuous' dependent variable (e.g., scores for some social behaviour). This type of ANOVA is used to test for differences between two or more independent groups while subjecting participants to repeated measures.

Interview data

In this thesis, the methodology chapter describes the process for the interviews in detail. When all interviews had been completed, the key issues were categorised and grouped using techniques suggested by Dick (2000). Themes were analysed by grouping the key issues according to their differences and similarities.

6.3.2 Data evaluation techniques applied for each research questions.

Table 6.1 summarises the data analysis techniques used in this study.

TABLE 6.1 – Data analysis techniques used in this study

	Descriptive Statistics	***Pearson's Correlations***	***t-test / Wilcoxin test***	**ANOVA**	**Interview Data**
H1			**X**	**X**	
H2		**X**	**X**		
H3				**X**	
H4	**X**		**X**		
H5		**X**	**X**		
H6		**X**	**X**		
H7	**X**				
H8					**X**
H9					**X**
H10					**X**
H11					**X**

Hypothesis 1 – data analysis techniques

H1: *The new artefact will positively influence teachers' intention to use it.*

Two statistical data analysis techniques were used to address H1: *t*-tests and ANOVAs. The *t*-test statistical technique used, compared the continuous dependent variable (behavioural intention) across the two, both pre and post measure. Where the behavioural intention construct was significantly different, then it could be concluded that the artefact redesign had an effect on the end-user's behavioural intention to use an IS when recording student behaviours.

Table 6.2 shows the second data analyses used to address H1. It shows that ANOVAs are used to examine the correlations between the 'between group' IV (gender, age, role type, time in role, time in organisation), and the continuous DV (behavioural intention).

Table 6.2 – One-way between-groups analysis of variance

	Between group IV	Within group IV	Continuous DV
*ANOVA	Gender	Time	Behavioural Intention
*ANOVA	Age	Time	Behavioural Intention
*ANOVA	Role Type	Time	Behavioural Intention
*ANOVA	Time in Role	Time	Behavioural Intention
*ANOVA	Time in Organisation	Time	Behavioural Intention

* A one-way between-groups analysis of variance (ANOVA) for this analysis.

Hypothesis 2 – data analysis techniques

H2: *Performance expectancy, effort expectancy, social influence, facilitating conditions will mediate teacher's intention to use the new artefact.*

These two statistical data analysis techniques were used to address H2: a paired-sample *t*-test, and Pearson's *r* correlation (the application of these are described in Table 6.3). The paired-sample *t*-test is employed to examine changes in attitudes with respect to the UTAUT constructs of: performance expectancy, effort expectancy, social influence, hedonic motivation, facilitating conditions and habit. The potential changes to these constructs are measured across the two surveys applied pre and post-implementation of the trial artefact.

Table 6.3 – Statistical data

	Statistical test	Dependent variable	Independent variable
H2	*t*-test	Performance expectancy, effort expectancy, social influence, hedonic motivation, facilitating conditions, habit	Time
H2	Pearson's Correlation	Performance expectancy, effort expectancy, social influence, hedonic motivation, facilitating conditions, habit	Behavioural intention
H2	Pearson's Correlation	Behavioural intention	Appraisal frequency
H2	Pearson's Correlation	Facilitating conditions, habit	Appraisal frequency

The second set of data analyses for H2 uses Pearson's correlation coefficient to examine the relationships between: i) performance expectancy, effort expectancy, social influence, hedonic motivation, facilitating condition, habit and behavioural intention; ii) behavioural intention and appraisal frequency; and iii) facilitating conditions, habit and appraisal frequency. *Mean, Standard Deviations, Effect sizes and Cohen's d*, are provided for all Pearson's correlations that are calculated.

Hypothesis 3 – data analysis technique

H3: *The new artefact design will have an impact on the individual.*

The data analysis technique used to address H3 was a one-way, between-groups analysis of variance. Table 6.4 shows that ANOVAs are used to examine the correlations between the 'between group' IV (gender, age, role type, time in role, time in organisation), and the 'continuous' DV (individual impact). Importantly, role type is scrutinised within this question.

Table 6.4 – One-way between-groups analysis of variance

	Between group IV	Within group IV	Continuous DV
*ANOVA	Gender	Time	Individual impact
*ANOVA	Age	Time	Individual impact
*ANOVA	Role type	Time	Individual impact
*ANOVA	Time in role	Time	Individual impact
*ANOVA	Time in organisation	Time	Individual impact

Hypothesis 4 – data analysis technique

H4: *Did the newly instantiated artefact lead to increased use?*

Two statistical techniques are employed to address this hypothesis: paired sample *t*-test, and SQL data analysis. The *t*-test statistical technique compared the continuous dependent variable (appraisal frequency – UTAUT) across the two, both pre and post measures.

Data mining of the SQL database provided descriptive statistics on actual use of the legacy and trial artefact, and describes phenomena. First, the use patterns of the new artefact over the six-month trial are described, and then compared with the historical use patterns over the same period for the previous year. 'Use' differences between staff members who used the new artefact and those who continued to use the legacy IS were examined (particularly, gender and teacher type). Finally, the types of reported behaviours (categories of behaviours) are presented in this section.

Hypotheses 5 & 6 – data analysis techniques

H5: *The new artefact will improve perceptions about the system and information quality.*

H6: *The new artefact will have a positive impact on the individual and the organisation.*

Table 6.5 – Statistical data

	Statistical Test	Dependent Variable	Independent Variable
H5&H6	*t*-test	Individual Impact, Organisational Impact, System Quality, Information Quality, Satisfaction.	Time
H5&H6	Wilcoxin's test	Individual Impact, Organisational Impact, System Quality, Information Quality, Satisfaction.	Time

The data analysis techniques used to investigate H5 and H6 can be seen in Table 6.5. To address H5 and H6, a paired-sample *t*-test is employed to examine changes in individual impact, organisational impact, system quality, organisational quality, and satisfaction.

The second set of data analysis uses Wilcoxin's non-parametric tests; these are similar to the *t*-test, except they take distributions that may not be normal in to account.

Hypothesis 7– data analysis techniques

H7: *The new artefact will improve the quality of data measuring student behaviours.*

Data mining of the SQL database provided descriptive statistics on the amount and type of behavioural data entered through both the instantiated artefact and the legacy IS.

Hypotheses 8, 9, 10 and 11 – data analysis techniques

H8: *Teachers will perceive the artefact has having utility for their role.*

H9: *Teachers will use the artefact uninhibited by exogenous factors to the artefact.*

H10: *Stakeholders will perceive a positive relationship between artefact quality and their reporting behaviours.*

H11: *Teachers will perceive a positive relationship between their reporting behaviours and student outcomes.*

For hypotheses 8, 9, 10 and 11, qualitative analyses are completed using coding processes found in grounded theory (Glaser, 1994). This study follows processes as stated by Babchuk (1997). Data is taken from the interview passages by extracting the informant’s words and/or phrases. These concepts are then classified according to a predefined schema, and as defined by the goals of the research. These classified words and concepts are further classified by their frequency across the various role types of the informants.

6.4 DATA PREPARATION

6.4.1 Survey data preparation

The survey data for this study were prepared for analysis by assigning a value of ‘5’ to those questions where the response equalled ‘strongly agree’ and a value of ‘1’ to those responses that equalled ‘strongly disagree’. Reverse scoring was applied to items 19, 23, 25, and 28. The questionnaire used in this study is in Appendix 9. Once the responses to each question had been assigned a value, the relevant questions for each scale were grouped, and the newly named constructs that reflected the scale were formed (e.g. performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, habit, behavioural intention, and frequency of use). The differences between group means on these scales were then analysed.

6.4.2 Interview data preparation

Once the first round of interviews had been conducted, the interviews were individually interpreted. The credibility of the findings was improved through a coding process, as found in grounded theory (e.g. Glaser, 1992), and the approach taken in this thesis follows Babchuk (1997). First data/interview is recorded, then keywords or phrases and concepts are noted and classified.

The first round of interviews was analysed to identify areas of similarity and disagreement in the collected data. New questions were devised to further identify and explore how widely identified phenomena occurred (Dick, 1998). This meant altering the interview design and the probes was necessary in successive interview rounds. Finally, a compiled set of results – highlighting keywords, phrases, and concepts – was produced as part of this results section.

6.5 SURVEY SAMPLE

The following section describes the survey sample. First, the age and gender of the sample are shown graphically; then the role types, experience in those roles, types, and years at the College are then described in detail.

Figure 6.0 shows that the age distribution for the male respondents in this survey looks normal. The one for females, however, looks skewed towards the younger age categories. The highest number of respondents to the survey was the male 45–54 age category. Females had a relatively low number of respondents to the survey across the 35–44, 45–54, and 65-74 age categories.

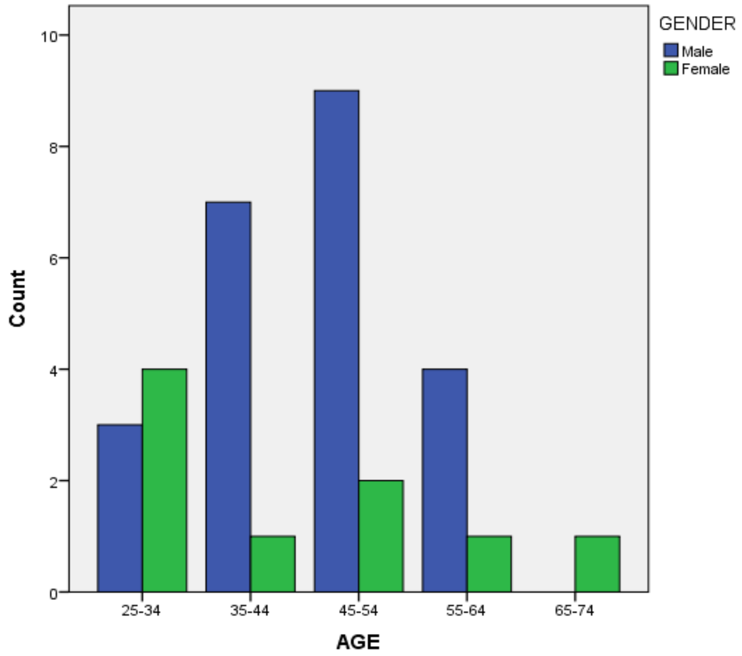


Figure 6: Survey sample showing the gender and age distribution for respondents

Table 6.6 (below) shows the role types for each respondent in the survey, with teachers having the highest frequency (17) followed by heads of curriculum (11).

Table 6.6 - Role types of survey respondents

Role type	Frequency	%	Cumulative %
Teacher	17	53.10	53.10
House guardian	3	9.40	62.50
Head of curriculum	11	34.40	96.90
Vice rector	1	3.10	100.00
Total	**32**	**100.00**	

Table 6.6 highlights the frequency and percentage of respondents by role type. Table 6.7 highlights the frequency and percentage of respondents in the sample, according to their experience in their current role. Sixty-eight per cent of respondents indicated that they had 10 years or less experience in their current role.

Table 6.7 – Experience in current role (years)

Role length	Frequency	%	Cumulative %
1–2	8	25.00	25.00
3–5	6	18.80	43.80
6–10	8	25.00	68.80
11–15	4	12.50	81.30
16–20	2	6.30	87.50
20+	4	12.50	100.00
Total	**32**	**100.00**	

Table 6.8 (below) describes the respondents according to their ‘length of employment’, and shows that most (34.40%) have worked at the College between 6 to 10 years.

Table 6.8 – Employment length at college (years)

Role Length	Frequency	%	Cumulative %
1-2	5	15.60	15.60
3-5	3	9.40	25.00
6-10	11	34.40	59.40
11-15	4	12.50	71.90
16-20	2	6.30	78.10
20+	7	12.90	100.00
Total	**32**	**100.00**	

6.6 CONSTRUCT RELIABILITY

This section contains data about the validity and reliability of the UTAUT and IS-impact constructs used in this study. The reliability of a measure refers to the degree to which the instrument is free of random error, and is concerned with consistency and the stability of the measurement. Internal consistency tends to be a frequently used type of reliability in the IS domain (Sekaran, 2003). In this study, Cronbach’s coefficient alphas, which are calculated based on the average inter-item correlations, were used to measure internal consistency. The reliability coefficient test was run on SPSS for each set of constructs and the results are presented in Tables 6.9 and 6.10. Overall, the result shows that all *alpha* values of the study instrument are reliable and exhibits appropriate construct reliability. According to DeVellis (2012), the Chronbach’s ideal *alpha* coefficient for each construct and the scale should be above 0.7. He points out, however, that Chronbach alpha values are quite sensitive to the number of items in the scale. With scales that have less than ten items, it is common to find low Chronbach values (e.g. 0.5). Tables 6.9 and 6.10 shows Cronbach's coefficient *alpha* for each of the constructs found within the IS-impact and UTAUT scales. The system quality construct within the IS-impact scale has a Chronbach alpha less than 0.7 (0.63).

Table 6.9 – IS-impact construct validity – internal reliability

Construct	No. of Items	Cronbach Alpha (α)
Individual impact	4	0.85
Organisational impact	8	0.93
Information quality	10	0.74
System quality	15	0.63
Satisfaction	7	0.94
IS-impact scale overall	44	0.94

The results below in Table 6.10 show that the UTAUT instrument is reliable and has construct reliability. All items within UTAUT, with the exception of Habit (0.67) had a Chronbach *alpha* greater than 0.7.

Table 6.10 – UTAUT construct validity – internal reliability

Construct	No. of Items	Cronbach Alpha (α)
Performance expectancy	3	0.88
Effort expectancy	4	0.82
Social influence	5	0.90
Facilitating condition	3	0.78
Hedonic motivation	3	0.93
Habit	3	0.67
Behavioural intention	3	0.91
Frequency of use	6	0.75
Appraisal behaviour	2	0.82
UTAUT scale overall	30	0.87

6.7 SURVEY RESEARCH RESULTS

This section provides the results for each of the research questions under the headings described by the hypotheses.

6.7.1 Did the redesign of the instantiated artefact influence teacher's intention to use it?

The first set of results examined changes to the 'behavioural intention' construct measured across the two surveys with a paired-samples *t*-test using repeated measures, both pre and post application of the new artefact. The results showed that there was no significant differences between pre ($M = 14.47$, $SD = 3.84$) and post ($M = 15.75$, $SD = 3.16$), $t\,(31) = 1.72$, $p = 0.096$ application of the artefact, with respect to the behavioural intent to use the new artefact to make appraisals for students.

The second set of analyses examined whether gender, age, role, 'time in role', and 'time in organisation' (demographic factors) were significant 'between group' factors. These analyses can be seen in Table 6.11. The ANOVA in Table 6.11 refers specifically to a factorial repeated measure ANOVA.

Table 6.11 –Analyses of 'between group' IVs, 'within group' IVs and 'continuous' DVs

	Between group IV	Within group IV	Continuous DV
ANOVA	Age	Time	Behavioural intention
ANOVA	Gender	Time	Behavioural intention
ANOVA	Role	Time	Behavioural intention
ANOVA	Time in role	Time	Behavioural intention
ANOVA	Time in organisation	Time	Behavioural intention

Age and behavioural intention

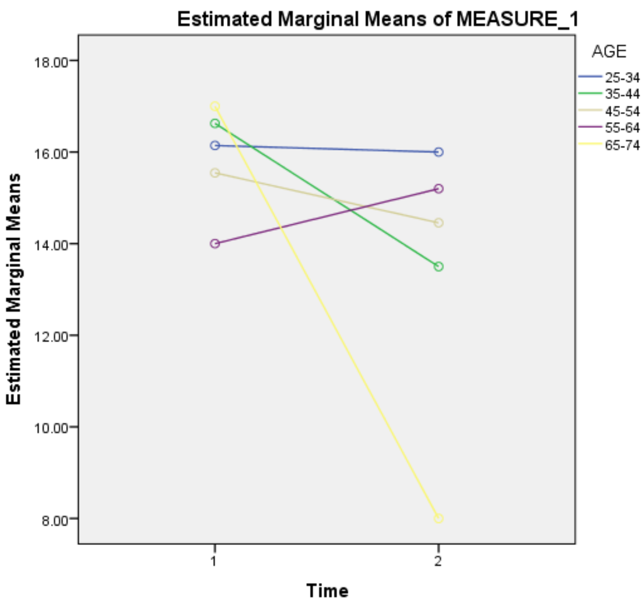


Figure 6.1: Showing the changes to 'behavioural intention' pre and post application of the artefact across each age group surveyed.

Within subjects main effect

The results showed that there was a significant effect of (IV) time on (DV) behavioural intention at the $p < 0.05$ level. The Wilks' Lambda (λ) test indicated a significance with $p < 0.05$. $F(1,4) = 6.02$, $p = 0.021$, $\eta^2 = 0.182$. According to Cohen (1988), a partial eta squared score larger than 0.14 is considered significant. The effect size for this result, as measured by partial eta squared = 0.182 and, therefore, not significant. See the section below on tests for homoscedascity (i.e. Box's test and Levene's test).

Between subjects main effect

The results showed that there was not a significant effect of (IV) age on (DV) behavioural intention at the $p < 0.05$ level. $F(1,4) = 0.432$, $p = 0.432$, $\eta^2 = 0.060$.

ANOVA test validity

The results of the ANOVA (factorial repeated measure, or mixed 'between-within' subjects) can only be valid if the inter-correlations have homogeneity. This is measured by two post-hoc tests: Levene's test, and Box's test.

Tests for homoscedascity

Levene's test is an inferential statistic used to measure the equality of differences in a variable calculated for two or more groups. Most statistical procedures assume that variances of the population (from which the sample is drawn) are equal. This assumption is investigated by Levene's test, which tests the null hypothesis that the population variances are equal (called homogeneity of variance, or homoscedasticity). For this study, if $p < 0.05$, it is assumed that the differences in sample variance are unlikely to have occurred from random sampling, and that there is a difference between the variances within the population.

Box's *M* tests the homogeneity of inter-correlations. "For each of the levels of the between-subjects variable, the pattern of inter-correlations among the levels of the within-subjects variable should be the same" (Pallant, 2103, p. 286). This statistic is considered to be sensitive. Significance is considered when *alpha* is less than 0.001. For the ANOVA (factorial repeated measure) to be valid, therefore, a $p < 0.001$ is required. The results of the Levene's for the 'age' ANOVA analysis indicated equal variances ($F = 0.040$, $p > 0.05$). Box's test of equality of covariance matrices was not significant ($F = 0.040$, $p = 0.842$).

Gender and behavioural intention

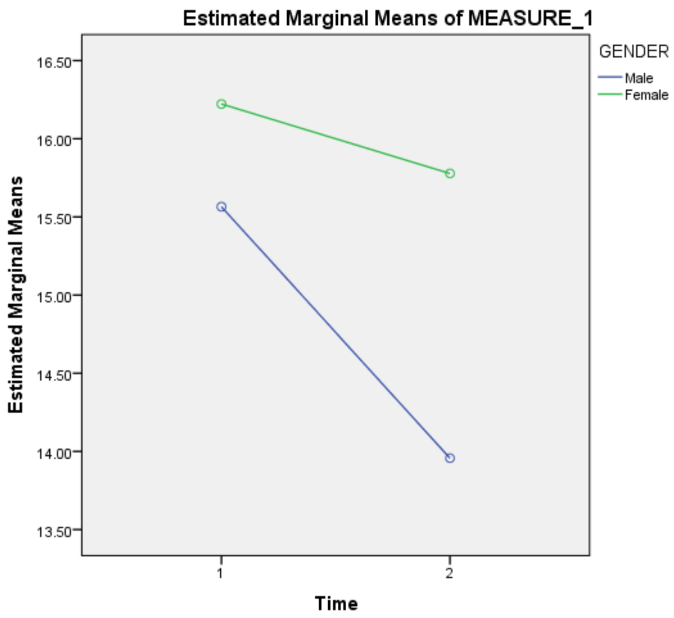


Figure 6.2 Showing changes to behavioural intention pre and post application of the artefact across each gender surveyed.

Within subjects main effect

The results showed that there was not a significant effect of (IV) time on (DV) behavioural intention at the $p < 0.05$ level. The Wilks' λ test indicated significance with $p > 0.05$. $F\,(1,30) = 1.51$, $p = 0.230$, $\eta_2 = 0.048$.

Between subjects main effect

The results showed that there was not a significant effect of (IV) gender on (DV) behavioural intention at the $p < 0.05$ level. $F\,(1,30) = 1.27$, $p = 0.269$, $\eta_2 = 0.041$

ANOVA test validity

The results of the Levene's test for the age ANOVA analysis indicated equal variances ($F = 0.040$, $p > 0.05$). Box's test of equality of covariance matrices was not significant ($F = 0.091$, $p = 0.965$).

Role type and behavioural intention

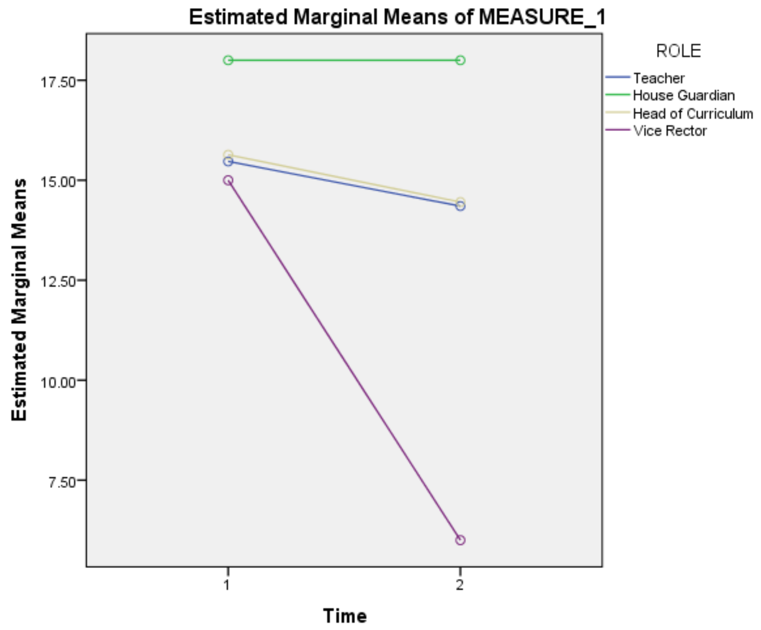


Figure 6.3 Shows the changes to behavioural intention pre and post application of the artefact, across each of the role types surveyed.

Within subjects main effect

The results showed that there was a significant effect of (IV) time on (DV) behavioural intention at the $p < 0.05$ level. The Wilks' λ test indicated significance with $p < 0.05$. $F\,(1,28) = 4.95$, $p = 0.034$, $\eta 2 = 0.150$. The partial eta squared score is larger than 0.14 and, therefore, not considered significant.

Between subjects main effect

The results showed there was not a significant effect of (IV) role type on (DV) behavioural intention at the $p < 0.05$ level. $F\,(1,28) = 2.22$, $p = 0.108$, $\eta 2 = 0.192$.

ANOVA test validity

The results of the Levene's test for the age ANOVA analysis indicated equal variances ($F = 0.935$, $p > 0.05$). Box's test of equality of covariance matrices was not significant ($F = 0.132$, $p = 0.941$).

Years of service at the College and behavioural intention

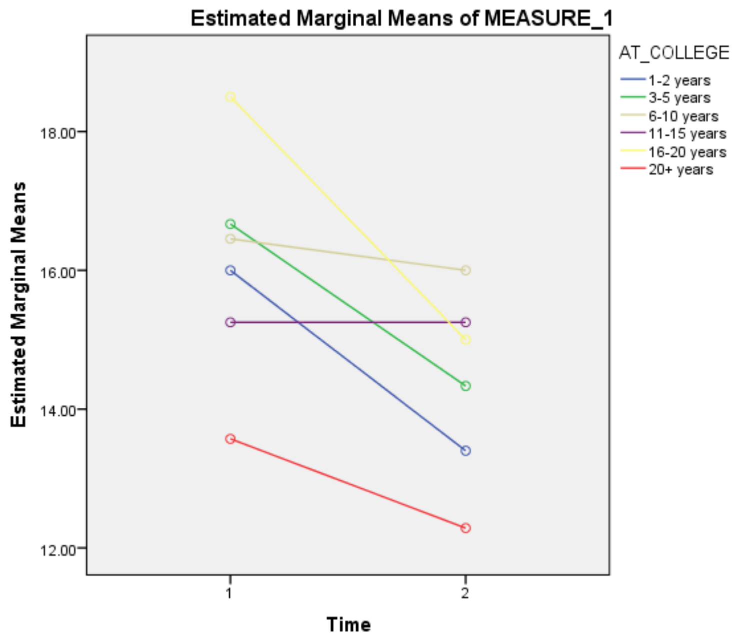


Figure 6.4 Shows the changes to behavioural intention across the number of years of service at the College pre and post application of the artefact.

'Within subjects' main effect

The results showed that there was not a significant effect of (IV) time on (DV) behavioural intention at the $p < 0.05$ level. The Wilks' λ test indicated significance with $p > 0.05$. $F(1,26) = 0.362$, $p = 0.870$, $\eta_2 = 0.065$.

'Between subjects' main effect

The results showed that there was not a significant effect of (IV) years at the College on (DV) behavioural intention at the $p < 0.05$ level. $F(5,26) = 1.46$, $p = 2.35$, $\eta_2 = 0.192$.

ANOVA test validity

The results of the Levene's for the age ANOVA analysis indicated equal variances ($F = 1.205$, $p > 0.05$). Box's test of equality of covariance matrices was not significant ($F = 0.870$, $p = 0.552$).

Years of service in role and behavioural intention

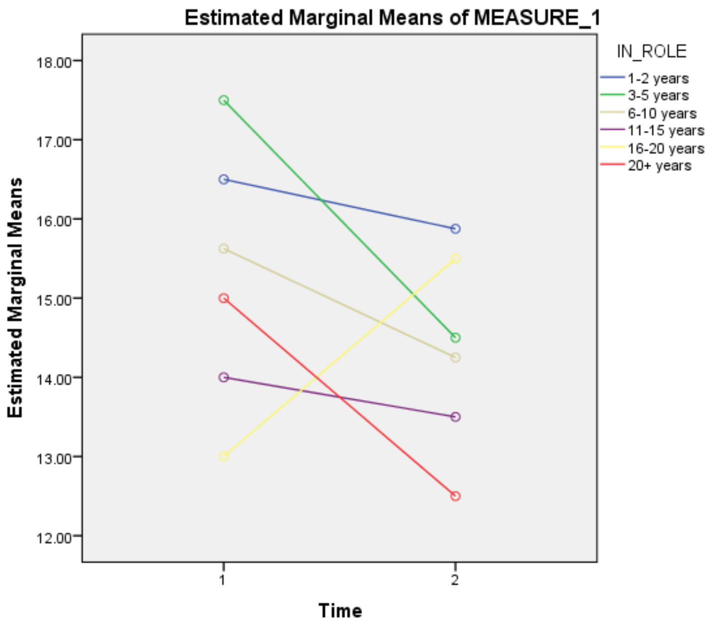


Figure 6.5 Shows the changes to behavioural intention across the number of years of service in the role pre and post application of the artefact.

Within subjects main effect

The results showed that there was not a significant effect of (IV) time on (DV) behavioural intention at the p<0.05 level. The Wilks' λ test indicated significance with $p > 0.05$. $F(1,26) = 0.613$, $p = 0.691$, $\eta^2 = 0.105$.

Between subjects main effect

The results showed that there was not a significant effect of (IV) 'years of service in the role' on (DV) behavioural intention at the $p < 0.05$ level. $F(5,26) = 0.741$, $p = 0.600$, $\eta^2 = 0.125$.

ANOVA test validity

The results of the Levene's for the age ANOVA analysis indicated equal variances ($F = 1.52$, $p > 0.05$). Box's test of equality of covariance matrices was not significant ($F = 1.027$, $p = 0.421$).

6.7.2 What factors mediated teacher's intention to use the new artefact?

The table below shows the paired sample *t*-test for the UTAUT scale.

Table 6.12 – Paired sample *t*-test for UTAUT scale

				95% Confidence				
	Mean	***SD***	***SEM***	***Lower***	***Upper***	***t***	***df***	***Sig.***
Performance expectancy	–3.40	3.65	0.64	–4.72	–2.08	–5.27	31	0.001
Effort expectancy	–4.00	4.47	0.79	–5.61	–2.38	–5.05	31	0.001
Social influence	–0.031	3.79	0.67	–1.40	1.33	–0.04	31	0.963
Facilitating conditions	–1.61	3.40	0.61	–2.86	–0.36	–2.63	30	0.013
Behavioural intention	–1.28	4.22	0.74	–2.80	0.24	–1.71	31	0.096
Appraisal frequency	–1.78	3.40	0.600	–3.00	–0.56	–2.97	31	0.006

The *t*-test results showed that the constructs of performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC), and appraisal frequency (AF) were significantly different between the pre and post-tests. Also, the constructs of social influence, and behavioural intention were not significantly different between the pre and post-tests.

Wilcoxin tests

Table 6.13 shows the constructs of 'social influence' and 'behaviour intention' were not significantly different pre and post instantiation of the artefact, but all other constructs were. These results show the same statistical significances as found through the application of the *t*-tests for each construct of the UTAUT scale.

Table 6.13 - Wilcoxin non-parametric tests for constructs in the UTAUT scale

UTAUT Construct	Mean 1	Mean 2	Z statistics	Sig (2-tailed)
Performance expectancy	9.67	15.62	–4.085	0.001*
Effort expectancy	11.75	16.63	–3.954	0.001*
Social influence	12.00	11.15	–0.604	0.557
Facilitating conditions	14.14	14.62	–2.380	0.016*
Behavioural intention	17.57	12.00	–1.338	0.186
Use	9.88	16.35	–28.34	0.003*

** Statistical Significance*

UTAUT constructs and their relationships

The various relationships between the constructs that make up the UTAUT scale are modelled in the format specified by Venkatesh, Morris, Davis and Davis (2003). Figure 6.6 (below) shows these relationships pre-instantiation of the artefact.

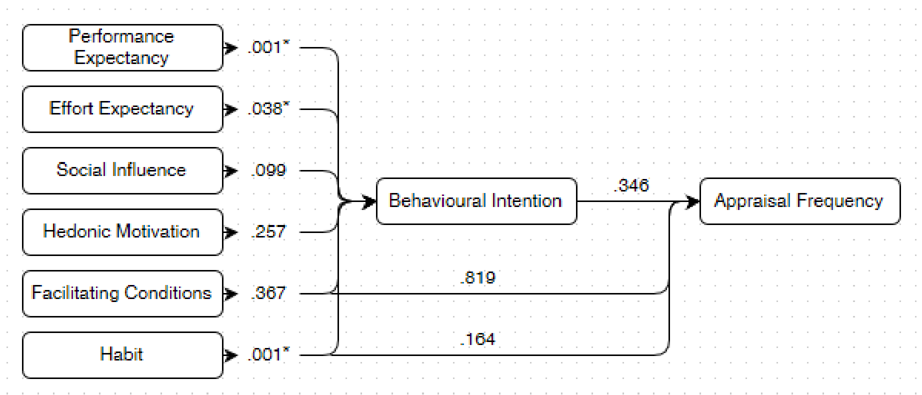


Figure 6.6: Pearson's correlations between the various constructs of the UTAUT model (pre-implementation of the artefact). The model shows that the correlations found in this study do not directly fit with the relationships specified in the Venkatesh, Morris, Davis and Davis (2003) model.

This figure shows that performance expectancy, effort expectancy, and habit were correlated to behavioural intention prior to instantiation of the artefact. Figure 6.7 (below) shows all correlations of the UTAUT model post instantiation of the artefact. In this model, the relationship between 'behavioural intention' and 'use' was established.

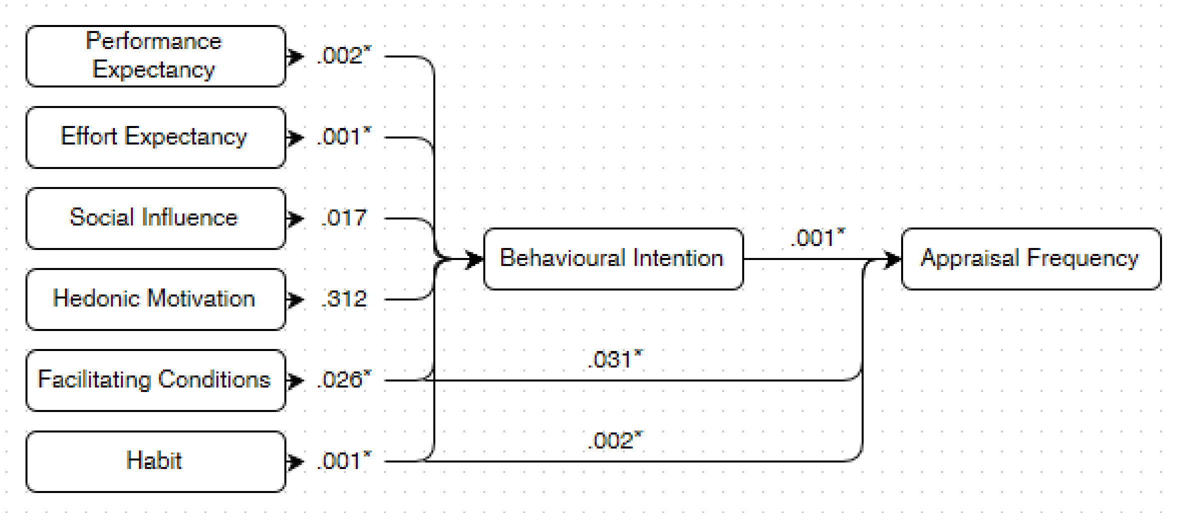


Figure 6.7: Pearson's correlations between the various constructs of the UTAUT model (post-implementation of the artefact). The model shows an increased number of construct correlations according to the relationships specified in the Venkatesh, Morris, Davis and Davis (2003) model.

Effect sizes for correlations

Effect sizes for each of the correlations examined in this study were calculated using Cohen'*sd* (Cohen, 1988). The calculations are only made for the relationships found in Figure 6.7. This formula is stated as:

$$d = M_1 – M_2/\sigma \text{ pooled, where } \sigma \text{ pooled} = \sqrt{} [(\sigma\ 1^2 + \sigma\ 2^{2)} / 2]$$

The *Effect size* and the *per cent of non-overlap* between any two constructs can be seen in Table 6.14, which shows the mean, standard deviation, effect size, and per cent of non-overlap for each of the correlations examined between variables within this study.

According to Cohen (1988), an *effect size* is considered to be small if $d = 0.2$, medium when $d = 0.5$, and large if $d = 0.8$. *Effect sizes* can also be considered in terms of the per cent of overlap between two distributions. An effect size of 0.2 indicates that the two distributions have a non-overlap of 14.7%. An *effect size* of 0.5 indicates that the two distributions have a non-overlap of 33.0%, and an *effect size* of 0.8 indicates a non-overlap of 47.4% between two distributions.

TABLE 6.14 – Ordered effect size, means and standard deviations

Construct 1	*Mean*	*SD1*	Construct 2	*Mean*	*SD2*	*Effect Size*
Performance expectancy	27.34	5.48	Behavioural intention	30.22	5.62	0.25
Effort expectancy	41.88	6.10	Behavioural intention	30.22	5.62	0.70
Facilitating conditions	27.66	5.42	Behavioural intention	30.22	5.62	0.22
Facilitating conditions	27.66	5.42	Appraisal frequency	18.15	4.07	0.71
Habit	25.97	5.51	Appraisal behaviour	18.15	4.07	0.63
Behavioural intention	30.22	5.65	Appraisal behaviour	18.15	4.07	0.77

6.7.3 Did the artefact have an impact on the individual?

Individual impact

A 'mixed between–within subjects' ANOVA analysis examined whether 'role type' (demographic factors) was significant to 'between group' factors, with respect to the perceived individual impact of the new instantiated artefact. The ANOVA in Table 6.15 refers specifically to a factorial repeated measure ANOVA.

Table 6.15 –Analysis of 'between group' IVs, 'within group' IVs and 'continuous' DVs

	Between group IV	Within group IV	Continuous DV
ANOVA	Role Type	Time	Individual Impact
ANOVA	Role Type	Time	Organisational Impact

Figure 6.8 (below) shows the *mean* scores for each role type at the College. These scores are for individual impact as a result of introducing the artefact.

Within subjects main effect

The results showed that there was a significant effect of (IV) time on (DV) individual impact at the $p < 0.05$ level. The Wilks' λ test indicated significance with $p < 0.05$. F (1,28) = 0.797, p = 0.014, η_2 = 0.079. The *partial eta squared effect size* (0.079) is considered large.

Between subjects main effect

The results showed that there was not a significant effect of (IV) role type at the College (DV) individual impact at the $p < 0.05$ level. F (3,28) = 2.72, p = 0.059, η_2 = 0.230.

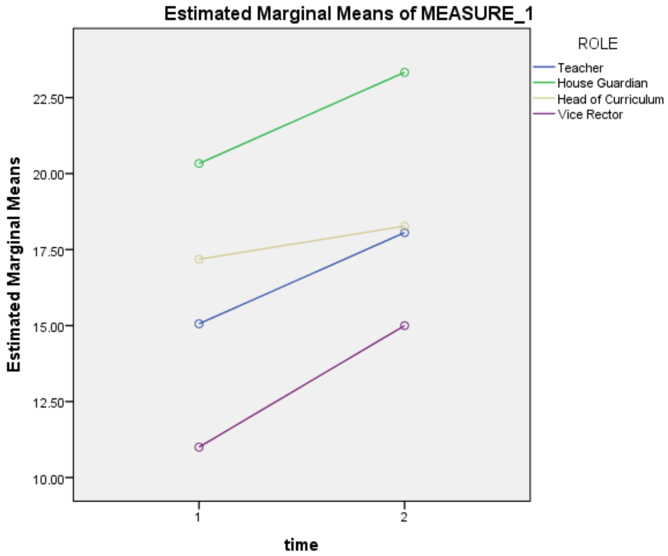


Figure 6.8: Mean individual impact scores by role type

ANOVA test validity

The results of the Levene's test for the 'age' ANOVA analysis indicated equal variances ($F = 2.78$, $p > 0.05$). Box's test of equality of covariance matrices was not significant ($F = 1.08$, $p = 0.38$).

Organisational impact

A 'mixed between-within subjects' ANOVA analysis examined whether role type (demographic factors) were significant 'between group' factors, with respect to the perceived organisational impact of the new instantiated artefact. The ANOVA in Table 6.15 refers specifically to a factorial repeated measure ANOVA. Figure 6.9 (below) shows the *mean* scores for each 'role type' at the College. The mean scores are for the perceived organisational impact as a result of the introduction of the artefact.

Within subjects main effect

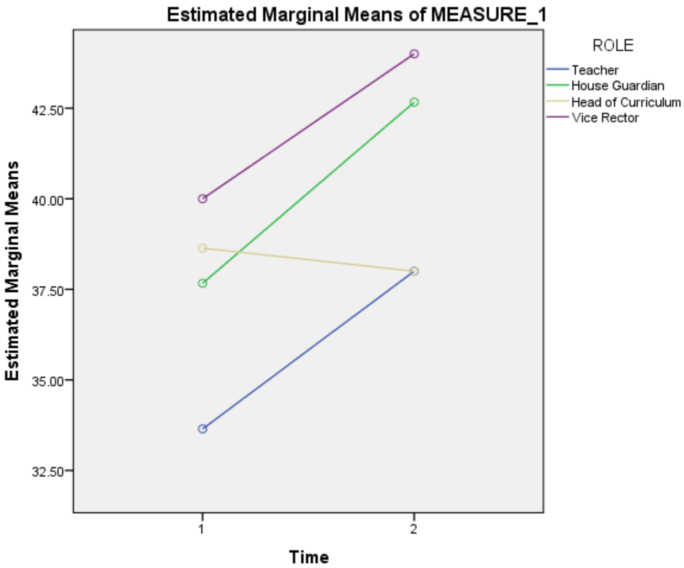
The results showed that there was not a significant effect of (IV) time on (DV) organisational impact at the $p < 0.05$ level. The Wilks' λ test indicated significance with $p < 0.05$. $F\,(3,28) = 0.189$, $p = 0.153$, $\eta 2 = 0.169$. The *partial eta squared effect size* (0.079) is considered large.

Between subjects main effect

The results showed that there was not a significant effect of (IV) ‘role type’ at the College (DV) organisational impact at the $p < 0.05$ level. F (3,28) = 1.07, $p = 0.396$, $\eta 2 = 0.099$.

ANOVA test validity

The results of the Levene’s for the age ANOVA analysis indicated equal variances ($F = 1.03$, $p > 0.05$). Box’s test of equality of covariance matrices was not significant ($F = 1.78$, $p = 0.11$).



4

Figure 6.9: Mean organisational impact scores by role type

6.7.4 Did the newly instantiated artefact lead to increased use?

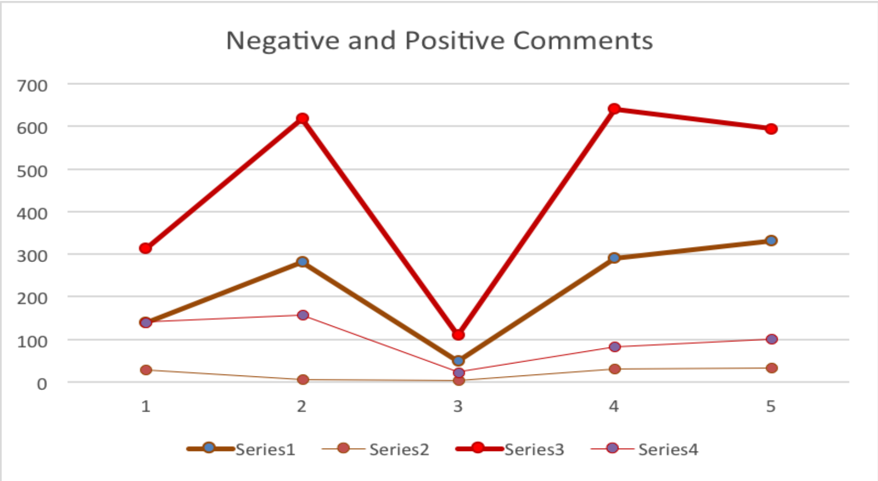
This research question is addressed by providing descriptive statistics mined from the main student data system (SDS). Table 6.16 (below) characterises the descriptive data presented for this hypothesis.

Table 6.16 – SQL data collected to address Hypothesis 3

ID.	Descriptive statistic
1	Historical comparisons between the total number of positive and negative comments reported during the trial period (2014) and the same previous 6-month period (2013).
2	Historical comparisons on the ratio of positive to negative appraisals reported by teachers during the trial period (2014), and the 6-month period (2013).
3	A comparison of reporting behaviours of those teachers who used the artefact, and those who did not participate in its trial. Total comments, type of comments and ratio of positive to negative comments are compared.
4	A comparison of reporting behaviours between primary school teachers and secondary school teachers are made.
5	A comparison of reporting behaviours between males and female teachers are made.
6	Historical comparison of the behaviour types reported in the classroom (2014 and 2013)

Historical comparisons – negative and positive comments

Figure 6.10 highlights the number of positive and negative comments made in 2014 (bold lines) compared to the previous year (non-bold lines).



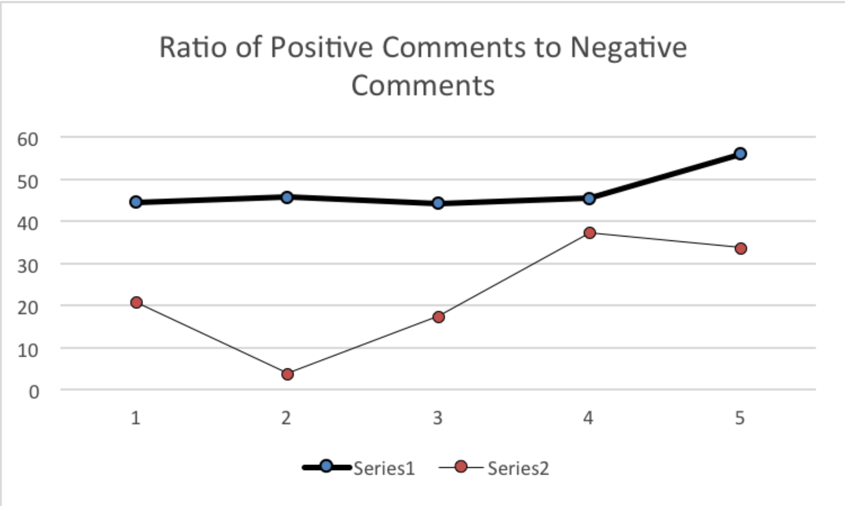
Series 1 – negative comments (2014); Series 2 – positive comments (2014);
Series 3 – negative comments (2013); Series 4 – positive comments (2013).

Figure 6.10: Negative and positive comments reported in 2013 and 2014 (during the trial period)

The trial period was for six months; however, graphs in this results section do not show data for January, as no behavioural entries were made during that month. Figure 6.10 clearly shows an increase in the number of behavioural comments recorded for students between the current and previous years. This graph represents all teachers at the College, not just those that participated in the trial of the new artefact. The data shows that the reporting of behaviours between the two years seems to follows a similar pattern – that is, the number of behaviours reported in a given month in 2014 increases and decreases similar to the equivalent month in 2013.

Historical comparisons – ratio of comments

The data shows that teachers had a greater ratio of positive to negative comments during the trial period when compared to the same period in 2013. This graph (Figure 6.11) represents all staff, whether or not they participated in the trial.



Series 1 – ratio of comments (2014); Series 2 – ratio of comments (2013).

Figure 6.11: Highlights the ratio of positive to negative comments made in 2013 (non-bolded line) and 2014 (bolded line).

Characteristics of all comments during the trial period

Table 6.17 (below) shows the number of behavioural comments made overall during the trial period. It shows the total number of positive and negative comments, as well as the ratio of these two during the trial period. The table shows that, generally, both positive and negative comments increased during the trial period, and that their ratio remained relatively constant. The month of June shows a marked increase in the number of positive comments relative to negative one – reported as 55.97%.

Table 6.17 – Month by month comparison of artefact use to make appraisals

Month	Total comments	Positive comments	Negative comments	Ratio of comments %
February	452	139	313	44.41
March	902	283	619	45.72
April	160	49	111	44.14
May	933	291	642	45.33
June	928	333	595	55.97

Comparison of IS and artefact use during trial period – by school type

Table 6.18 (below) shows the difference in use patterns for those teachers who trialled the new artefact compared to those who continued to use the legacy IS. The average number of overall behaviours reported by those teachers undertaking the trial was 69.32; compared to an average of 39.15 those using the legacy IS. Teachers generally, whether using the new artefact or the legacy IS, consistently reported more negative behaviours than positive ones.

Teachers who used the new artefact, however, had a higher ratio of positive to negative comments. Primary school teachers consistently reported a higher number of comments, with a higher ratio of positive to negative, compared to their secondary counterparts.

Table 6.18 – Comparison of user behaviour: legacy IS vs new artefact

		Total comments	Positive comments	Negative comments	Ratio of comments %
Overall	Artefact	69.33	25.92	43.41	59.68
	Legacy	39.15	10.66	28.49	39.86
Secondary	Artefact	45.49	15.06	30.43	52.12
	Legacy	38.58	9.92	28.66	36.97
Primary	Artefact	83.00	35.80	47.20	77.51
	Legacy	42.03	12.49	29.54	44.55

Comparison of IS and artefact use during trial period – by gender

The results show that females using the new artefact reported a greater average number of behavioural incidents; however, males using the legacy IS reported the highest number (see Table 6.19).

Table 6.19 – Comparison of IS and artefact use during trial period: male vs female

		Total Comments	Positive Comments	Negative Comments	Ratio of Comments %
Artefact	Male	67.29	42.71	24.58	57.04
	Female	73.63	44.87	28.75	65.26
Legacy	Male	43.53	31.60	11.93	42.28
	Female	38.70	28.20	10.50	39.08

6.7.5 Was the artefact perceived to improve Information and System Quality?

Table 6.20 (below) shows the results of the paired sample *t*-test for the IS-impact scale. The results show that the means for the constructs of information quality (IQ) and system quality (SQ) were significantly different between the pre and post-tests.

6.7.6 Did the artefact have an impact on the organisation?

Table 6.20 shows the results of the paired sample *t*-test for the IS-impact scale. All constructs within the scale showed significant differences between pre- and post-test measures. This means that the artefact had a significant effect for individual impact, organisational impact, information quality, system quality, and satisfaction.

Table 6.20 – Paired sample *t*-test for IS-impact scale

				95% Confidence				
Construct	**Mean**	**SD**	**SEM**	**Lower**	**Upper**	***t***	***df***	**Sig.**
Individual impact	–2.37	3.42	0.60	–3.60	–1.14	–3.92	31	0.001
Organisational impact	–2.68	5.97	1.05	–4.83	–0.53	–2.54	31	0.016
Information quality	–4.65	5.97	1.05	–6.80	–2.50	–4.41	31	0.001
System quality	–9.71	7.23	1.27	–12.32	–7.10	–7.59	31	0.001
Satisfaction	–7.71	8.14	1.44	–10.65	–4.78	–5.35	31	0.001

Table 6.21 (below) shows the *effect sizes* between II, OI, IQ and SQ and satisfaction. The effect size was considered large for II, IQ and SQ.

Table 6.21 – Ordered effect size, means and standard deviations

Construct 1	Mean	SD1	Construct 2	Mean	SD2	Effect Size
Individual impact	34.69	7.17	Satisfaction	68.66	8.78	0.90
Organisational impact	74.56	11.14	Satisfaction	68.66	8.78	0.28
Information quality	95.78	10.08	Satisfaction	68.66	8.78	0.82
System quality	128.97	8.78	Satisfaction	68.66	8.78	0.96

Table 6.22 (below) shows the results for the Wilcoxin's test. These show the same statistical significances found through the application of the *t*-tests for each construct of the IS-impact scale.

Table 6.22 – Wilcoxin non-parametric tests (IS-impact scale)

IS-impact construct	Mean 1	Mean 2	Z statistics	Sig (2-tailed)
Individual impact	8.50	15.25	–3.540	0.001*
Organisational impact	11.94	17.02	–2.580	0.009*
Information quality	15.80	16.63	–3.464	0.001*
System quality	5.00	16.37	–4.765	0.001*
Satisfaction	3.50	16.35	–4.482	0.001*

6.7.7 Did the artefact improve data quality?

This question is addressed by providing descriptive statistics obtained by data mining the main student data system (SDS). Table 6.23 (below) characterises the descriptive data presented to address this hypothesis.

Table 6.23 – SQL data collected to address Hypothesis 3

ID.	Descriptive statistic
1	Historical comparisons between the total number of positive and negative comments reported during the trial period in 2014, and the equivalent 6-month period in 2013.
2	Historical comparisons on the ratio of appraisals reported by teachers during the trial period in 2014, and the equivalent 6-month period in 2013.
3	Historical comparisons of the number and types of categories of behaviours reported

Comparison of types of behaviours reported – 2013 to 2014.

Figure 6.12 shows the categories of behaviour reported using the legacy IS. It also shows that the majority of reported classroom behaviours were negative (represented as the red section of the pie graph). Only a small number of behaviours were categorised as positive within the classroom. Most notable was that only 1% of reported behaviours in the classroom were related to academic behaviour. Also noted were the limited number of categories (types of behaviour) that were reported using the legacy IS: only four within the classroom in 2013.

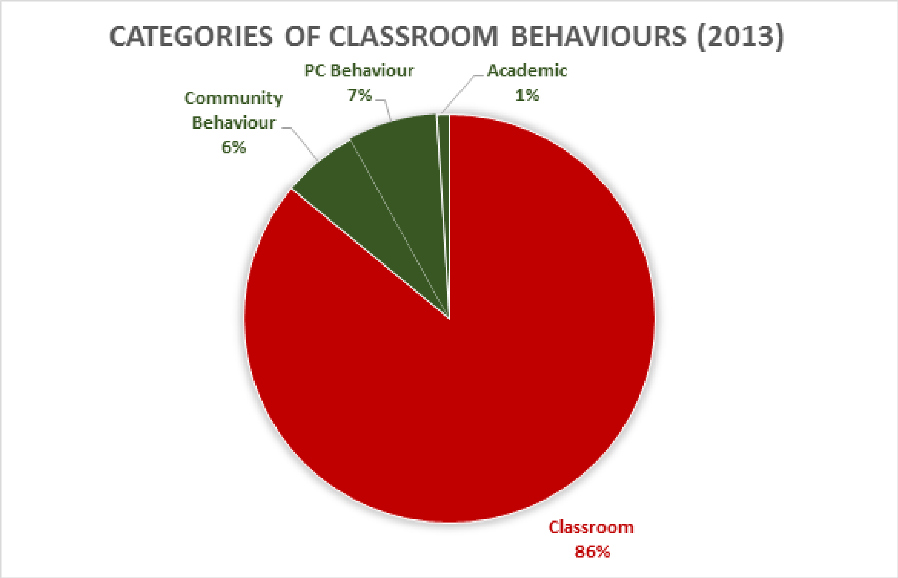


Figure 6.12: Shows the number of reported classroom behaviours and their categories in 2013.

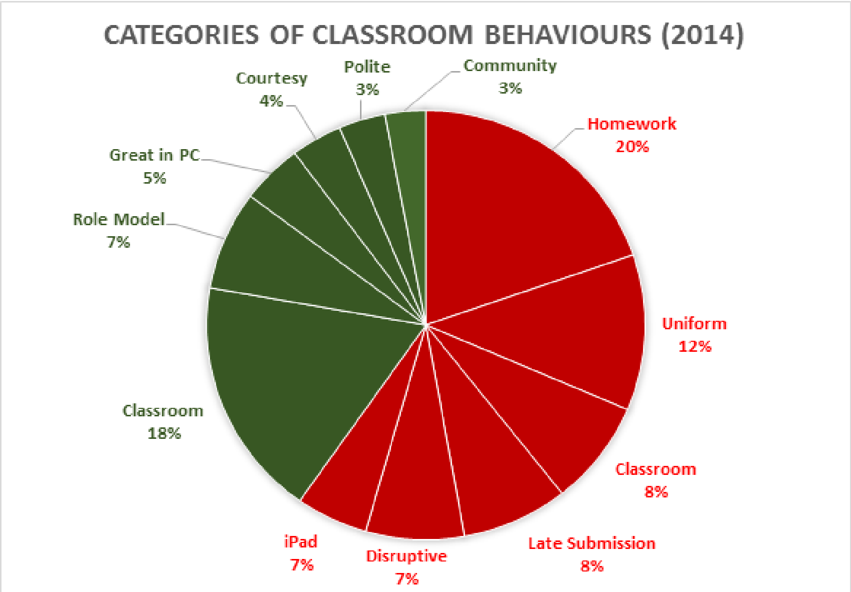


Figure 6.13: Shows the number of reported classroom behaviours and their categories in 2014.

Figure 6.13 shows the number of reported classroom behaviours and their categories in 2014, and shows the increase in positive comments. These behaviours were reported using both the legacy IS and the new artefact. It was not possible to differentiate the types of behaviours reported using the new artefact and the legacy IS.

6.8 CONVERGENT INTERVIEW RESULTS

Data from convergent interviews is provided to address the three research questions for Hypotheses 8, 9, 10 and 11. A copy of the Interview Question Guide used for these interviews is provided in Appendix 3. In this section, there are six parts: the first describes the sample of interviewees; four parts address the last four research hypotheses of this thesis; the final part summarises this section. The next part of this section describes the sample for the convergent interviews.

6.8.1 INTERVIEW SAMPLE

Table 6.24 describes the sample for the convergent interviews.

Table 6.24 – Demographic information for convergent interviewees

Round	No.	Age	Sex	Tenure in role (years)	Role	Highest level of education
1	1	35–44	M	16–20	HG	Bachelors
	2	35–44	M	16–20	HOD	Bachelors
	3	55–64	M	11–15	Teacher	Bachelors
	4	45–54	M	11–15	IT	Bachelors
2	1	25–34	F	6–10	HG	Masters
	2	45–54	M	11–15	HOD	Bachelors
	3	45–54	M	>20	Teacher	Masters
	4	35–44	M	6–10	IT	Masters
3	1	35–44	M	6–10	HG	Masters
	2	45–54	M	6–10	HOD	Bachelors
	3	45–54	F	6–10	Teacher	Masters
	4	25–34	M	0–5	IT	Masters

Twelve staff members were interviewed, including three house guardians, three teachers, three heads of departments, and three IT staff. Exactly 50% of the staff had a master’s degree, while 50% had received their bachelor’s degree. Eighty-three per cent of interviewees were male, and the age distribution of respondents was spread from 25–34 to 55–64. Table6.24 displays the demographics of the interviewees within the sample.

The following four research hypotheses are addressed as a single block – that is, the responses made in the interviews address all three directly or indirectly:

6.7.8 – Teachers will perceive the artefact has having utility for their role (H8).

6.7.9 – Teachers will use the artefact uninhibited by exogenous factors to the artefact (H9).

6.7.10 – Stakeholders will perceive a positive relationship between artefact quality and their reporting behaviours (H10).

6.7.11 – Teachers will perceive a positive relationship between their reporting behaviours and student outcomes (H10).

The information collected from the interviews is categorised under the following headings:

- the role of data and information systems in education;
- data the respondent has used to inform practice;
- engagement issues with the use of technology as a whole;
- engagement issues with information systems and data;
- quality of data;
- quality of legacy IS;
- quality of artefact;
- artefact quality correlation with teacher reporting behaviour; and
- teacher feedback link correlation to student outcomes.

As part of the data-coding process in convergent interviewing, if all three respondents in a role type reported the response, the response is viewed as significant and highlighted in blue. Two or more responses by role type and the response type are highlighted in yellow.

The role of data and information systems in education

Table 6.25 shows the varying perceptions on how data and information systems (IS) are used within education, and are grouped by role type. It shows that house guardians (HG) perceive data as a tool for tracking students' academic and behavioural outcomes, and that information systems are a repository for details such as the student's family details and timetable information.

Table 6.25 – Role of data and information systems in education

Role type:	HGs			HoDs			Teachers			IT staff		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
Track academic performance	X	X	X	X	X	X	X		X			
Track student behaviours	X	X	X	X		X			X			
Student background /circumstances	X	X	X									
Planning						X			X			
Timetable information	X	X	X			X						
Historical comparisons for cohorts and students				X	X	X	X					
For evidence-based communication				X			X					
Improve learning outcomes for students (feedback)								X	X			

Heads of departments (HoDs) primarily see the use of data and IS as a way of tracking students and their cohorts' progress. HoDs reported that data and IS are primarily used for tracking historical comparisons between semester and yearly results, while teachers primarily view them as a way of tracking student performance and as a tool for improving student outcomes.

Data that is used to inform practice

Table 6.26 shows how respondents viewed the role of information systems and data in their role. House guardians (HGs) used the widest variety of data sources in their daily practice. Because the reporting of behavioural data by teachers was perceived to be inconsistent, HGs tended to seek as many sources of information as possible to form views on student behaviours and student progress.

Table 6.26 - Data that is used to inform practice

Role type:	HGs			HoDs			Teachers			IT staff		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
External sources (e.g. NAPLAN, QCS, ICAS)						X	X					
Student SIS (summative data)	X	X	X	X	X	X	X	X	X			
Formative data (spread sheets)	X	X		X	X	X	X	X	X			
Anecdotal data (both academic and behavioural) from staff	X	X	X									
Anecdotal data (both academic and behavioural) from students	X	X	X									
Personal observation with evaluations based on experience					X	X	X	X	X			
Emails	X	X	X									

For example, one HG stated, “I will use as much information as I can get my hands on to make decisions about students”. Another stated, “I tend to use multiple sources of information to look for trends in behaviour rather than use single bits of information on its own”. Sources of data and information for HGs included the student SIS, formative data, anecdotal evidence from staff and students, and personal observations. Heads of department and teachers used three sources of information: summative data stored in the student SIS; formative data kept in personal spreadsheets; and anecdotal data gathered from their personal experiences. While HoDs relied more heavily on summative data to make historical comparisons, teachers tended to trust their own judgments based on personal observation – comments such as, “I use my own resources, experience, anecdotal experiences, and my academic background to make judgments on how students are progressing.” Respondent 3 stated, “I like to keep personal data so that I have easy references to refer to when I talk to parents.”

Engagement issues with the use of technology

Table 6.27 shows the reported issues with the use of technology as a whole within the domain. It shows, in general, that the factors of ‘confidence / skill level’, habit, and the time to use and learn new technology were the main barriers to its use.

Table 6.27 – Engagement issues with the use of technology

Role type:	**HGs**			**HoDs**			**Teachers**			**IT staff**		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
Resistance										X	X	
Confidence / skill level			X		X	X	X		X	X	X	
Habit	X			X	X	X	X	X	X			
Time to use and learn			X	X	X	X		X	X	X	X	X
Struggling to keep up with the rate of change of technology	X					X		X				
Quality of technology	X			X	X			X				
No conceptual understanding (point to point understanding only)				X						X	X	X

The issues reported were common across nearly all role types. IT staff reported resistance to using technology, and a lack of conceptual understanding, as barriers to engaging with it.

Engagement issues with the use of data to inform practice

Table 6.28 shows why respondents do not engage with the use of data to inform on them of the quality of their practice. The reasons varied between the different role types. HGs reported that habit, legitimacy of data, and the urgency to engage in the use of data as main reasons. For example, respondent 9 stated, "I have had multiple meetings with my staff to show them how and when I use the information entered into student SIS. I have had these meetings to encourage them to enter data into the student SIS. I have told them, explicitly, that I cannot help you with managing students if I do not have any supporting documented evidence. Teachers, however, continue to do what they have always done."

Table 6.28 – Engagement issues with the use of data to inform practice

Role type:	**HGs**			**HoDs**			**Teachers**			**IT staff**		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
Not a data-driven culture				X		X	X	X	X	X	X	X
Validity – anecdotal evidence more reliable than data and data systems				X	X	X	X	X	X			
Legitimacy (why collect data?)	X	X	X	X	X	X				X		
Empowerment (use technology and interpret the data)	X				X			X				
No urgency – does not immediately affect, therefore, not seen as a priority	X	X	X									
Mistrust of how and why data is being collected (e.g. performance based pay)					X	X		X				
Habit – used to doing things the old way	X	X	X			X				X		
Quality of IS for managing and entering data					X	X		X				
Complexity of reporting requirements in schools				X	X			X		X		

HoD's perceive an array of issues with using data to inform their practice. Primarily, the validity and legitimacy of the data is seen as problematic. Responses such as, "In order to use data, you have to trust oneself and the system. Neither of these is true." Another HoD responded, "I mean if you take the example of performance-based pay. There are definitely problems around the validity of the data and the intent behind the process. I think if teachers are going to use data in any meaningful way, they need to be comfortable with what they are doing, and they need to ensure that it has value. Both of these have to be aligned."

Teachers and IT staff reported that lack of engagement with data is due to not having a culture of using data. Statements from teachers include, "I don't receive any feedback at all about students or my practice that is data-based. I don't receive any reports in any way. I don't even receive a summary of the summative data that is put into the student SIS. No reflection is possible across any dimension."

Further comments include, "I don't have the skills to analyse it. That role belongs to someone else in the College. That data would be better utilised by middle management, who then should send it back to me in a digestible form."

Quality of data issues

Table 6.29 shows the reported issues with the quality of data recorded and used within the domain. The table shows that HGs have issues with the inconsistent reporting of information, its reliability, and its timeliness. "The information that we receive is very inconsistent. Some teachers use the new behavioural mobile app, and I can get more of an idea of what is going on. Other teachers just handle all behavioural incidents themselves. Sometimes, they do not send any information at all. Sometimes, they forget to enter the data and will tell you about incidents several days later when it is really too late for me to act in any meaningful way."

Table 6.29 – Quality of data issues

Role type:	**HGs**			**HoDs**			**Teachers**			**IT staff**		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
Inconsistent reporting	X	X	X	X	X							
Reliability of information	X	X	X	X	X	X	X	X				
Timeliness of data	X	X	X		X							
Too much information						X				X		
No systems in place to analyse data				X	X	X	X	X		X	X	
Interpretation of data is inconsistent				X						X	X	

HoDs reported that data was most problematic in its reliability, consistency, and the lack of systems in place to analyse the data. For example, one commented, "I think teachers have no real understanding of why data is captured and what it is used for. The power of data is not appreciated. I think they also question its value in accordance with the time investment required to capture the data.”

IT staff tended the value the richness of the data that was being captured; however, they expressed the view that it was not being used in any meaningful way.

Legacy information systems quality

Table 6.30 shows the reported perceptions about the legacy student IS used to record data within the College. Interviewees reported that the student SIS was extremely rich in its functionality; however, the practicality of using it in the classroom was perceived as problematic. HGs reported the limitations of the artefact introduced as part of the trial study: “Although it was useful for teachers, I was still required to use the full version for my role. I, therefore, used the new mobile app in a limited way.”

Table 6.30 – Legacy information systems quality

Role type:	**HGs**			**HoDs**			**Teachers**			**IT staff**		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
Difficult to use. – too much on screens				X				X				
Inflexibility of reporting for formative data					X							
Not practical on a mobile device / in classroom								X	X			
Functionality is rich (HG perspective)	X	X	X									
Resolution issues on projectors												X

Mobile app (artefact) quality

Table 6.31 highlights the feedback from interviewees on their perceptions of the usefulness of the new mobile app. All role types reported that the artefact was fast and easy to use:

- “Ability to enter multiple student behaviours quickly was the real advantage.”
- “I like the way that the app gives the information about a student immediately based on the timetable and the proximity to the student.”
- “The iconography and the fact that we did not have to type in anything was excellent.”
- “It was very quick and visual. This makes recording a comment in the class much quicker. This definitely won teachers over.”

- "I see the attempt of the app to integrate its use as a natural part of what a teacher does and that's fantastic, but it will always get in the way of being in the moment with your students."

Table 6.31 – Mobile app (artefact) quality

Role type:	**HGs**			**HoDs**			**Teachers**			**IT staff**		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
Positive – functionality							X					
Positive – ease of use	X	X	X	X	X	X	X	X	X	X	X	X
Positive – speed to use	X	X	X	X	X	X	X	X	X	X	X	
Positive – feedback to students/parents, house guardians	X	X	X			X	X	X				
Positive – mobile based	X			X		X	X		X		X	X
Negative – limited scope	X			X		X						
Improves consistency of reporting	X	X										
Improves the validity of data		X	X							X	X	
Improves timeliness of data	X	X	X			X						

HGs and teachers also had a number of positive experiences with the 'feedback' functionality:

- "The strength of the app is that feedback can be easily given to parents. This is wonderful. I had one example where one parent rang me and told me that the email they received about their son (not the best student) was the best news that they had received all year".
- "I like the fact that the data is live. I get live emails about student behaviours. I think that this is the way to go long term. I would love to be able to continue to get a drip feed of what is happening with my students throughout the day".

Artefact quality link to teacher reporting behaviour

Table 6.32 shows a summary of respondents' perceptions on the link between app quality and teacher reporting behaviour. The table shows that HGs believed that the app would have facilitated a greater number of reported behaviours by teachers.

Table 6.32 – Artefact quality correlation to teacher reporting behaviour

Role type:	HGs			HoDs			Teachers			IT staff		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
More reported behaviours	X		X			X		X				
A richer range of reported behaviours	X		X			X						
Improved ratio of reported behaviours						X						
Teachers not aware of behaviour reinforcement schedules and theory	X								X			
Timeliness of feedback on their own reporting behaviour												

Teacher feedback behaviour correlation to student outcomes

Table 6.33 shows the beliefs that the various role groups had about the relationship between teacher feedback behaviour and student outcomes. HGs had the strongest attitudes on this topic, believing that it is an expectation of students to behave to a high standard; however, they did strongly feel that positive student feedback was related to positive outcomes for the student, and that communication of these positive behaviours further reinforces it.

Table 6.33 – Teacher feedback behaviour correlation to student outcomes

Role type:	HGs			HoDs			Teachers			IT staff		
Respondent:	1	5	9	2	6	10	3	7	11	4	8	12
Expectation is for students to behave well – positive comments are not needed for expected behaviour	X	X	X	X	X	X		X				
Ratio of Positive and Negative comments to outcomes												
Positive Teacher Feedback improves student outcomes	X	X	X	X	X	X		X				
Negative Teacher Feedback disengages students	X	X	X									
Informed Parents further reinforces negative and positive behaviour.	X	X	X			X						
Immediacy of feedback is important	X	X	X									
Not aware of behaviour reinforcement schedules							X		X			

HGs believed negative feedback disengages students, and they believed that for feedback to be effective, it was important it be immediate. HoDs also believed that students were expected to behave to a high standard, and that positive feedback could have a positive effect their behavioural and academic outcomes. The teacher group reported that they were unaware of the relationship between teacher feedback and its relationship to student outcomes.

6.9 CHAPTER CONCLUSION

Within this chapter the research questions and research hypotheses under investigation were stated. The data analysis techniques used to investigate each of these research questions was provided. This chapter validated the constructs of the UTAUT and IS-impact scales, as well as the scales themselves.

Also, this chapter provided the raw results for each of the research questions and the resultant research hypotheses proposed in this study. The acceptance of the new artefact during the trial period was measured using the UTAUT scale, and the impact to the organisation was measured using the IS-impact scale.

Interview data was collected to further understand why, or why not, the artefact was accepted by end-users, and it provided a rich context to the user's engagement levels with the artefact. SQL data was provided in this chapter describing the use patterns of the new artefact. These 'use patterns' were compared to those of the previous year, thus providing an insight into the effect of the trial artefact.

The next chapter reviews the major patterns and observations found within these results. Discussions on the trends in the data, and the exceptions them, are also highlighted in the following chapter, and kernel theories related to user behaviour are introduced. In particular, the theory of reasoned action (TRA) and the theory of planned behaviour are presented. These theories provide a basis for understanding the phenomena observed in this study.

CHAPTER 7: DISCUSSION

7.1 INTRODUCTION

As stated in the introductory chapter, this thesis aims to further knowledge of information systems design within the education context. The literature review (Chapter 2) discussed and defined organisational quality (OQ), which in education is a complex phenomenon. So, to position this study, the literature review provided the theory to OQ and highlighted a framework of issues associated with achieving it. As part of this definition, the philosophy of continuous improvement (CI) was introduced and discussed, and the use of data as part of a CI philosophy and its importance to OQ was justified.

The literature review explored educational examples where data and the CI philosophy were currently being adopted and used. Schools undertaking the DDDM were studied as part of the literature review and their successes and difficulties with it were documented. Noting these issues, the second objective of this study (after defining OQ) was to identify those barriers to data collection and data use in schools. Once these barriers had been defined, it was the purpose of this study to design, develop and instantiate an artefact that would lead to improved data use to inform teacher practice.

The artefact design approach taken was complex. First the purpose and function of the IS was addressed. The design methodology was detailed in the design cycle chapter, and the artefact is defined as the sum of the requirements defined in the EIA. Once the artefact had been designed from an architectural perspective, further design considerations were made to ensure that quality information was available throughout the defined continuous improvement cycle. Figure 7.0 shows the data/information cycle developed and included as part of the functionality of the artefact.

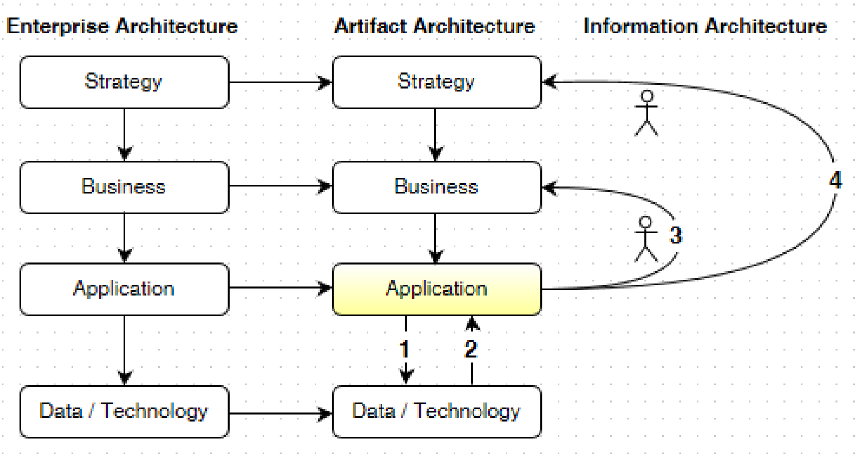


Figure 7.0 Artefact architecture development process, including the information flow paths.

Figure 7.0 also shows the information flow paths that form the continuous improvement cycle for this service:

- the user writes data to the data stores (1).
- the user also receives feedback about the quality of this data (2).
- the user receives feedback at an application level about their work behaviour in terms of aligning it to best practice standards (3).
- the user also receives feedback from the application about whether their actions align with the organisational strategy (4) for this business service.

The unique environmental factors hindering the usability of IS, and subsequent data use in the classroom, were documented as part of this study. Teachers strongly argued it was impractical to enter data in the classroom while teaching. This thesis documented several issues in regards to this (highlighted in Figure 7.0 as flow path 1). Many issues reported by teachers during the investigations in this thesis were found to be similar to those shown in Figure 2.4. (chapter 2, p.78)

A novel technology, two mobile apps, was developed to improve the ability of teachers to use the artefact within the classroom environment, and a technical description for these apps is presented in Chapter 5. By developing this technology for the education space, it was believed that teachers could be empowered to use both the IS and data within the classroom. This design addressed the information flow path (1 & 2) for teachers.

These apps included specifically designed functionality that enabled teachers to exercise best-practice behaviour management in the classroom, and provided immediate feedback about their actions according to this ‘best practice’. This design addressed information flow path (3) shown in Figure 7.0.

The apps also provided comparison data (information) on teacher’s behaviour management practice in relation to that of other teachers at the school. A major part of behaviour management requires that students receive consistent feedback on a behaviour they are exhibiting from their seven teachers. Inconsistent feedback frustrates teachers and students and diminishes and reinforcement strength. This functionality is addressed by information flow path (4) shown in Figure 7.0.

By satisfying the four information flow paths identified in Figure 7.0, it was expected that data and information would be perceived as accurate, relevant and timely and, therefore, would be used to inform and improve practice.

The rest of this chapter is dedicated to determining the success of the artefact. The success of its design is evaluated according to its ability to address the research questions and research hypotheses presented in the results chapter. This chapter, therefore, discusses the research results for each research hypothesis, and other than this introduction, has eight sections: the first seven discuss the results under the headings of the research questions; the final section contains the chapter summary.

7.2 HYPOTHESIS 1

H1 – The new artefact will positively influence teachers’ intention to use it.

Attitudes towards the legacy IS

To examine this hypothesis, the Pearson’s *r* correlations between all UTAUT constructs, for both the legacy IS and the newly instantiated artefact, were calculated and examined. The correlations for the legacy IS can be seen in Figure 7.1 (below), and they are arranged to reflect the behavioural model proposed by Venkatesh, Morris, Morris and Davis’ (2003).

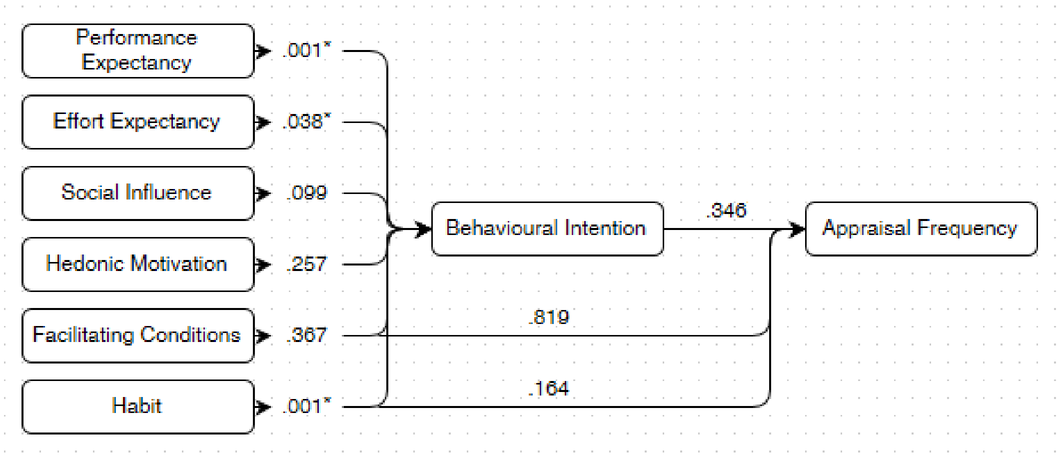


Figure 7.1 Correlations for the constructs of the UTAUT scale found in this study (pre-instantiation of the artefact).

The results section showed that, for the existing legacy IS, performance expectancy, effort expectancy and habit were positively correlated with 'behavioural intention' – but it appeared that there were no correlates to 'use'.

The kernel theories on which the UTAUT scale is based are introduced to discuss the implications of these results. These describe the constructs of an entity and the relationships between these constructs for a given phenomenon. In information systems research, kernel theories advise design solutions and govern their requirements (Nunamaker, Chen & Purdin, 1991; March & Smith, 1995; Simon, 1996; Walls, Widmeyer & El Sawy, 2004). By examining the constructs, and the relationships that form these kernel theories, the analogous constructs and relationships found within this study can be compared and contrasted. The discussion in this chapter can be grounded through this process.

Although the development of the UTAUT instrument was based on the revision of eight behaviour models, *the theory of reasoned action* and the *theory of planned behaviour* provide the strongest insights into the relationships that exist between the various UTAUT constructs (Venkatesh, Morris, Davis, Davis; 2003). These two kernel theories are discussed in the next two sections.

7.2.1 Theory of reasoned action

The theory of reasoned action (TRA) is a model introduced by Fishbein and Ajzen (1975) to predict the strength of intention to perform a particular behaviour. The constructs of TRA include: behavioural intention (BI), attitude (A), and subjective norms (SN). The relationships between these constructs are shown in Figure 7.2. In TRA, *behavioural intention* measures a person's intention to perform a behaviour, and the strength of this intention is based on the person's attitude and subjective norms. The *attitude* is determined through beliefs about the consequences of performing the behaviour, as well as the evaluation of the consequences associated with the behaviour.

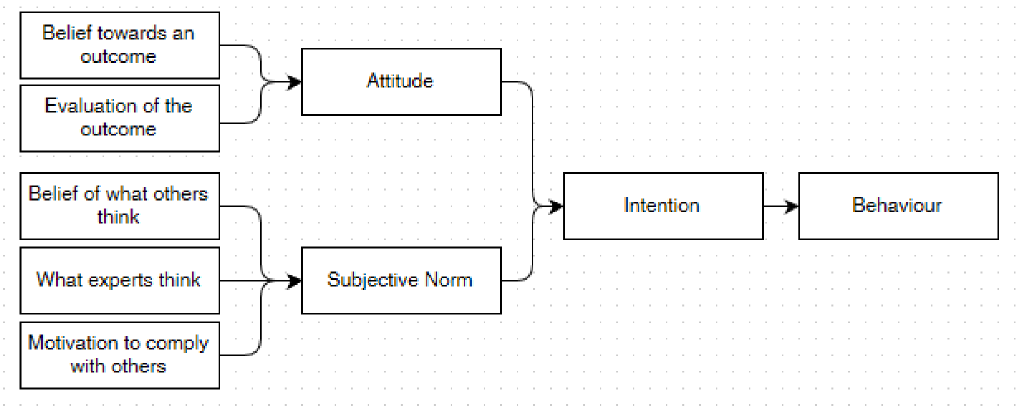


Figure 7.2: Shows the constructs that make up the theory of reasoned action.

The *subjective norm* is seen as a combination of: i) belief in what others think; ii) belief in what experts think; and iii) motivation to comply with others (Fishbein & Ajzen, 1975).

The TRA model has been shown to have limitations, including a significant risk of confounding the constructs of *attitude* and *subjective norms* (Sniehotta, 2010). A second limitation is the assumption that when someone forms an intention to act, they are free to act without the influence of external forces. Authors, such as Sheppard, Hartwick and Warshaw (1980), when commenting on the predictive power of TRA question the validity of TRA construct relationships when users do not have control over their behaviour.

In reality, a person's behaviour is constrained by organisational factors, such as limited ability, time, and socio-political forces. Hale, Householder and Greene (2002) state that the theory of reasoned action is only valid when the behaviour is of one's own volition. Those classed as unethical (Chang, 1998), habitual, spontaneous, or without thought are suggested to fall outside the boundaries of the theory (Bentler & Speckart, 1979). These factors contribute to a decreased predictive power of the model (Hox, de Leeuw, Vorst, 1996). As a result of this criticism, the *theory of reasoned action* was revised by Ajzen (1980) and is currently known as the *theory of planned behaviour*.

7.2.2 Theory of planned behaviour

Ajzen (1985, 2002) extended the TRA by developing the *theory of planned behaviour* to consider the user's *perceived behavioural control* in performing behaviours. This theory acknowledges that behavioural intention is not the exclusive determinant of behaviour when unconscious or external forces are present.

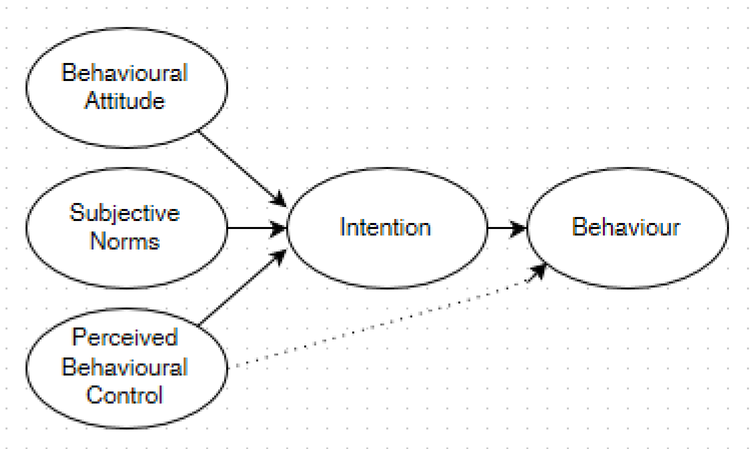


Figure 7.3: Model of constructs for the theory of planned behaviour

According to the theory of reasoned action, intention is dependent on: i) behavioural attitude; ii) subjective norms; and iii) perceived behavioural control. Importantly, it is noted as part of this model that the level of perceived behavioural control can directly influence behaviours.

Other authors have developed more complex 'intention–behaviour' models; however, these are based on the theory of planned behaviour. Eagley's and Chaiken (1993), for example (see Figure 7.4), propose an elaborate model describing the relationships between attitudes and behaviours.

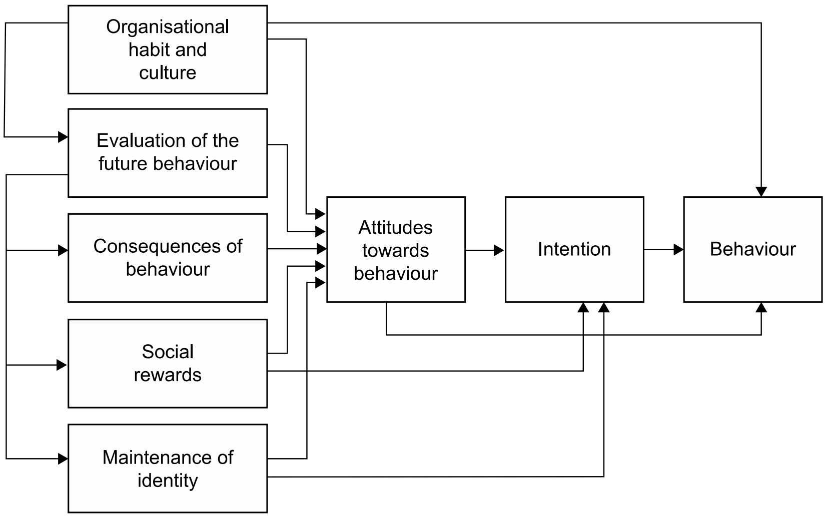


Figure 7.4: A composite attitude behaviour model. Source: Eagley, A and Chaiken, S. (1993).

"According to this model, attitudes towards a particular behaviour are determined by the sum of organisational culture and habits, evaluations of the future behaviours required of the change, consequences (the positive and negative) of the behaviour and three classes of anticipated outcomes of behaviour (utilitarian, normative and identity)" (Eagley and Chaiken, 1993).

This model also states that an individual is most likely to create the intention to behave a certain way based, primarily, on the strength of cultural norms and habits associated with previous roles. These behaviours are 'couched' within a political and historical context where the interaction of the individual with the organisation has guided the previous behaviour leading to the current status quo. These habits 'anchor' the formation of new intended behaviours.

'Habits', in Eagley and Chaiken's (1993) attitude-behaviour model, are described as those unconscious behaviours that occur with little cognitive input. The habits and the culture of an organisation distort and anchor any evaluation of the future required behaviours. Political, social and interpersonal experiences and knowledge veto the power of ideological values in behaviour formation, particularly if these ideological values do not align with the stakeholders past experiences.

Eagley's and Chaiken (1993, p. 478) state: "attitudes may lead to new behaviours but the organisational environment needs to guide the behavioural direction and reinforce this new behaviour or sets of behaviours. Through this process, new behaviours may gain subjective permanence".

Construct relationships – legacy IS

Prior to the instantiation of the artefact, the results of this study suggested that IS-use behaviours were moderated through factors unrelated to user intentions. Although the results showed that performance expectancy, effort expectancy and habit were related to behavioural intention, behavioural intention was not related to use. This suggests that using the existing legacy IS was more likely because of exogenous factors to the user.

The results from the convergent interviews support the notion that user behaviour was more likely the result of external factors than the user's behavioural intention. Direct feedback from users during the convergent interviews, for example, questioned the purpose of collecting data when the school did not have a data culture. The feedback suggests that the 'user behaviour' with the existing legacy IS was executed by teachers to meet demands specified by management.

Construct relationships – artefact

When the Pearson's *r* correlation is calculated and examined for the UTAUT constructs post implementation, the relationship between behavioural intention and appraisal behaviour was established. According to the theory of planned behaviour, there are two possible explanations for this phenomenon: i) the antecedents to behavioural intention have reached a threshold of quality that allows users to consider the artefacts use; ii) the user perceives that external factors that dissuaded them from using it have been removed or improved.

It is difficult to gauge the exact reasons for restablishing the link between behavioural intention and use, although clearly the antecedents to behavioural intention (performance expectancy, effort expectancy, facilitating conditions, hedonic motivation and habit) were significantly different pre and post measurement (shown in Figure 7.5). The results also showed that facilitating conditions and habit were correlated to appraisal frequency. Therefore, it can be concluded from these results, that the artefact design clearly improved those factors (endogenous to the user) that lead to increased 'use'.

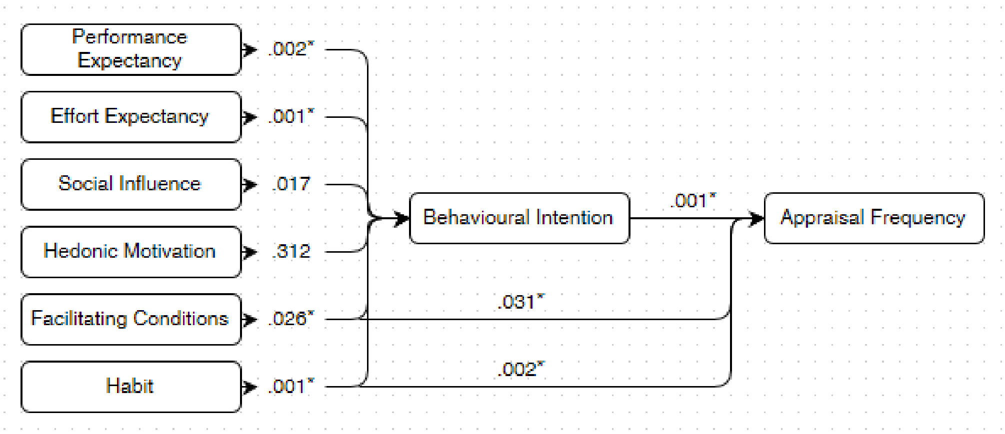


Figure 7.5: Model of correlations between constructs within the UTAUT scale.

Within this study, 'use' is described according to the information flow path it facilitates. The results above indicate that the new artefact design has facilitated 'use' that aligns with information flow path (1), and information flow path (2). When information flow paths (3) and (4) are examined, the exogenous factors (organisational factors) become more of a barrier to use.

The artefact developed for this thesis was specifically designed to align with behaviour management best practice and to the service strategy. The results from the IS-impact scale show that users perceived the artefact, with this specific design, as having better information and system quality. This study found, however, that there was only some evidence that data was being used to improve alignment with behaviour management best practice. There was even less evidence to suggest that this data was being used to align to the service strategy.

Given these results, this study identifies two exogenous factors (to the artefact) that are barriers to technology acceptance and use: i) the user's relationship with the goals of the business service; and ii) the user's relationship with the service strategy. These exogenous factors have not been identified in previous IS research.

Venkatesh, Thong, Xu (2012) recognise the limitations of the UTAUT model, and acknowledge detractors such as Benbasat and Barki (2007), who state that exogenous factors (such as habit) have been largely ignored by the model. Both Venkatesh et al. (2007) and Davis, Bagozzi and Warshaw (1989) call for further work in extending the UTAUT model to include "new constructs and relationships that furthers the generalisability of UTAUT to different contexts" (Venkatesh, Thong, Xu, 2007, p. 159).

The results of this study found and support the proposal that the generalisability of the UTAUT model can be improved through testing the relationship between the user and the goals of the business and service strategy. There are advantages in using these exogenous variables because of their potential to be inclusive of all IS and organisational contexts.

Potentially, this could eliminate the need to include every exogenous variable that exists in every context. This recommendation is elaborated on in the final chapter of this thesis.

Change in attitudes between the legacy IS and the new artefact

A major anomaly found in the results was that the behavioural intentions construct pre and post instantiation of the artefact was not significantly different. As Venkatesh et al. (2003) state "the role of intention as a predictor of behaviour (e.g. usage) is critical and has been well established in IS and the reference disciplines" (Venkatesh, Morris, Morris, and Davis, 2003, p. 427). It is expected, therefore, that if there was a significant difference found between the means of performance expectancy, effort expectancy, facilitating conditions, hedonic motivation and the habit construct, then this should be reflected in the behavioural intention construct.

A possible explanation for this may be related to questions that make up the construct of behavioural intention. Options in the behavioural intentions construct include: 'I intend to use the artefact in the future'; 'I plan to use the artefact frequently'. Teachers who participated in the trial might signal that they would not continue to use the artefact in the future based on the premise that this was just a trial. One limitation of this study, therefore, may be the validity of the UTAUT scale. The questions on the UTAUT scale appear to be engineered more for an ex-post facto research design than for an experimental research type one.

Another possible explanation may be related to the fact that the application domain was not perceived as having a 'data culture'. This was a strong perception, uncovered in the convergent interviews, across all 'role types'. As stated by Eagley and Chaiken's (1993), "behavioural intentions are said to be determined by the sum of organisational culture and habits, evaluations of the future behaviours required of the change, consequences (the positive and negative) of the behaviour and three classes of anticipated outcomes of behaviour (utilitarian, normative and identity)".

The convergent interviews identified multiple exogenous reasons for why the teaching staff did not engage with data: i) the organisation was not a data-driven culture; ii) teachers' anecdotal evidence was seen as more reliable than data and data systems; iii) issues with using technology and interpreting the data; iv) no urgency – not a priority; v) mistrust of how and why data was being collected – e.g. performance-based pay; vi) habit – used to doing things the old way; and vii) the complexity of the reporting requirements in schools.

Regardless of the quality of IS, it is difficult to overcome these exogenous factors, regardless of the possible positive consequences from using the artefact. Clearly, there are two sets of forces (endogenous and exogenous factors) that influence behavioural intentions. Within this study, exogenous factors play a major part in influencing behavioural intention.

This study cannot draw conclusions for improved behavioural intentions as a result of the predictive validity of the behavioural intention construct, even though the antecedents to behavioural intention, and use, were significantly different pre and post instantiation. Particularly given that 'use' is different pre and post implementation, one can draw the conclusion that there may be problems with the validity of the behavioural intention construct within the UTAUT scale.

7.3 HYPOTHESIS 2

H2 – Performance expectancy, effort expectancy, social influence and facilitating conditions will mediate teacher's intention to use the new artefact.

From the results discussed for the previous hypothesis, performance expectancy, effort expectancy, facilitating conditions, and habit are clearly correlated with and mediate a user's intention to use the artefact. When the *t*-test examined if there were significant differences between these constructs pre and post surveys, it was shown that performance expectancy, effort expectancy, facilitating conditions, hedonic motivations, and habit had significantly improved across the surveys – and the construct of social influence had not significantly changed.

These results are expected given that the artefact was designed to reduce the number of IS user interactions. This improved 'efficiency of use' logically leads to improved performance and reduced effort for the user. The artefact was also designed specifically to compliment teacher behaviour in the classroom, so it is expected that the facilitating conditions would be different pre and post implementation. In terms of hedonic motivation, users responded best (highest *Mean*) to the option 'using the artefact is enjoyable'. Finally, significant differences were found with respect to the 'habit' construct, which suggests that users were able to quickly adopt the new artefact as part of their teaching.

7.4 HYPOTHESIS 3

H3 – The new artefact design will have an impact on the individual.

The purpose of this hypothesis was to examine whether the artefact had an impact on the users according to their role within the organisation. In section 2.4, the concept of continuous improvement (CI) was discussed, as were the responsibilities of the various roles in an organisation with respect to the information is generated in the CI cycle. Within this section, the concept of 'define, measure, analyse, improve and control' (DMAIC) is introduced.

Figure 7.6 highlights the major stakeholder groups within the application domain: leadership team, pastoral care coordinators, and teachers.

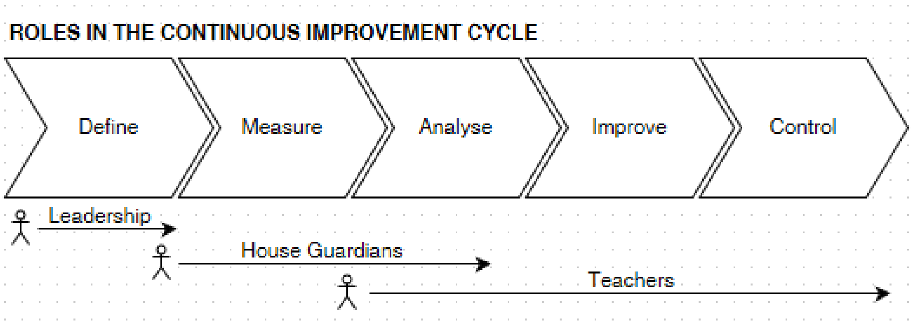


Figure 7.6: Artefact use by various stakeholders throughout the CI Cycle.

The figure also displays the CI framework adopted for this study, which uses the five stage approach of define, measure, analyse, improve and control (DMAIC). CI is argued as the optimal approach to quality management within schools (Boynton, Victor & Pine; 1993).

Figure 7.6 shows that the primary role of the leadership team and the deputy principal (pastoral care) in the management of student behaviour is to define standards and measures of student behaviour. House guardians (HGs), the pastoral care coordinators, have several responsibilities in terms of data, as the measure and analyse these behaviours. House guardians use the generated data to justify actions and proactively implement behaviour management programs. Given the multidimensional role of the HG in regards to behaviour, it is expected that house guardians would experience the biggest individual impact from the instantiation of the artefact.

The role of the teacher is to analyse, improve and control behaviour in the classroom. This is done through direct and indirect action. The indirect actions require teachers to work with the HGs in controlling behaviour. HGs have reported that the best way to achieve this is through consistently and accurately reporting behaviour using an IS. The HGs have reported the biggest advantages of the IS are the automated live updates (emails), which allow them to be responsive in their role. Consistent reporting by teachers also allows HGs to meet weekly to determine trends and issues associated with student behaviour. Given the requirements of teachers to enter data, it is expected that the instantiation of an artefact that improves data entry will significantly impact teachers.

The results of this study found that the instantiation of the artefact did have a significant ‘within-subjects main effect’. This means that the artefact had a significant impact on users across time. The results also showed that HGs had the highest *mean* scores, followed by heads of departments, teachers and, last, the vice rector (see Figure 6.8). However, there were no significant differences between the *mean* scores of each of the ‘role types’.

This result is not surprising, although it was predicted that HGs would be significantly more impacted by the artefact then others. Careful design consideration was given to all parts of the data cycle during the artefact design, development and instantiation. The impact of the artefact according to the results was, therefore, equally perceived across all role types.

7.5 HYPOTHESIS 4

H4 – The new artefact design will lead to increased use.

One objective of the new artefact design was to ensure its usability. Teachers previously reported the legacy IS as impracticable, particularly for reporting student behaviours inside the classroom. The natures of these problems were reported in section 2.4, which discussed the importance of accurate and timely reporting to the validity of any student behaviour management program. The main objective of the artefact design, therefore, was to instantiate an IS that facilitated its use is the classroom, thereby increasing the validity of the data reported. The evaluation criteria for this design success would be reflected by: i) any increase in the number of reported behaviours using the new artefact; ii) an increase to the number of categories of behaviours reported, reflecting a greater accuracy of types reported; and iii) the reporting of behaviours in a way that reflects best behaviour-management practice. The information used to answer this question was gathered using the structured query language (SQL) data of the student information system (SIS).

7.5.1 Artefact – total use

This SQL data clearly shows that the total number of appraisals made against students increased over 2013 and 2014. When a comparison of the number of appraisals made by users trialling the artefact against those continuing to use the legacy IS, the results showed that artefact users consistently made more comments (69.33) than the legacy IS users (39.15). These figures represent the average number of comments made per teacher throughout the trial. These results clearly showed a 56.47% increase in the number of reported behaviours using the new artefact. As reported in the convergent interviews, one of the great design advantages for teachers was the ability to make multiple entries for a single behaviour across many students.

In a traditionally designed IS, the student is first identified in the student table, a behaviour is then selected from the behaviour table, and these two fields are then linked in a third table as a behaviour record entry. The new artefact departs from this procedure, and was specifically designed to allow quick multiple entries. Multiple students could be identified automatically based on proximity and temporal triggers, and multiple targeted behaviours could be prepared before class – therefore, during class, the process of recording behaviours was a simple drag and drop process.

The success of this design element is supported by the SQL data. Forty-three per cent of all data entered into the database was completed as multiple entries – that is, successive entries for the same behaviour by the same teacher at the same time. The largest categories of these ‘multiple behaviour entries’ were homework (20%), uniform (12%) and late submissions (8%). During the corresponding 2013 period, these categories were not reported on at all using the legacy IS.

Further results, relevant to this hypothesis, showed that primary school teachers consistently recorded more appraisals than their secondary counterparts. Using the legacy IS, primary school teachers made an average of 42.03 comments, in comparison to secondary teachers average of 38.58. Using the new artefact, primary teachers averaged 83 comments in comparison to 45.49 comments for their secondary counterparts. This represented an increase of 54.81% in the number of recorded appraisals. The combination of the artefact and its use by the primary school teachers produced the highest number of appraisals during the trial period.

The differences between the primary and secondary teacher usages are likely to be culturally based – that is, the relationships between teacher and student may be closer and perceived as more important, especially given the amount of time primary teachers spend with their students. The nature of secondary teaching tends to be very content focused. For example, one comment made during the convergent interviews was that “the secondary school teacher has 40 minutes to fit as much content as we can in to the period”.

7.6 HYPOTHESIS 5

H5 – The new artefact will improve perceptions about the system and information quality.

The scale used to measure the impact of the artefact on the organisation was the IS-impact scale, and the IS-impact model is shown in Figure 7.7.

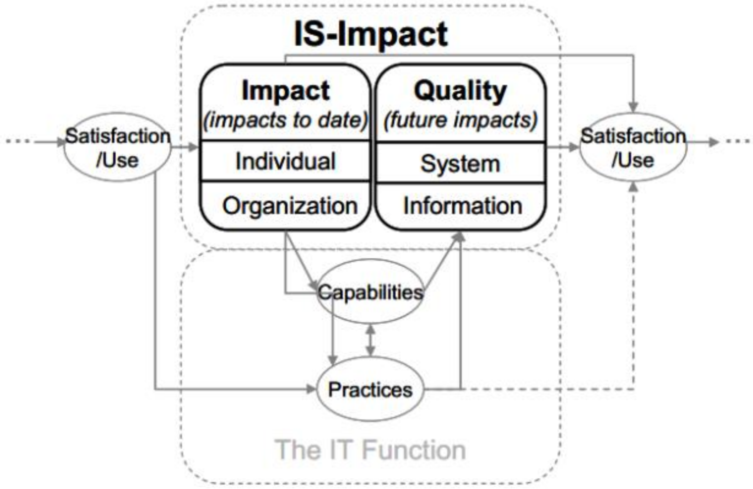


Figure 7.7: The IS-impact model.

The IS-impact measurement tool is based on Delone and Mclean’s information systems success (ISS) model (1992). Its scale consists of four dimensions, and these constructs are validated through a comprehensive study conducted by Gable, Sedara and Chan (2008). The

IS-impact model includes four dimensions and two halves. Impacts (impacts to date) are explicitly and intentionally measured at the same time as quality (future impacts).

The results showed that the artefact did have a significant effect on information quality (IQ) and system quality (SQ). The repeated *t*-tests showed that IQ and SQ were significantly different pre and post-tests, and significantly correlated to satisfaction. When looking at the *effect sizes* for these correlations, IQ and SQ had a large *effect size*. End users, therefore, perceived that the artefact had a positive effect on information quality and system quality. This result was expected given that the information flow paths were designed directly for the end-user in mind. The artefact was designed to give immediate feedback to the teacher about whether their actions aligned to the best practice (business architecture) and to the organisation's strategy (strategy architecture). It was expected, therefore, that end-users should perceive improvements to IQ and OQ.

7.7 HYPOTHESIS 6

H6 – The new artefact will have a positive impact on the individual and the organisation.

The repeated *t*-tests showed that individual impact and organisational impact (OI) were significantly different pre and post-tests. When examining the OI from a CI perspective, the results showed that leadership team members scored highest for perceived organisational impact. This was followed by the house guardians with the second highest *mean* scores. This 'between-group' effect was not, however, significant. This result was not expected. Given that the leadership team members have a whole-of-organisation perspective, it was expected that there would be a 'between-group' effect. It appears that a similar organisational impact was perceived across all groups.

To further elaborate on how the artefact affected on the organisation, data from convergent interviews was used. This described how the users interacted with the IS to perform best-practice behaviour-management techniques. The next section discusses this interaction effect on the organisation.

7.7.1 Artefact – use for best practice

Section 4.6 of this thesis briefly discussed behaviour management theory, and Table 5.4 introduced a number of design elements to facilitate best behaviour-management practice: schedule of feedback, specificity of feedback, immediacy of feedback, consistency of feedback, and the cost-benefit of feedback.

Quality of feedback

One of the key findings produced in the evaluation of the legacy IS was the low ratio of positive to negative comments recorded against students. The assumption was that teachers recorded mainly negative comments because the legacy IS was difficult to use and, therefore, only serious negative behaviours were recorded. The belief was that an artefact designed to more easily record behaviours would facilitate a better balanced ratio of student feedback. The results showed that in 2013, the peak positive to negative feedback ratio (PNR) was 37.29%. In 2014, the average PNR for teachers using the legacy IS was 39.86%; for those using the trial artefact, the PNR was 59.68%. This constituted a 19.80% improvement in the PNR through the use of the trial artefact in comparison to the legacy IS (2014). This PNR, however, was still significantly short of the desired ratio as specified by behaviour management theory.

Results from the convergent interviews showed that both teachers and HGs believed that positive feedback was vital to reinforce student outcomes. Teachers, however, believed that they should only give positive feedback when it was ‘above and beyond’ what was expected. HGs confirmed that this was the belief of teachers. The HGs discussed that negative reinforcement by teachers disengages students from the teaching and learning process. Teachers, however, did not reflect this sentiment throughout the convergent interviews. HGs stated that teachers give more negative appraisals than positive ones because of habit and culture. One teacher reported in the convergent interviews that he was not aware of behaviour reinforcement theory.

Timeliness of feedback and specificity of feedback

Behaviour management theory states that the time between the behaviour and feedback on it is vital for its reinforcement. One functionality of the artefact, therefore, was to automatically generate detailed emails about the student's behaviour to use as feedback. These emails could easily be sent to significant members of the student's social group/community.

Feedback from the convergent interviews indicated this functionality was an extremely effective tool for mobilising parent's engagement with house guardians on student behaviour matters. Feedback from parents to HGs was that they were generally delighted to hear positive affirmations about their sons. Comments such as "this is the best news that I have heard all year" supported the effectiveness of this functionality. In contrast, one anecdote from the interviews mentioned how one parent did not open the email generated from the system as they perceived it was negative, and they could not cope with this news at that time.

Consistency of feedback

Due to more behaviours being reported, and an increase in the richness of this reporting, it is logical to conclude that the consistency of feedback improved for the users who trialled the artefact. However, despite this improvement, HGs still expressed concern about the inconsistent use between teachers using the newly instantiated artefact and the legacy IS to report behaviours.

Cost-benefit of feedback

Finally, the results from the convergent interviews suggest that teachers did not view the cost-benefits of providing feedback to students in a positive way. Generally, teachers believed that the school did not have a data-driven culture and, therefore, it was pointless engaging with data. There was also strong evidence that teachers continued to believe that the data that they collected themselves through observation was the most trustworthy and reliable source of information (see Table 6.27).

Overall, it can be concluded that the artefact improved information quality, and this had an impact at both an individual and organisational level. The results from the convergent interviews suggest that the improved quality of data was only used in limited ways, and that exogenous factors anchored the full potential of the artefact in the organisation.

7.8 HYPOTHESIS 7

H7 – The new artefact will improve the quality of data measuring student behaviours.

Data quality

To address this hypothesis, 'data quality' was examined according to its quality dimensions: accuracy, timeliness, consistency, and completeness. The accuracy and timeliness of data was assured through the redesign of the artefact, which included the development of a metadata model. Data validation, according to the metadata model, occurred at the point of data entry. Also, the timeliness of the data was assured by providing users with an immediate summary of relevant data updated at the time of entry.

A further analysis of the SQL data examined whether the data was both *complete* and *consistent, and this* showed that the completeness of the data, as evidenced by the variety of behaviours reported, had increased. In 2013, four behaviour categories were reported on: negative-classroom, positive-academic, positive-pc behaviour, and positive-community behaviour. However, in 2014, there were twelve categories: negative-homework, negative-uniform, negative-classroom, negative-late submission, negative-disruptive, negative-iPad, positive-classroom, positive-role model, positive-great in PC, positive-courtesy, positive-polite, positive-community. This increase of categories provides HGs (as reported in the convergent interviews) a richer understanding of the types of and frequencies of behaviours occurring in the classroom. Although the richness of reporting was improved through the use of the artefact, HGs could not rely on this data source alone. Given the diverse acceptance and use of the artefact, HGs still heavily relied on anecdotal evidence about student behaviours.

7.9 HYPOTHESIS 8

H8 – Teachers will perceive the artefact has having utility for their role.

The results from the convergent interviews showed that interviewees with differing role types tended to have different foci when evaluating the utility of the artefact. House guardians, for example, viewed the utility of the artefact from both a usability perspective and a quality of data perspective. Both heads of departments (HoDs) and teachers still tended to focus on the usability aspects of the artefact. For example, they reported that the artefact's best quality was its ease and speed of use, and liked the fact that it was mobile based.

Interestingly, not a single member of staff reported on the flow of information or feedback loops that were part of the artefact's application. These feedback loops were designed to inform the user on the quality of their appraisal behaviour and that of their colleagues. This feature was designed to provide instant feedback to help evaluate the proximity of 'their practice' to 'best practice'. This functionality was not mentioned as being either positive or negative in the interview scripts.

7.10 HYPOTHESIS 9

H9 – Teachers will use the artefact uninhibited by exogenous factors to the artefact.

The results from the convergent interviews showed that use of the artefact was inhibited by exogenous factors to the IS. In general, the three biggest barriers to using the technology were: i) habit/culture; ii) time to use and learn the technology; and iii) having the confidence/skill level to use the technology. The feedback from staff suggested the main reason for not using data to inform their practice was that the school itself did not have a culture of evaluating the available data. In general, there were a number of reasons presented in the responses for not using data. Heads of department showed their willingness to use data to inform practice but, at the same time, reported seven different barriers for doing so. Many of these barriers were the same that as those discovered in the literature review. Throughout the interviews, many staff members had to be prompted to clarify their responses. They acknowledged the difficulties with expressing the complexities around the purpose of and, therefore, how data might actually be evaluated.

7.11 HYPOTHESIS 10

H10 – Stakeholders will perceive a positive relationship between artefact quality and their reporting behaviours.

The results showed that only HGs believed a higher quality artefact would lead to improved quality of reporting. They perceived that an improved artefact would lead to a greater frequency of reporting and a greater richness of reported behaviours. When prompted in the interviews, teaching staff were unable to make links between artefact quality and the reporting of behaviours, and did not report on: improved timeliness of data; the opportunity to provide students a more balanced schedule of reinforcements; or the feedback loops that the artefact provided. These results indicate that teacher concerns, in regards to data and student behaviour management, do not extend beyond data entry.

7.12 HYPOTHESIS 11

H11 – Teachers will perceive a positive relationship between their reporting behaviours and student outcomes.

Clearly the results showed that the HGs were acutely aware of the power of teacher feedback and its effect on the students' behavioural outcomes. Through their experience, they were able to provide first-hand examples of how teacher feedback affects the students both positively and negatively. Heads of department expected the students to behave well and that positive comments should be earned. They did not believe in giving positive comments for the sake of conforming to behaviour management best practice. The most surprising result for this hypothesis was that teachers were unable to report any correlations between their feedback and the outcomes of student behaviour.

7.13 DISCUSSION SUMMARY

This chapter began by discussing the strengths and weaknesses of the predictive validity of the UTAUT model. In particular, the weakness in the predictive validity of the UTAUT model was centred on accounting for those exogenous variables to the user. Due to the mixed methodology (convergent interviews) used in this study, more details about the effect of exogenous variables to behavioural intention and use could be forwarded. Through the use of the UTAUT and convergent interviews, this study accounted for both the effects of exogenous and endogenous to behavioural intention and use of the newly instantiated artefact.

End-users, as evidenced by the UTAUT questionnaire results, perceived that effort expectancy, performance expectancy, facilitating conditions, hedonic motivation, and habit were improved through the use of the artefact. Unfortunately, this study could not conclude that these improved constructs lead to an increase behavioural intent to use the artefact. This study made comment in regards to the predictive and nomological validity of the behavioural intention construct used within this study.

The results from the UTAUT showed that the newly designed artefact had an effect on use, but was limited to information flow paths (1) and (2). The results from the convergent interviews showed that exogenous factors acted as barriers to using the improved quality of data to inform teacher practice – information flow paths (3) and (4).

The results from the IS-impact scale indicated that the artefact did have a positive impact on all end-users. There were, however, no between-group effects (role type) for ‘individual impact’. The results clearly show that information quality and system quality were perceived to improve with the implementation of the new artefact. This study can draw definite conclusions that the artefact design method (Figure 7.8 below) led to improved artefact quality.

The SQL data analysis supported the finding that information quality had improved, and clearly showed an improvement in the range and type of data entered into the database from the instantiation of the new artefact. The UTAUT questionnaire showed that use rates between the legacy IS and the instantiated artefact was significantly different.

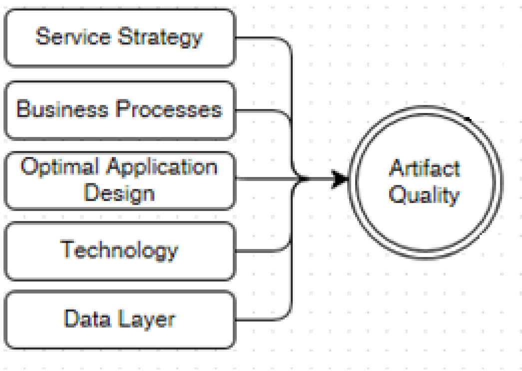


Figure 7.8: Using the EIA procedures espoused by Hellmuth and Stewart (2014) to define the artefact clearly had a positive impact on artefact quality perceptions.

The SQL data supported this improved rate of use. A direct comparison between those who used the artefact and those who did not could be completed.

This study cannot definitively determine reasons for the interaction between users and information flow paths (3) and (4). While there was improved ratio of student appraisals using the new artefact, this improvement was limited. The results from the convergent interviews suggested that teachers were more likely to continue their normal habits, even with direct feedback suggesting they were not aligning their work habits with best behaviour management practices.

As per behaviour management models, this study finds that the use of data throughout the CI cycle is anchored by exogenous variables, such as organisational habit and culture. It was reported in the convergent interviews that there was not a culture of using data to inform teacher practice. It was shown that teachers typically did not engage with the use of data for many of the reasons, and these were similar to those highlighted in Figure 2.4 (literature review). Many teachers at the application domain did not have an explicit understanding of behaviour management principles. They, therefore, were unable to perceive the value of the artefact with the incorporated behaviour management functions.

It was shown in the convergent interviews that teachers did not make the link between artefact quality and student behavioural outcomes and, therefore, judged the artefact quality according to its utility to make their role easier. This was evidenced according to effort expectancy, and performance expectancy *mean* scores on the UTAUT scale. These scores were significantly different pre and post measures for teachers with a large *size effect.*

To overcome the issues of habit and culture as barriers to IS use, teachers require a greater understanding of behaviour management. As the attitude-behaviour model states, teachers need to be made explicitly aware of the direct effect their appraisal behaviour has on the student (consequences of behaviour). The artefact developed for this study provides feedback to teachers on their appraisal behaviours so they can evaluate the quality of their own feedback behaviours (evaluation of future behaviours). This step will only be possible once teachers are explicitly aware of the consequences of not appraising students according to best practice.

7.14 SUMMARY

This section presents explanations for the results observed in this study. It has also presented the composite attitude-behaviour model as a comparative model to explain those observed behaviours found. The composite-attitude behaviour model suggests that although end-users clearly perceived the utility and quality of the newly instantiated artefact, there appeared to be many other factors that influenced the intention of teachers to use it. The composite attitude behaviour model discussed these antecedents to ‘intention to use’ and actual use. The conclusion and recommendations chapter discusses these antecedents further.

CHAPTER 8: RIGOR CYCLE

8.1 INTRODUCTION

The instantiation of the artefact demonstrated the power of the EIA to address the critical components of the business service, and the rigorous application of EIA methods has effectively addressed the elements of problem wickedness. The resultant information system (IS) is the sum of the artefacts revealed through this analysis.

Through the use of the EIA, this study identified four key information flow paths needed as part of the continuous improvement cycle. The study's goal was to improve the quality of these information flow paths and, thus, the ability to continually improve the service, the service unit, and the service strategy.

A number of key design concepts were developed and contained within a mobile app to facilitate the four identified information flow paths. The app was deployed, and its effects on teacher reporting and pastoral care management were the subject of the results and discussion chapter. These chapters highlighted and discussed the success of the artefact in achieving the research goals as stated in this thesis.

This section addresses how the use of the EIA and the subsequent instantiation of the artefact facilitated the development of theory. The EIA developed in this case study has addressed all the required elements to define, delineate, and develop design science research theory. Gregor and Jones (2007), in their seminal paper on design science theory, describe the elements and outputs required by DSR necessary for the production of design research theory: i) purpose and scope; ii) constructs; iii) principles of form and function; iv) artefact mutability; v) testable propositions; vi) justificatory knowledge; vii) principles of implementation; and viii) an expository instantiation. These elements of design theory are discussed in the next eight sections.

8.2 PURPOSE AND SCOPE

According to Gregor and Jones (2007), the DSR theory element *purpose and scope*, defines the relationship between the artefact and its environment. They state that “The artefact should be understood in terms of the environment in which it is to operate” (Gregor & Jones, p. 322). The nature of this relationship defines the boundaries of the research and, therefore, the boundaries of the theory being evaluated. Within this research, the strategy layer of the EIA defined the problem space or, more specifically, the service strategy of the Pastoral Care Service Unit defined the problem space. The service strategy for the Unit is to consistently provide students with feedback about their behaviour (subjective appraisals), thus aligning student behaviour with the goals of the service unit and the organisation.

The methodology of the relevancy cycle within this research was defined as the process of identifying multiple entities related through their participation in a common function. This function is theoretically aligned with the goals outlined in the strategic layer; however, the ill-defined relationship between the multiple entities and their attributes prevents the goals stated in the strategic layer from being realised. The scope of the artefact design was established to address these misalignments.

Figure 8.0 (below) shows that the architectural requirements for the artefact are gathered directly from the enterprise architecture – specifically, the architecture of the Pastoral Care Service Unit. The figure shows that the artefact is developed to align the software abstract layers to the requirements stated at each layer of the EIA. Figure 8.0 also shows that this research concerns itself further by specifically improving four identified information flow paths, which, although critical to quality outcomes in education, have not been designed well in the previous education-based IS. The reasons for this are explained in section 5.2. The four information paths are defined in the next four parts of this section.

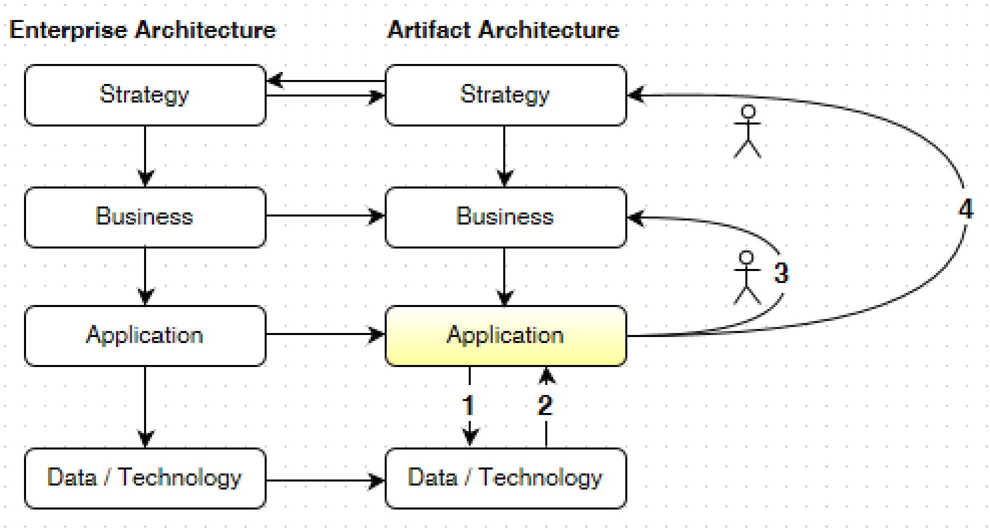


Figure 8.0: This figure defines the architectural boundaries of the Pastoral Care Services Unit and the resultant architecture of the artefact. This scope of this thesis was to align the artefact to the enterprise as well as to improve the four information flow paths identified. The relationship between the artefact and its environment is shown.

Information flow path (1)

The first information flow path (1) was examined and redesigned to improve data entry methods conducive to classroom environments. An overview of this problem was provided in section 4.4.

Information flow path (2)

The second information flow path (2) improves what and how information is presented within the application and, therefore, improves the timeliness, validity, and relevance of the data. The stated problems with the quality of data were highlighted in section 4.5.

Information flow path (3)

Information flow path (3) provides teachers with information about the quality of their subjective appraisals in alignment with the business strategy. In EIA standards, a business process flow is defined within the business architecture layer. Within this layer, the business processes are mapped using notation such as BPMN 2.0. The goal of this layer is business process optimisation (TOGAF® v 9.1). A business process is improved through sequencing several tasks across several stakeholders (OMG, 2014). Through implementing these defined business processes, consistency within and between tasks can be improved for that business function.

For the purposes of this thesis, it is vital that the difference between tasks and subjective judgments is clarified. In the business process described as 'behaviour management', teachers will not undertake tasks until first a subjective judgment about a student's behaviour is completed. It is moderating and providing consistency to these subjective judgments that this thesis seeks to improve. It is the consistency and quality of these subjective judgments that determines the quality of the service.

As defined in the design cycle (section 4.6), the artefact was designed to provide immediate feedback to teachers about the quality of their appraisals. This feedback provides the teachers with the total number of appraisals and the ratio of appraisal types given to a student.

Information flow path (4)

Information flow path (4) provides teachers with information about the quality of their subjective appraisals in alignment with the service strategy. Rarely within the corporate world will a 'customer's experience' be dependent on the subjective feedback from seven different sources within the business. This, however, is the nature of education. Constant, timely, and consistent feedback from multiple teachers is required for the incremental improvement to a student's behaviour. Typically, within IS, feedback to stakeholders is delivered via reports. At the application layer, a reporting tool is usually used to generate specifically designed reports that are then sent to the stakeholders. This process, however, is not deemed effective enough in education management where a number of stakeholders require instant and continuous feedback about behaviours in order to make quality subjective judgments.

The artefact instantiated for this thesis provides data to the teachers about the types of feedback provided to students in comparison to all other teachers within the college. Through this data, a teacher can modify appraisal behaviours so that that consistency can be aligned across all teachers.

Summary

This section has clearly defined the purpose and scope of this research, which was defined by the service strategy – it is summarised as developing an IS that facilitates 'consistent feedback to both students and teachers which help guide their behaviours towards desired target behaviours'. It was stated that the key to achieving this goal was the continuous flow of consistent, valid, and reliable data to and from stakeholders. Figure 8.0 (above) highlights the various constructs of the wicked problem, and defined the relationships between the various constructs of the problem.

8.3 CONSTRUCTS

To clearly define relationships between entities, as well as the artefact to its environment, it is essential that the *constructs* used in the research be clearly defined. Walls, Widmeyer, and El Sawy (1992), based on work from Dubin (1978), state four considerations for describing constructs: the units of interaction; law of interaction between the units; boundaries to which the theory is expected to hold; and system conditions where the theory is not expected to hold.

The example provided in this study used the techniques in TOGAF-v 9.1 to deconstruct the problem space, and the units and their interactions were described by undertaking this process. Through focusing on problem interactions between units, the laws that drive these interactions were defined and redefined through research testing. Through researching these defined 'laws of interaction', their application and limitations were also defined.

8.3.1 Units of interaction

Within this study, seven units of interaction were identified for 'a service' to have a successful continuous improvement cycle, and these are shown in Figure 8.1.

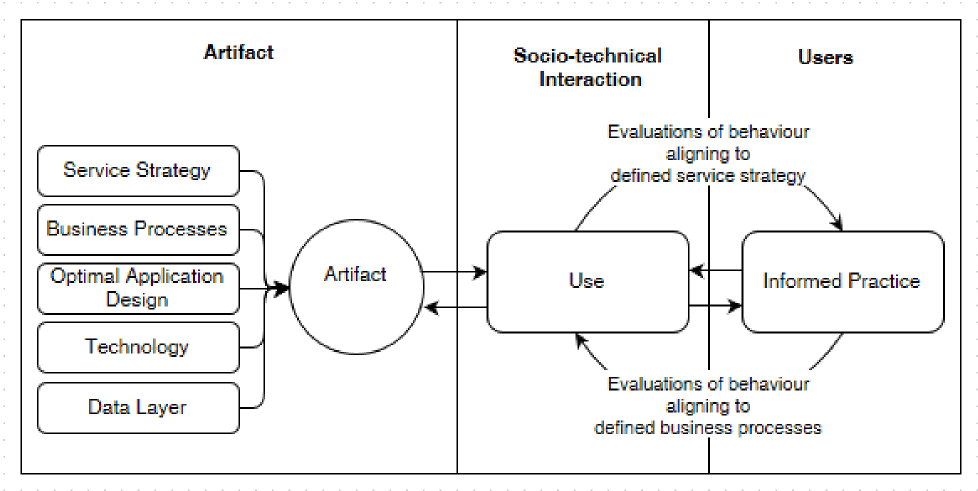


Figure 8.1: Shows the units of interaction, which are defined according to whether there is an interaction between the various components of the artefact, an interaction between the artefact and the users, or as an interaction between the various constructs of a human behaviour.

Table 8.0 – Units of interaction in a continuous improvement cycle

Type	#	Unit 1	Unit 2	Research evidence
Artefact	1	EIA–artefact alignment	Artefact quality	Through using quantitative and qualitative instruments, this study's results clearly show the method of aligning the artefact requirements to the enterprise architecture led to artefact quality, which is measured using the IS-impact scale.
Socio-technical	2	Artefact quality	Use	UTAUT results support this interaction
	3	Information quality	Use	UTAUT results support this interaction
	4	Use	Information quality	SQL data shows that the use of the artefact improved volume and data quality
Human Behaviour	5	Information quality	Quality of informed practice according to best practice (as defined in the business layer).	There was some evidence to support an improved alignment of teacher behaviours with best practices. Through direct comparison of use behaviour for trial and non-trial users, it was seen the artefact affected the quality of feedback to students.
	6	Information quality	Quality of informed practice as defined by the strategy for the service and the service unit (as defined in the service layer).	There was no evidence to support the idea that teachers consciously corrected their behaviour to align it with the service strategy.
	7	Quality of informed practice	Organisational maturity	Evidence suggests that the organisation is not mature in its data culture. Many exogenous factors (organisational/socio-political) negatively influence interactions #5 and #6.

8.3.2 Laws of interaction

The interaction of the units is shown in Figure 8.1 and described in Table 8.0 (above). The figure shows that for education services to have a continuous improvement (CI) cycle:

a) it requires all units of interaction described in Table 8.0;
b) that once the artefact is shown to provide quality information at each stage of the CI cycle, incremental improvements to service quality depend on the maturity of the organisation (i.e. the effect of exogenous variables to individual use); and
c) that there is an interdependency of information systems quality and organisational maturity in establishing CI cycles.

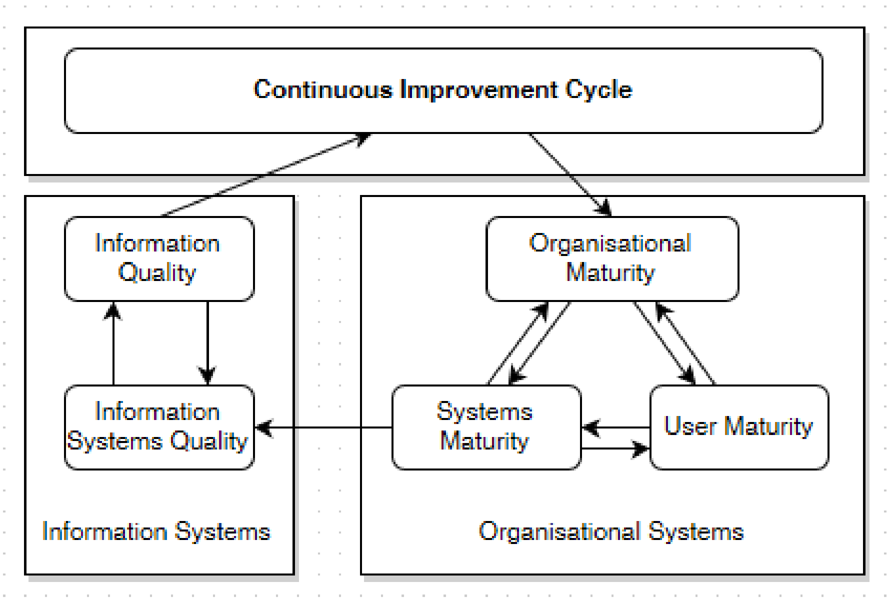


Figure 8.2: Shows that the continuous improvement cycle is related to information/system quality from each stage of the cycle, and that the use of this information depends on organisational maturity, which consists further of systems and user maturity. There is an independency between information/system quality and organisational maturity, which makes it difficult to establish CI cycles within education.

8.3.3 Boundaries of interaction

Table 8.1 – Boundaries of interaction

Type		Unit 1	Unit 2	Boundaries of interaction
Artefact	1	EIA–artefact alignment	Artefact quality	This methodology is best used to define the problem and determine the artefact requirements when the wicked problem is characterised as complex enterprise problems that span multiple layers or departments.
Socio-technical	2	Artefact quality	Use	Utility is defined by the EIA.
	3	Information quality	Use	Utility is defined by the EIA.
	4	Use	Information quality	Dependent on the environmental conditions of the classroom.
Human Behaviour	5	Information quality	Quality of informed practice according to best practice (as defined in the business layer).	Dependent on organisational maturity
	6	Information quality	Quality of informed practice as defined by the strategy for the service and the service unit (as defined in the service layer).	Dependent on organisational maturity
	7	Quality of informed practice	Organisational maturity	Organisational maturity rating of 2 is required according to the capability maturity model (Carnegie Mellon University)

Table 8.1 states the boundaries for each unit of interaction for the model in Figure 8.1. The table states that the method used to define and develop the artefact is most appropriate when the wicked problem is characterised as a complex enterprise problem spanning multiple layers or departments within the enterprise. Both the artefact and information quality in this study depended on requirements obtained from analysing the enterprise architecture. Information quality and artefact quality are, therefore, bound by the enterprise requirements.

The architecture of the artefact is specifically designed to suit schools and organisations where:

- there are many users in the organisation with the same defined role;
- the users make subjective evaluations and judgements as part of their role;
- the evaluations and judgements made as part of these roles are consistent (which is vital for the organisation); and

- the roles that make subjective evaluations are functionally different from the management of these roles (the diverse nature of these potentially leads to a breakdown of the CI cycle).

Once data quality is shown at each of stage in a CI cycle, it depends on the culture and maturity of the organisation to use this data to inform and improve practice. The maturity of the organisation could potentially be measured using scales similar to the Carnegie Mello University's 'capability maturity measures' (Remy, 1997; Ibbs and Kwak, 2000).

8.4 PRINCIPLES OF FORM AND FUNCTION

Once the constructs of the problem space are defined, they can be used to describe the architectural and functional structure of the artefact. The purpose of the DSR theory output *principles of form and function* is to describe the artefact by mapping its conceptual structure, functions, attributes and properties (Gregor & Jones, 2007). Table 8.2 shows a concept map developed as part of this research. It provides a conceptual overview of the artefact's form and function, and uses two dimensions to classify the wicked problem type. One dimension defines at what abstract level of the organisation the wicked problem exists, and a wicked problem may exist across one or more of the abstract layers of the enterprise.

Table 8.2 – Artefact's form and function

Wicked problem type	Physical component	Human computer (HCI) interaction	Human
Strategic design		Realisation design	
Business design		Process design	Process design
Application design		Object design	
Data design	Object design		
Physical design			

. The second dimension for classifying the wicked problem defines the problem as a technical, human, or an interaction of both (sociotechnical interaction). The artefact design type that targets these elements of the wicked problem is described using van Aken's (2004) design classifications. The artefact is described as an IS object design at the data and application layer.

At the data layer, a set of web-services is designed, built and introduced into the organisation. These web-services allow for the fluent and efficient access to and from the database directly from the application. At the application layer, the interface of the artefact is redesigned for compatibility of use in the classroom. Through the object redesign at these two layers, the ability of teachers to enter data and the resultant quality of data is vastly improved.

At the business layer, the business processes are redefined to include functionality associated with best-practice behaviour-management. The process of designing and implementing information flow-paths for effective subjective evaluations is also completed.

The artefact is developed to meet the realisation design described in the strategy layer for the pastoral care services. Table 8.0 represents the structure of an instantiated artefact for this research. The entities and components of the wicked problem are categorised according to the abstract layers of an EIA. The artefact component has been described for entities in each EIA layer of the wicked problem.

8.5 ARTEFACT MUTABILITY

There is a recognition in DSR that IS artefacts are in a constant state of change. The characteristic of this is often referred to as the ‘artefact’s mutability’. O’Hear (1989) describes this in terms of its evolutionary trajectory, and asks: “What are the likely future iterations to the design of the artefact?” This section, therefore, describes how and what the likely future changes of this design might be.

The purpose of the artefact is to improve the consistency of subjective evaluations. There are many industries and professions that make subjective evaluations; doctors, for example, make daily subjective evaluations on palliative care. There are multiple dimensions and considerations in these subjective evaluations.

The types of data that doctors require to make subjective evaluations are very different to those used by teachers. The artefact design for this profession will likely depend on the stated business processes in the context of the service strategy. It is the combination of the business processes in the context of the service strategy that future iterations of the design instantiated in this study will be made.

This thesis justifies its artefact design based on kernel theories from the psychology discipline. Specifically, kernel theories used for predicting human behaviour forms the basis for design in this research. It is speculated that the types of refinement to future iterations will likely address those antecedents to behavioural intention.

8.6 TESTABLE PROPOSITIONS

Testable propositions, or hypotheses, about an artefact's effect on the problem space is an important part of establishing design theory (DT) in DSR. Gregor and Jones (2007) stated that "these propositions can take the general form: If a system or method that follows certain principles is instantiated then it will work, or it will be better in some way than other systems or methods." Considering the artefact example in Table 8.0, the testable proposition is that an artefact with the specific architecture as defined in the business, application and data layers will have an effect on the specific goals stated in the strategic layer. The goals of pastoral care services can be described from several perspectives, and this study frames them from a continuous improvement data cycle perspective – and this is dependent on four information flow paths that, in turn, are dependent on:

1. A quality artefact, – that leads to improved use.

A key element of this study was that the artefact be designed for improved use within the classroom. Specifically, with the use of Bluetooth sensors, the number of user interactions per data entry was reduced. This facilitated increased use and, therefore, increased quality data.

2. Effective use – that leads to quality information for all other information flow paths of the CI cycle.

This study found that increased use of the artefact led to a perceived increase in the quality of information, and this was the basis of quality for all other information flow paths.

3. User feedback about user behaviour in proximity to desired business processes – this facilitates the alignment of user behaviour to the desired business processes.

If a teacher receives feedback about their behaviour and can determine its proximity to the desired business processes for that service, then a teacher should adjust their behaviour to attain best practice as described in the business service. The artefact developed for this study provides this feedback to teachers. However, as described in the discussion chapter, a number of exogenous factors must be viewed as positive for the specific behaviour to occur.

4. User feedback about their behaviours in proximity to the desired service strategy will lead to aligned user behaviour.

As stated in the previous paragraph, for teachers to modify their behaviour, they must see that it also align with the strategy of the organisation. In reality, users are more likely to behave according to the expectations of their social group rather than the strategic direction of the organisation. A key characteristic of wicked problems is that stakeholders often have differing values when it comes to the vision and strategy for a particular service. This makes it difficult, from a design perspective, to provide teachers information about their behaviour with respect to its proximity to any service strategy.

For this study, the information provided to teachers (through the functionality of the app) included the ability to evaluate their behaviour in comparison to other teachers. It was felt that this would be a more powerful moderator when it came to aligning with the strategy of the service – but this, of course, depends on the teachers evaluating the strategy of the service as positive.

The success in achieving those goals in the strategic layer is measured through both qualitative and quantitative measures established at the start of the project. Walls, Widmeyer, and El Sawy (1992) define design theories as “composite theories that further encompass those kernel theories from natural science, social science and mathematics”. They differentiate design theories from natural and social sciences, in that design science is the application of natural and social sciences in practice. Through applying these theories in practice, empirical support for that theory can be obtained.

Using an EIA in this research allows the easy identification of those natural and social science theories that needed to be further explored and tested as part of DSR. The kernel theories, explored for this research, aligned to those goals outlined in the strategic layer.

8.7 JUSTIFACTORY KNOWLEDGE

The nature of the goals specified at the strategy layer guide the justificatory knowledge within this section. As this thesis concerns itself with technology use and the shaping of user behaviour, much of the basis for design is taken from theories in the field of psychology and behavioural modification. The 'theory of reasoned action' and the 'theory of planned behaviour' are used to discuss many of the results collected and observed in this study. In the discussion chapter, these theories highlight the need to concurrently address both individual and organisational factors when shaping user behaviours as part of a CI cycle.

Table 8.3 – Principles for the implementation of the artefact

1	Define the enterprise information architecture of the application domain.
2	Determine why the strategy for the service unit (the focus of research) cannot be fulfilled from a user, IS, and/or user-IS interaction perspective.
3	Classify and define the wicked problem according to the architectural gaps identified in the EIA.
4	Classify and define the wicked problem in terms of its units, constructs, and interactions.
5	Determine that the gaps preventing the organisational service strategy from being realised cannot be fulfilled by using existing design or technology.
6	The defined information flow paths for the continuous improvement cycle are identified.
7	The barriers to quality information for each information flow path are identified.
8	The artefact is designed, built, and instantiated, aligning the relationships between the various units and constructs that define the wicked problem.
9	The effectiveness of the artefact in improving the service strategy is measured.

8.8 PRINCIPLES OF IMPLEMENTATION

Gregor and Jones (2007) describe this theory component as the process by which the artefact is instantiated. Simon (1996) states that it is necessary to define the process by which the artefact is instantiated, for the product and the process are linked. Further to this, it was contested in Hellmuth and Stewart (2014) that the definition of the wicked problem, the process for its development, and the product are inextricably linked within design science.

The principles guiding implementation for this research are described in Table 8.3 (above). All of the elements of this table have been defined in the relevancy and design chapter.

8.9 AN EXPOSITORY INSTANTIATION

This study has clearly instantiated an artefact. The artefact is described as the sum of all of the architectural, business, functional, design and data requirements that were specified in the relevancy and design chapters.

8.10 CHAPTER CONCLUSIONS

This chapter clearly defines all of the design theory elements to forward design theory. The study first defined the purpose and scope of the artefact, which was described according to the artefact's relationship to the environment in which it exists. The artefact was developed to improve the data flow paths that form the continuous improvement cycle. By doing this, it was hypothesised that the perceived quality of the pastoral care service strategy would be improved. The constructs of the study were defined through the development of enterprise information architecture (EIA):

1. Artefact quality. The quality of the artefact was defined and improved through the application of the EIA, and this identified a number of quality issues with the existing artefact. Importantly, it identified that the artefact needed to be redesigned to improve its conduciveness to use in the classroom and, therefore, improve the resultant data quality. The artefact quality was measured using Gable, Sedara and Chan's (2013) IS-impact model, which measures the quality of the artefact according to the information quality, system quality, its perceived impact on the individual, and its perceived impact on the organisation.
2. As stated in the Eagley and Chaiken (1996) composite-attitude behaviour model, ensuring a quality artefact will not guarantee use in itself. This study, therefore, builds two additional information paths to facilitate the use of the artefact. The first of these

provides instant data to the teacher about their behaviours in proximity to the de*fined business processes*. This is shown in Figure 7.6 as information flow path (3).

3. A second information path delivers instant data to the teacher about their behaviours in proximity to the *service strategy*. This is shown in Figure 7.6 as information flow path (4).

The success of this design is measured through the UTAUT scale and the feedback obtained from the convergent interviews. In section 8.3.3, the units of interaction and the laws that bind them were described. Table 8.0 represents the units and their interactions.

The principles of form and function were described in section 8.4 using van Akens (2004) classification schema. The artefact was described as: an object design at the data and application layer; a process design at the business layer; and a realisation design at the strategy layer. Section 8.5 stated that the design presented in this thesis is best suited for a scenario where there are many users in the organisation making subjective evaluations and judgements as part of their role. It is critical for these users that data is of high quality so that correct subjective evaluations can be made.

It was speculated that the artefact's mutability would most likely depend on requirements at the strategy and business layer. It was also suggested that most iterations to improve artefact design would centre on improving the quality of subjective evaluations, either through feedback, or by improving the likelihood of using the artefacts through improving the antecedents to use.

The testable proposition of this study was that the consistency and quality of subjective evaluations could be improved through the combination of: i) quality artefacts; ii) user feedback about behaviours in proximity to desired business processes; and iii) user feedback about their behaviours in proximity to the desired service strategy. The kernel theories underlying this testable proposition come from the natural sciences, in particular psychology and behaviour management.

Finally, this chapter provided the principles guiding the implementation:

1. Define the enterprise information architecture of the application domain;
2. Determine why the strategy for the service unit (the focus of research) cannot be fulfilled from a user, IS, and or user-IS interaction perspective;
3. Classify and define the wicked problem, according to the architectural gaps identified in the EIA;
4. Classify and define the wicked problem in terms of its units, constructs, and interactions;
5. Determine that the gaps preventing the organisational service strategy from being realised cannot be fulfilled by using existing design or technology;
6. The defined information flow paths for the continuous improvement cycle are identified;
7. The barriers to quality information for each information flow path are identified;
8. The artefact is designed, built and instantiated, aligning the relationships between the various units and constructs that define the wicked problem; and
9. The effectiveness of the artefact in improving the service strategy is measured.

This chapter has succinctly described the outputs of design science, as required, to propose design science theory. The next chapter summaries all of the activities conducted as part of this study, as well as the theory produced by this thesis and its limitations.

CHAPTER 9: SUMMARY AND CONCLUSIONS

9.1 INTRODUCTION

Australian schools over the last five years have received generous funding from the Australian federal government to provision information technology infrastructure. Through this improved funding, many opportunities (both research and organisational) are now possible that were not previously available (Hickling-Hudson, 2006). This improved IT infrastructure has led to unprecedented teacher and student access to technology. To date, however, this information technology has been used in limited ways with many perceived personal, organisational, and cultural factors acting as barriers to use (McNaught, Philip, Rossiter & Winn, 2000). As one author states, "There is not a universal, shared vision regarding the use of technology in the classroom and teachers are confronted with many theories and instructional designs. They are bombarded with confusing even romantic views of what the technology is capable of delivering" (Romeo, 2006; p. 150).

Education researchers cite the increasing need for improved information systems with improved data storage and data retrieval capacity. The ability to present the data in meaningful formats to school leaders and teachers has been emphasised (Rudner and Boston, 2003). Although technology may be available, school leadership personnel often do not allocate the resources necessary to establish coherent and high-level data-system capability (Olson, 2002).

To develop such technology, organisational requirements and sociotechnical barriers need to be considered. Identifying the exact requirements for any class of school-based information system, as well as the exact nature of how and why barriers to use exist, is complicated. Finding a solution to these problems can be even more difficult. Within the literature, these problems are referred to as *wicked problems*. Buchanan (1992, citing Rittel & Webber, 1973) define a wicked problem as a class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision-makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing.

This thesis had two broad goals. The first was to define the exact nature of the wicked problem being researched. Once that was defined, the second goal was to design, develop, instantiate, and evaluate an artefact that would facilitate the continuous improvement cycle for one educational service. The success of the instantiated artefact in meeting the research goals was discussed in depth in the discussion chapter. The theory for developing this class of information system and its application to other classroom-based services were forwarded in the rigor chapter.

Through the completion of this research, seventeen separate research contributions have been made towards the effective use of information systems in the classroom. These contributions are broadly categorised as either a research contribution to industry (development processes and product), or a research contribution to academia (research processes). These contributions are described over the next two sections.

9.2 RESEARCH CONTRIBUTIONS

9.2.1 Key contributions to industry

This research was the first to recognise that IS design is a major barrier to the continuous improvement of classroom-based education services. While the use of data has been the focus of QM programs in education for more than a decade, most research on data has been conducted from an end-user perspective. This research was the first to attempt to develop design theory that describes the necessary structures for classroom-based information systems, which are viewed as integral to any quality management system in education.

This study showed that artefact design could be further refined to improve data quality, facilitating continual improvements to teacher practice and student outcomes. An important part of this design centred on the need to develop novel technology that would compliment an environment where users were limited with respect to time and attention.

Finally, from an industry perspective, this study identified and mapped the endogenous and exogenous barriers to IS use. This is important for the future success of implementing IS within education, and the key contributions from this research is summarised in Table 9.0.

Table 9.0 – Key contributions to industry

1	Recognised that current IS design is a barrier to use in the classroom.
2	Recognised that current IS design limits the quality of data that describes student learning in the classroom.
3	Described the attributes for data quality in teaching and learning.
4	Modelled the efficacy of using EIA modelling for the developing artefact structures.
5	Produced novel IS technology that compliments the teaching and learning process, thereby, increasing its usability in the classroom.
6	Produced theory describing artefact structure that facilitates data accuracy, data timeliness, data consistency and data completeness with respect to describing student learning in the classroom.
7	Produced theory describing artefact structure that facilitates the continuous improvement cycle to teacher practices and student learning in the classroom.
8	Identified endogenous and exogenous barriers to IS use in the classroom, for the purpose of identifying change management practices to facilitate IS implementations.

9.2.2 Key contributions to academia

This study makes nine key research contributions to academia, and these are summarised in Table 9.1. The first contribution is made with regards to recognising that service-oriented architecture (SoA) is integral to quality management programs in education. This study, within the parameters of the SoA, described the need for data and its importance to the transformational quality to schools.

Table 9.1 – Key contributions to academia

1	Defined the structure and requirements for quality management programs within education.
2	Framed the requirements for data quality as part of quality management programs within education.
3	Provided an evaluation of the utility of the Alturki, Gable and Bandara (2011) roadmap.
4	Extended the relevance cycle within the Alturki, Gable and Bandara (2011) roadmap.
5	Highlighted volitional issues with the UTAUT scale in IS studies.
6	Affirmed the utility of the IS-impact scale in IS studies.
7	Affirmed the need for both quantitative and qualitative methods in DSR.
8	Affirmed the utility of the convergent interview technique in IS studies.
9	Modelled the link between IS quality, use, data quality, and continuous improvement in education.
10	Produced design theory for classroom based IS using Gregor and Jones' (2005) units of design theory, thereby, testing the efficacy of the Gregor and Jones' (2005) method for defining IS theory.

To effectively develop new artefacts addressing the research problem, this study both modified and successfully affirmed many of the existing design science methods. The new and modified methods used in this study make a unique contribution to the advancement of DSR methods, and is described in the next section.

Methods in design science research – contributions

The methodology used in this study, although adopted from Alturki, Gable and Bandara (2011), differs in that emphasis is placed on formalising an approach for completing the relevance cycle. Specifically, this is used to classify and define the research problem and the artefact's development requirements. This newly developed 'relevance cycle method' compliments and extends the Alturki, Gable and Bandara (2011) roadmap.

Relevance cycle method – research contributions

Several research papers distinguish design science from solutions engineering based on whether the investigated research problem is classified as wicked (Buchanan, 1992; Coyne, 2005; Hevner & Chatterjee, 2010). Before this research, no rigorous methods for scoping, classifying, and defining the nature of wicked problems were available. In a comprehensive literature review on DSR methodology, Alturki, Gable and Bandana (2011) identified fifteen key DSR papers that explicitly discuss DSR methodology. Of these, five briefly deal with the concept of problem wickedness and problem relevancy. These five papers, however, only briefly provide insight to the problem of establishing research relevancy (March & Storey, 2008; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Vaishnavi & Kuechler, 2004; Hevner, March, Park & Ram, 2004; Cole, Purao, Rossi, & Sein, 2005). A wider review of papers from the engineering and design fields reveals greater insights and perspectives into the nature and structure of wicked problems (such as Walls, Widmeyer & El Sawy, 1992; Eekels & Roozenburg, 1991; Nunamaker, Chen, Purdin, 1990; Takeda, Veerkamp, Tomiyama, & Yoshikawam, 1990). These papers, however, also do not provide any detailed means for defining, classifying, documenting or communicating the nature of the wicked problem being addressed. They merely discuss what is and is not a wicked problem. The

Alturki, Gable and Bandara's DSR (2011) roadmap, therefore, simply describes the relevance cycle as 'needs' (2011, p. 111).

Rittel and Webber (1973) make a number of pertinent points about the nature of wicked problems in their seminal paper. Importantly, they state that "the formulation of the wicked problem is the problem!" – and "the process of formulating the problem and of conceiving a solution are identical" (Rittel and Webber, 1973, p. 161). Given that wicked problems are defined as complex problems where solutions are anchored by human finitude and normative constraint (Farrell & Hooker, 2013), then clearly a more formalised approach to defining the wicked research problem was required.

Within the relevance cycle of this study, the use of an EIA technique is used to classify and define the wicked problem, as shown in Figure 9.0.

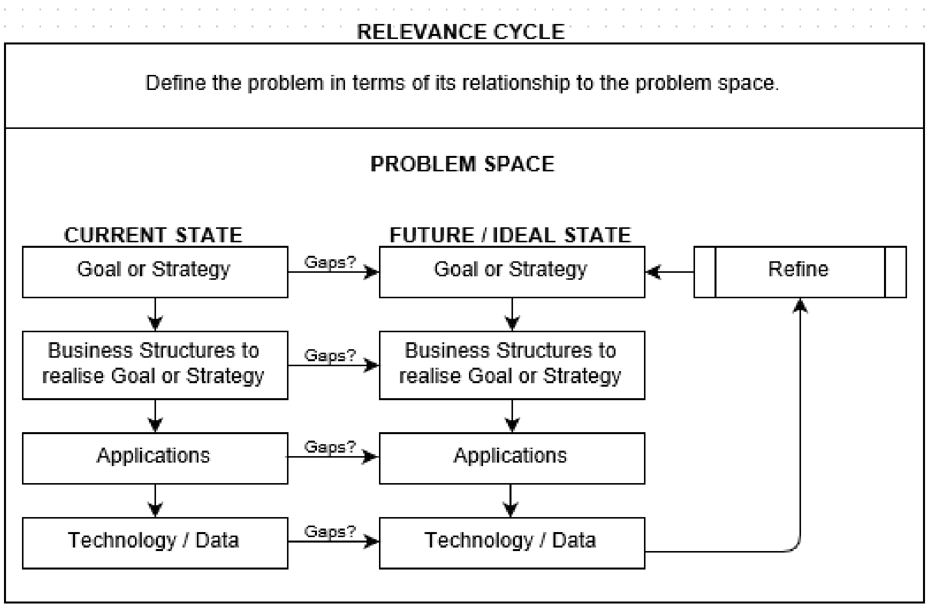


Figure 9.0: A graphical representation of the method used for the relevance cycle in this DSR.

The figure shows that the current state of the problem space, with respect to the research problem, is defined using the abstract layers as defined by TOGAF–v 9.1. The relationship between each layer is also defined as part of this definition. The future state of the problem space is defined and a gap analysis between the current and future state is performed. A number of further iterative changes to the EIA layers may occur to achieve the final state of the novel artefact. In this research, the problem space was an entire enterprise, but it is projected that this method could be scalable for smaller problem spaces.

The unique application of the EIA modelling method has been shown to be useful for: i) classifying, defining and modelling the wicked problem; ii) proving problem wickedness and relevancy; iii) a mechanism for stimulating design pathways for artefact development; and iv) developing design theory according Gregor and Jones (2005) units of design theory. These benefits are further elaborated in Hellmuth and Stewart's (2014) paper on the use of enterprise information architecture methods in DSR.

Design cycle

Once the wicked problem and the solution requirements had been defined, steps 5 to 12 of Altuki, Gable and Bandara's DSR roadmap were completed. For this research, steps 1–4 of the design cycle are completed in the relevance cycle, and steps 13–15 in the rigor cycle. Steps 5–12 of the DSR roadmap were evaluated as appropriate and effective in the development of the resultant artefact. The description of the artefact is further articulated in the *Executive Summary to Industry* and Hellmuth and Stewart's (2015) paper.

Rigor cycle

Within the rigor cycle of this research, a number of methods used to evaluate the socio-technical effect of the artefact to both individual users and 'the problem space' being investigated. This study adopted three measures to examine the socio-technical effect: i) unified theory of acceptance and use of technology; ii) IS-impact; and iii) convergent interviewing techniques.

Unified theory of acceptance and use of technology (UTAUT)

The UTAUT was applied in this study to measure the acceptance of the artefact, and the results showed some volitional issues with its application. The questions on the UTAUT scale appear to be engineered more for an *ex-post facto* research design than for an experimental research one. A major limitation to this research, therefore, is the construct validity of

UTAUT. This study recognised the need for modifications to the scale, particularly in research where information systems are trialled for a set period of time.

IS-impact scale

The Gable, Sedara and Chan (2008) IS-impact scale in this study was shown to have appropriate construct reliability, and was perceived as an appropriate measure to use. The IS-impact, together with the UTAUT results, represented the quantitative results for the study. One limitation of the design science methodology is related to the sample size. Given that design science requires the implementation of ‘experimental artefacts’, it is difficult to implement such risky artefacts on a large scale. Quantitative results, therefore, often require the use of qualitative techniques to give further validity to the results found using quantitative techniques. This study used two further techniques to study the effects of the instantiated artefact. The first is described as an analysis of SQL data to examine the data accuracy, timeliness, consistency and completeness. The second technique involved the use of convergent interviews.

Convergent interviews

Convergent interviews gain a qualitative understanding of the wicked problem and the artefact’s effect in solving the stated business problem. They allow feedback from a diverse array of organisational stakeholders in the application domain and, therefore, have the potential to provide rich insights to those factors that lead to, or act as, barriers to use. Convergent interviewing is a recommended interview technique when complex issues need to be identified. It differs from other methods in that it focuses on interviewing participants who are characteristically different. Through interviewing a full range of end-users, key issues related to the problem set can be attained (Jepson & Rodwell, 2008). Convergent interviewing is characterised as a technique applied a number of times in the application domain and converges on the issues with each round of interview. They have been found to be valid and reliable across a variety of settings (Lincoln & Guba, 1985). In this study, the convergent interview technique is applied to range of user types to investigate their interaction with the artefact.

For this study, the use of the convergent interview technique revealed information that many not have been yielded from other techniques. Through their use, similarities and differences between the various user perceptions could be discerned, and a rich and diverse range of perspectives was gained.

Design theory

This summary, as part of the rigor cycle, describes the use and application of the Gregor and Jones principles for defining the theory (DST) emanating from this research, and this research is the first of its kind to use this technique to describe DST. The rigor section successfully describes the eight DST elements: *purpose and scope*, *constructs*, *principles of form and function incorporating the underlying constructs of the artefact*, *artefact mutability*, *testable propositions*, *justificatory knowledge*, *principles of implementation* and *expository instantiation*. Through this technique, this study advances grounded theory for the design, development, and instantiation of classroom-based information systems. Further elaboration on IS design theory for classroom-based education software is made in the conclusion chapter.

9.2 RECOMMENDATIONS FOR FUTURE RESEARCH

This section makes six recommendations for future design science research (four directly related to the design science research methodology,) and these are summarised in Table 9.2.

Table 9.2 – Recommendations for future DSR

1	Formal methods for developing a scalable approach to defining wicked problems in IS.
2	Ensure that the units of artefact design and interaction are drafted as soon as possible in the research. Continually iterate through the units and their interactions as the DSR process evolves.
3	Design theory for the capture, storage, retrieval and consumption of student learning metadata.
4	Further development of the Bluetooth framework for the elegant capture of data within the classroom environment.
5	Modifications to the UTAUT scale for trial artefacts.
6	The development of scales to measure the influence of exogenous variables to the artefact.

9.2.1 Methodological recommendations

Recommendation 1 – modelling of wicked problems

In this study's first iteration, methodology problems were identified with scoping, classifying and defining complex wicked problems. It identified many sources of error from relying on end-users as the sole method for determining the wicked problems, and described these in section 3.1. This study also described the advantages of using the EIA method for defining, classifying, and communicating the nature of the wicked problem. Hellmuth and Stewart's (2014) paper contains a lengthy discussion on the importance of this method to establish: relevancy within design science research; the design components; and design theory. This method, used in this study, was suitable for a large-scale enterprise problem. It is suggested, however, that a similar but more generic approach to defining wicked IS problems (regardless of their scale) may be useful.

Recommendation 2 – artefact units and their interactions

Ensure that the DSR step of 'defining the units of the artefact and their relationships' are emphasised as part of any DSR methodology.

This study recommends that the units of the study and the relationships between them (that are the focus for the study) should be defined or drafted very early in the research. This study recommends the researcher continually monitor whether the units of study are still relevant through each iteration of the research stage. This part of the DSR method should be emphasised in discussions on design science research as the key step within design science.

Recommendation 3 – management of education metadata

Future iterations of the developed artefact will require further research and development if it is to be deployed on large scales. One large-scale problem is based on the definition, storage, retrieval and consumption of metadata that describes student learning. There are future design challenges to developing consistent yet agile, scalable and flexible information systems for the management of this metadata. This is a key requirement for the future success of the class of information system described in this research.

Recommendation 4 – Bluetooth framework development

Additional refinement to the artefact can be realised in subsequent research and/or development stages. Further changes to the BTLE 4.0 framework could, potentially, make future solutions more elegant. Originally, the artefact developed for this study continually polled the Bluetooth devices in the classroom to determine the closest student to the teacher. Testing this artefact version revealed too many short latency periods, thus, increasing the need for teacher attention to the artefact, and this was seen as undesirable. The solution was to use it with a manual button, as this was seen as less disruptive to the teacher than the continual polling. Development of the Bluetooth framework may potentially make this class of artefact more efficient for use inside the classroom.

Recommendation 5

The use of the UTAUT questionnaire will need to be considered if the artefact is for a trial implementation.

As highlighted in the discussion chapter, the predictive validity of the behavioural intention construct within the UTAUT has been questioned. This study recommends that if the research does plan to implement and measure a trial IS artefact, then formal modifications to the UTAUT research will need to be completed.

Recommendation 6

The consideration of exogenous factors when designing the artefact.

In this study, it was identified that many socio-political antecedents to behavioural intent can influence whether an end-user engages with the IS. It is recommended in future iterations to IS scales consider these exogenous factors. Venkatesh, Thong, and Xu (2012) state that by “adapting and extending UTAUT to include new constructs and altering existing relationships, the generalisability of UTAUT to a different contexts can advance theory” (p.159). This study recommends testing the maturity of the application domain as part of the design process. It is suggested that a scale that tests the relationship between the user and the business goals and service strategy may provide a strong indication of those exogenous factors likely to act as barriers to use. The design science methodology could then include the results of this analysis and shape the artefact design to take these exogenous (organisational) variables into account.

9.3 LIMITATIONS OF THE STUDY

The internal and external validity each have one major limitation in this study. The limitation to the internal validity is related to the behavioural intention construct belonging to the UTAUT scale. Clearly, the questions that make up the behavioural intention construct are not suitable for the type of study where the artefact can be perceived as a temporary object. For future studies similar to this one, the questions that make up this artefact need to reflect the its temporary nature.

The limitation to external validity relates to how representative the sample is of the population. The more representative, the more confident one can be in generalising from the sample to the population. Given the small sample, there are some limitations in generalising these findings.

9.4 CONCLUDING REMARKS

Previous research on data use has tended to focus on: i) interventions relevant to data use; ii) the relationship between data and aggregate outcomes; and iii) the technical quality of the outcome measures. These studies have inadequately provided any advancement towards the goals of improving the practice and effects of data use. They do not provide insight into the (complex) mechanisms through which education initiatives influence outcomes (Coburn & Turner, 2012; Colyvas, 2012; Honig & Venkateswaran, 2012; Little, 2012; Spillaine, 2012). As Coburn and Turner (2012, p. 101) state, “understanding outcomes without understanding the mechanisms that produced them means that we have little insight into how to redesign data use interventions so as to increase their impact in practice.”

Contrary to previous studies on data use within education, this study has provided insight to the complex internal mechanisms of data use within education. It has provided effective methodologies for improving the quality of IS within the education context, and illustrated how improving the quality of IS improves the quality of information throughout the continuous improvement cycle. This study also provided insight into those endogenous and exogenous variables that influence the various stages of the continuous improvement cycle for one service.

The utopia for education, where each student can be profiled and their learning deficits addressed, was simply not possible previously with the available classroom resources. This problem, in part, has been due to the immaturity of the technology available in schools – it simply could not be used in ways that would allow a teacher to continuously collect data in the classroom. Therefore, the maturity of information systems before now is considered to have anchored the continuous improvement cycle in education.

This thesis has shown that with the availability of new school-based technology, the technology itself no longer needs be a barrier to the continuous collection of data in the classroom. This knowledge is an important fact to the progressive school leader. With this knowledge, the school leader has the potential to make a ‘quantum leap’ in the quality of education services provided to the students (Jackson & Marriott, 2012). This quantum leap, however, depends on improving those socio-political factors that anchor the use of information systems in informing teacher practice (Jaunch, 2010). It is imperative for the school leader to start building a data culture within the organisation so that technology can be used in progressive ways to continually improve the quality of education services.

REFERENCES

Abernathy, P. E. & Serfass. R. W. (1992). One district's quality improvement story. *Educational Leadership, 50*(3), 14-17. http://www.eric.ed.gov/ERICWebPortal/detail?accno=EJ454320

Aken, J. E. (2004). Management research based on the paradigm of the design sciences: The quest for field-tested and grounded technological rules. *Journal of Management Studies, 41*(2), 219–246.

Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211.

Ajzen, I. (2002). Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior. *Journal of Applied Social Psychology, 32,* 665-683.

Alturki, A, Gable, G. G. & Bandara, W. (2011) A design science research roadmap. In *Design science research in Information Systems and Technology, 2011* (Lecture Notes in Computer Science 6629), Springer, Milwaukee, Wisconsin, pp. 107-123.

Allan, L. (2010). Will the Australian national curriculum up the intellectual ante in classrooms? *Curriculum Perspectives (Journal Edition), 30*(3). http://eprints.qut.edu.au/32392/1/c32392.pdf

Almaula, V. & Cheng, D. (2012). *Bluetooth Triangulator*. Retrieved from https://cseweb.ucsd.edu/classes/fa06/cse237a/finalproj/almula.pdf

Argyris, C. (1993). *Knowledge for Action: A guide to overcoming barriers to organizational change.* Jossey-Bass Inc. San Francisco, CA.

Alonso, W. & Starr. P. (1987). *The Politics of Numbers*. Russell Sage Foundation, New York.

Anderson, E. (1995). High tech v. high touch: a case study of TQM implementation in higher education. *Managing Service Quality, 5*(2), 48-56. http://dx.doi.org/10.1108/09604529510083576

Atkinson, E. P. (1994). Developing an Education Quality Assurance Framework. Occasional Paper No. 34. Jolimont, Victoria: Incorporated Association of Registered Teachers of Victoria In. Berry, G. (1998). A quality systems model for the management of quality in NSW schools. *Managing Service Quality, 8*(2). 97–111. http://dx.doi.org/10.1108/09604529810206891

Ackoff, R. L. (1999). On Passing Through 80. *Systemic Practice and Action Research, 12*(4), 425-430. http://link.springer.com/article/10.1023/A%3A1022404515140#page-1

Armstrong, A. & Foley, P. (2003). Learning organisations – new paradigm or latest fad. *Comment Magazine, July*, 6-10. http://dx.doi.org/10.1108/09696470910462085

Asif, M., Awan, M. U., Khan, M. K. & Ahmad, N. (2013). A model for total quality in higher education. *Quality & Quantity, 47(4)*, 1883-1904.

Asubonteng, P., McCleary, K. J. & Swan, J. E. (1996). SERVQUAL revisited: a critical review of service quality. *Journal of Services Marketing, 10*(6), 62-81. http://dx.doi.org/10.1108/08876049610148602

Argyris, C. (1994). Good communication that blocks learning. What is a Learning Organization? *Harvard Business Review*. Reprint 1997, Boston.

Babakus, E. & Boller, G. W. (1992). An empirical assessment of the SERVQUAL scale. *Journal of Business Research, 24*(3), 253-268. http://dx.doi.org/10.1016/0148-2963(92)90022-4

Babchuk, W. A. (1997). *Glaser or Strauss: Grounded theory and adult education.* Paper presented at the Midwest Research-to-Practice Conference in Adult, Continuing and Community Education, Michigan State University, East Lansing, Michigan.

Baird, K., Hu. K. J. & Reeve, R. (2011). The relationships between organizational culture, total quality management practices and operational performance. *International Journal of Operations & Production Management, 31*(7), 789 – 814.

Baskerville, R., Pries-Heje, J. & Venable, J. (2009). Soft design science methodology. In: *DESRIST, 2009.* ACM, Malvern.

Barak, M. (2007). Transition from traditional to ICT-enhanced learning environments in undergraduate chemistry courses. *Computers & Education,* 48(1), 30-43. http://dx.doi.org/10.1016/j.compedu.2004.11.004

Bayraktar, E., Tatoglu, E. & Zaim, S. (2008). An instrument for measuring the critical factors of TQM in Turkish higher education. *Total Quality Management and Business Excellence, 19*(6), 551-574. http://dx.doi.org/10.1080/14783360802023921

Beizer, B. (1995). *Black-box testing: techniques for functional testing of software and systems.* John Wiley & Sons, Inc: New York, NY, USA.

Benbasat, I. & Barki, H. (2007). *Journal of the Association for Information Systems, 8*(4), 211-218. http://aisel.aisnet.org/jais/vol8/iss4/7

Bentler, P. M. & Speckart, G. (1981). Attitudes case behaviors: A structural equation analysis. *Journal of Personality and Social Psychology, 40*, 226-238.

Bernhardt, V. (2013). *Data Analysis for Continuous School Improvement.* New York, NY: Routledge.

Berry, G. (2002). Towards quality systems development in NSW public schools, school effectiveness and school improvement. *International Journal of Research, Policy and Practice, 13*(2), 201-223. http://dx.doi.org/10.1076/sesi.13.2.201.3436

Berry, G. (2010). Getting “Real” about teaching effectiveness and teacher retention. *Journal of Curriculum and Instruction, 4*(1), 1-15.

Bingimlas, K. A. (2009). Learning Environments: A review of the literature. *Eurasia Journal of Mathematics, Science & Technology Education, 5*(3), 235-245.

Boston, C. (2002). *The concept of formative assessment.* Retrieved 12 May, 2013. http://www.vtaide.com/png/ERIC/Formative-Assessment.htm

Boyd, D., Lankford, H., Loeb, S., Rockoff, J. & Wyckoff, J. (2007). The narrowing gap in New York City teacher qualifications and its implications for student achievement in high-poverty schools. *(CALDER Working Paper 10).* Washington, DC: The Urban Institute. Retrieved April 14, 2010 from http://www.caldercenter.org/PDF/1001103_Narrowing_Gap.pdf

Boynton, A. C., Victor, B. & Pine II, B. J. (1993). New competitive strategies: Challenges to organizations and information technology. *IBM Systems Journal, 32*(1), 40-64. http://dx.doi.org/10.1147/sj.321.0040

Braithwaite, V. (2000). *Restorative justice: Philosophy to practice.* Retrieved http://demgov.anu.edu.au/papers/Braithwaite2000RJPP.pdf

Brooks, F. P. Jr. (1987). No Silver Bullet: Essence and Accidents of Software Engineering. *IEEE Computer, 20*(4), 10-19.

Brooks, F. P. Jr. (1996). The computer scientist as a toolsmith II. *Communications of the ACM, 39*(3), 61-68.

Brosnan, M. J. (1999). Modeling technophobia: A case for word processing. *Computers in Human Behavior, 15*(2), 105–121.

BS 7850-1: "*Total quality management - Part 1: Guide to management principles*" (1992)

Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues, 8*(2), 5–21. http://dx.doi.org/10.2307/1511637

Burrows, D. C. (2011). *Teacher's use of data to guide instructional practice in elementary schools.* (Unpublished doctoral dissertation). Pennsylvania State University, Pennsylvania.

Burton-Jones, A. & Straub, D. W. (2006). Reconceptualizing System Usage: An Approach and Empirical Test. *Information Systems Research, 17*(3), 228-246.

Campbell, D. T. & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research.* Boston: Houghton Mifflin Company.

Chang, M. K. (1998). Predicting unethical behaviour: A comparison of the theory of reasoned action and the theory of planned behaviour. *Journal of Business Ethics, 17*(16), 1825-1834.

Chatterjee, S. & Hevner, A. R. (2006). *Proceedings of the first international conference on design science research in information systems and technology.* (DESRIST 2006). Claremont.

Cheng, Y. C. (1993). The theory and characteristics of school-based management. *International Journal of Educational Management, 7*(6), 6-17.

Cheng, Y. C. & Tam, W. M. (1997). Multi-models of quality in education. *Quality Assurance in* Education, 5(1), 22-31. http://dx.doi.org/10.1108/09684889710156558

Chittenden, F., Mukhtar, S. M. & Poutziopuris, P. (1996). BS 5750 and quality management in SMEs, in Blackburn, R. and Jennings, P. (Eds), *Small Firms - Contributions to Economic Regeneration*, Paul Chapman, London, 127-141. http://dx.doi.org/10.1177/0266242698171004

Choppin, J. (2002). *Data Use in Practice: Examples from the School Level*, paper presented at the Annual Conference of the American Educational Research Association, New Orleans, April 2002.

Coburn, C. E. & Turner, E. O. (2012). The practice of data use: an introduction. *American Journal of Education*, *118*(2), 99-111. http://www.jstor.org/stable/10.1086/663272

Cohen, J. (1988). *Statistical power analysis for the Behavioural Sciences*. 2nd Ed. Lawrence Belbaum Associates Publishers, New Jersey.

Cole, R., Purao, S., Rossi, M. & Sein, M. K. (2005). *Being proactive: where action research meets design research.* In: Twenty-Sixth International Conference on Information Systems. Citeseer, Atlanta.

Colyvas, J. A. (2012). Performance metrics as formal structures and through the lens of social mechanisms: when do they work and how do they influence? *American Journal of Education, 118*(2), 167-197. http://dx.doi.org/10.1086/663270

Coopey, J. (1995). The Learning Organization, Power, Politics and Ideology Introduction. *Management Learning, 26*(2), 193-213.

Coyne, R. (2005). Wicked problems revisited. *Design Studies, 26*(1), 5-17.

Cronbach, L. J. & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*(4), 281-302.

Cross, N. (2001). *Design/Science/Research: Developing a Discipline*, in the 5th Asian Design Conference: International Symposium on Design Science, Seoul, Korea: Su Jeong Dang Printing Company.

Cua, K. O., McKone, K. E. & Schroeder, R. G. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *Journal of Operations Management, 19*(6), 675-694. http://dx.doi.org/10.1016/S0272-6963(01)00066-3

Cummings. T. G. &Worley C. G. (2009). *Organization development and change.* Cengage Learning, Mason, Ohio.

Cuttance, P. (1994). *Building the future: Next steps in the development of quality assurance in the NSW school system.* Sydney: Department of School Education.

Danielian, H. J. (2009). *District level practices in data driven decision making*. (Unpublished doctoral dissertation). University of Southern California, Los Angeles.

Davis, F. D. (1986). *A Unified Theory of Acceptance and Use of Technology for empirically testing new end-user information systems: Theory and results*. (Doctoral dissertation, Sloan School of Management, Massachusetts Institute of Technology).

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology, *MIS Quarterly, 13*(3), 319–340.

Davis, F. D., Bagozzi, R. P. & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Davis, G. & Olson, M. (1985). *Management information systems: conceptual foundations, structure and development, 2nd Ed*. McGraw Hill.

Davis, K. E., Benedict K., & Merry, S. E. (2010). *Indicators as a Technology of Global Governance.* New York University Public Law and Legal Theory Working Papers No. 191, New York University School of Law, New York.

Dawson, V. (2008). Use of information communication technology by early career science teachers in Western Australia. *International Journal of Science Education,* 30(2), 203-219. http://dx.doi.org/10.1080/09500690601175551

DeLoach, R. (2012). *Factors that affect a school district's ability to successfully implement the use of data warehouse application in the data driven decision making process*. Retrieved 6, May, 2013. http://ir.library.oregonstate.edu/xmlui/handle/1957/33378

DeLone, W. H. & McLean, E. R. (1992). Information Systems Success: The Quest For The

Dependent Variable, *Information Systems Research, (3)*1, 60-95.

DeLone, W. H. & McLean, E. R. (2003). The Delone And Mclean Model Of Information Systems Success: A Ten Years Update. *Journal of Management Information Systems (19)* 4, 9-30.

Dembosky, J. W., Pane, J. F., Barney, H. & Christina, R. (2005). *Data driven decision making in Southwestern Pennsylvania School Districts.* Working paper. Santa Monica, CA: RAND.

Deming, W. E. (1986). *Out of the Crisis.* Cambridge, Massachusetts: The MIT Press.

Denise M., Jepsen, J. & Rodwell, J. (2008). Convergent interviewing: a qualitative diagnostic technique for researchers. *Management Research News, 31*(9), 650 – 658. 10.1108/01409170810898545

Devellis, R. F. (2012). *Scale development: Theory and applications, 3rd Ed.* Los Angeles: Sage.

Dial, E. E. (2011). *An examination of improvement paths taken by two previously underperforming schools to improve student outcomes.* (Unpublished doctoral dissertation). California State University, San Marcos.

Dick, B. (2000), *''Data-driven action research''*, available at: http://www.uq.net.au/action_research/arp/datadriv.html

Dickie, G. (1971). *Aesthetics: An introduction.* New York: The Bobbs-Merill Company.

Dimmock, C. (2013). *School-based management and school effectiveness. 3rd Ed*. New York, NY: Routledge.

Donhurst, M. J. (2009). *Educational assessment: exploring the relationship between computer adaptive testing, data analysis, and student achievement.* (Unpublished doctoral dissertation). De Paul University, Chicago.

Dorlman, R. & Steiner, P. O. (1954). Optimal advertising and optimal quality. *American Economic Review, Dec*, 822-836.

Dotchin, J. A., Oakland, J. S (1994). Total quality management in services: Part 3: distinguishing perceptions of service quality. *International Journal of Quality & Reliability Management*, *11*(4), 6–28. http://dx.doi.org/10.1108/02656719410057926

Dubin, R. (1978). *Theory Building*. Revised Ed. London: Free Press.

Duffin, M. (1994). Japan – Myth, Miracle or Menace? *The TQM Magazine, 6*(2), 45-47. http://dx.doi.org/10.1108/09544789410054046

Eagley, A. H., & Chaiken, S. (1993). *The Psychology of Attitudes*. Orlando, FL: Harcourt Brace Jovanovich.

Edwards, S. H. (2001). A framework for practical, automated black-box testing of component-based software. *Software Testing, Verification and Reliability*, *11*(2) 97-111.

Ehigie, B. O. & McAndrew, E. B. (2005). Innovation, diffusion and adoption of total quality management (TQM). *Management Decision, 43*(6), 925-940. http://dx.doi.org/10.1108/00251740510603646

Elken, M. (2007). *QU Trends 1995–2006 Literature overview*. Oslo: University of Oslo.

Elmore, R. (1995). Getting to scale with good educational practices. *Harvard Educational Review, 66*(1), 1-26. http://her.hepg.org/content/g73266758j348t33/

Emery, C. R., Kramer, T. R. & Tian, R. G. (2003). Return to academic standards: a critique of student evaluations of teaching effectiveness. *Quality Assurance in Education, 11*(1), 37-46. http://dx.doi.org/10.1108/09684880310462074

Espeland, W. N. & Sauder, M. (2007). The reactivity of rankings: how public measures recreate social worlds. *American Journal of Sociology, 113*(1), 1–40. http://www.jstor.org/stable/10.1086/517897

Evans, R. (1996). *The human side of school change: reform, resistance, and the real-life problems of innovation*. The Jossey-Bass Education Series. San Francisco: Jossey-Bass Inc.

Farrell, R. & Hooker, C. (2013). Design, science and wicked problems. *Design Studies, 34*, 681-705. https://dx.doi.org/10.1016/j.destud2013.05.001

Feigenbaum, A. V. (1991). *Total Quality Control*. 3rd Ed., New York: McGraw-Hill.

Ferguson, R. F. (1991). Paying for public education: New evidence on how and why money matters. *Harvard Journal on Legislation, 28*(2), 465-498. http://heinonline.org/HOL/LandingPage?collection=journals&handle=hein.journals/hjl28&div=24&id=&page=

Ferster, C. B. & Skinner, B. F. (1957). *Schedules of Reinforcement*. Englewood Cliffs, NJ: Prentice-Hall.

Fishbein, M. & Ajzen, I. (1975). *Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research.* Addison-Wesley, Boston.

Freeman, R. (1993). *Quality assurance in training and education*. London: Kogan Page.

Fullan, M. (1993). *Change forces: probing the depths of educational reform*. Levittown, PA: The Falmer Press, Taylor and Francis Inc.

Fullan, M. (2001). *The secondary meaning of educational change*. London: Teachers College Press.

Fuller, B. (1986). *Raising school quality in developing countries: what investments boost learning?* Retrieved 10 May, 2013, http://www-wds.worldbank.org

Fuller, M. (1965). *World Design Science Decade, 1965-1975*. World Resources Inventory.

Furneaux, B. (2005). *Theories used in IS research. Unified theory of Acceptance and Use Technology.* Retrieved from http://www.istheory.yorku.ca/UTAUT.htm

Gable, G. G., Sedera, D. & Chan, T. (2008) Re-conceptualizing information system success: the IS-impact Measurement Model. *Journal of the Association for Information Systems, 9*(7), 377-408.

Garfield, M. J. (2005). Acceptance of Ubiquitous Computing. *Information Systems Management, 22*(4), 24-31.

Garvin, D. A. (1986). Quality problems, policies, and attitudes in the United States and Japan: an exploratory study. *Academy of Management Journal, 29*(4), 653-673. http://dx.doi.org/10.2307/255938

Giaever, H. (1999). *Does total quality management restrain innovation? – a discussion of the effect of TQM in knowledge intensive organisations.* Approved as DNV report no.: 99-2036. Retrieved from http://www.giaever.com/does_total_quality_management_re.htm

Gilmore, H. L. (1974). Product conformance cost. *Quality Progress, 7*(5), 16-19.

Glaser, B. (1992). *Basics of grounded theory analysis: Emergence vs. forcing.* Valley, CA: Mill.

Gleasure, R. (2013). *What is a 'Wicked Problem' for IS Research.* SIG Prag Workshop Tilburg, The Netherlands, 5 July 2013.

Gleitman, H., Fridlund,A. J., & Reisberg, D. (2004). *Psychology*, 6th Ed. New York City, NY: W W Norton & Company Incorporated.

Godreau C. K. L. (2011). *A middle school principal"s and teachers" perceptions of leadership practices in data-driven decision making.* (Unpublished doctoral dissertation). University of Hartford, West Hartford.

Goe, L. (2007). *The link between teacher quality and student outcomes: a research synthesis*. National Comprehensive Centre for Teacher Quality. Washington, DC: National Comprehensive Centre for Teacher Quality.

Goldkuhl, G. & Lind, M. (2010). *A Multi-Grounded Design Research Process*. In: Winter, R., Zhao, J. L., & Aier, S. (eds.) DESRIST 2010. LNCS, vol. 6105, pp. 45–60. Springer, Heidelberg.

Goren, P. (2012). Data, data, and more data – what's an educator to do? *American Journal of Education, 118*(2), 233-237. http://www.jstor.org/stable/10.1086/663273

Green, D. (1994). *What is quality in higher education?* Bristol, PA: Taylor & Francis.

Gregg, D. G., Kulkarni, U. R. & Vinzé, A. S. (2001). Understanding the Philosophical Underpinnings of Software Engineering Research in Information Systems. *Information Systems Frontiers, 3*(2), 169-183.

Gregor, S. & Jones, D. (2007). The anatomy of a design theory. *Journal of the Association for Information Systems, 8*(5), 312–335.

Gregory, S. A. (1966). *The Design Method*. London: Butterworths.

Hale, J. L., Householder, B. J. & Greene, K. L. (2002). The theory of reasoned action. In J.P. Dillard & M. Pfau (Eds.), *The persuasion handbook: Developments in theory and practice* (pp. 259–286). Thousand Oaks, CA: Sage.

Hallinger, P. (2003). Leading educational change: reflections on the practice of instructional and transformational leadership. *Cambridge Journal of Education, 33*(3), 329-352. http://dx.doi.org/10.1080/0305764032000122005

Hanks, J. E. (2011). *Examining data-driven decision making in private/religious schools*. (Unpublished doctoral dissertation). University of Louisiana: Lafayette.

Haplin, T. & Morgan, T. (2010). *Information Modeling and Relational Databases*. Burlington, MA: Morgan Kaufmann Publishers.

Hargraves, A. (2005). Educational change takes ages: life, career and generational factors in teachers' emotional responses to educational change. *Teacher and Teacher Education, 21*(8), 967-983.

Harvey, L. & Knight, P. T. (1996). *Transforming higher education.* Bristol, PA: Taylor & Francis.

Hayes, J. (2004, October). *Ed tech trends: A 'first look' at QED's 10th annual technology purchasing forecast 2004-05*. Paper presented at the NSBA's T+ L_2 Conference, Denver, CO.

Hellmuth, W. J. & Stewart, G. (2014) Using enterprise information architecture methods to model wicked problems in information systems design research. In *Proceedings of the Pacific Asia Conference on Information Systems (PACIS 2014),* AIS Electronic Library (AISeL), Chengdu, China, pp. 1-17.

Hellmuth, W. J., & Stewart, G. (2015). *Information Systems Design for Continuous Improvement in Teaching and Learning.* Paper submitted to the European Conference on Information Systems, Munster Germany.

Henderson, J. C. & Venkatraman, N. (1993). Strategic alignment: leveraging information technology for transforming organizaions. *IBM Systems Journal, 32*(1), 4-16.

Hevner, A. R. (2007). A Three Cycle View of Design science research. *Scandinavian Journal of Information Systems, 19*(2), 87–92.

Hevner, A. R. & Chatterjee, S. (2010). Design Research in Information Systems: Theory and Practice. *Integrated Series in Information Systems, 22*. http://dx.doi.org/10.1007/978-1-4419-5653-8_1.

Hevner, A. R., March. S. T., Park, J. & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly, 28*(1), 75-105.

Hickling-Hudson, A. (2006). Rich schools, poor schools, boys and girls: computer education in Australian secondary schools. *Journal of Education Policy, 7*(1), 1-21.

Hill N., Brierley, G. & MacDougall, R. (2003). *How to measure customer satisfaction.* Hampshire: Gower Publishing.

Honig, M. I. & Venkateswaran, N. (2012). School–central office relationships in evidence use: understanding evidence use as a systems problem. A*merican Journal of Education,* 118(2), 199-222. http://www.jstor.org/stable/10.1086/663282

Hopkins University, Center for Research on the Education of Students Placed at Risk. Retrieved January 30, 2004, from www.csos.jhu.edu/crespar/techReports/Report67.pdf.

Houston, D. (2007). TQM and higher education: A critical systems perspective on fitness for purpose. *Quality in Higher Education, 13*(1), 3-17. http://dx.doi.org/10.1080/13538320701272672

Howe, K. R. & Eisenhardt, M. (1990). Standards for qualitative (and quantitative) research: A prolegomenon. *Educational Researcher, 19*(4), 2-9.

Hox, J., de Leeuw, E & Vorst, H. (1996). A reasoned action explanation for survey nonresponse, in Sepp Laaksonen (Ed). (1996). *International Perspectives on Nonresponse.* Helsinki: Statistics Finland, 101-110.

Hughes, P. W. (1988). *The challenge of identifying and marketing quality in education*. Ashton Scholastic, Sydney.

Ibbs, C. W. & Kwak, Y. H. (1997). *The benefits of project management—Financial and organizational rewards to corporations.* Project Management Institute, Upper Darby, Pa.

Idrus, N. (1996). Towards total quality management in academia. *Quality Assurance in Education, 4*(3), 34-40. http://dx.doi.org/10.1108/09684889610125850

Iivari, J. & Venable, J. (2009). Action research and design science research–seemingly similar but decisively dissimilar. In: *17th European Conference on Information Systems.*

Ikemoto, G. S. & Marsh, J. A. (2007). Cutting through the "data-driven" mantra: different conceptions of data-driven decision making. In, *Yearbook of National Society for the Study of Education, 106* (1), 105-131. http://dx.doi.org/10.1111/j.1744-7984.2007.00099.x

Investopedia. Definitions of a t-test. Retrieved from http://www.investopedia.com/terms/t/t-test.asp

Izumi, N. (1995). The recent history of managing for quality in Japan. 517-552 in *A History of Managing for Quality*, J. M. Juran, ed. Milwaukee: ASQC, Quality Press.

Jackson. K. M. & Marriott, C. (2012). The interaction of principal and teacher instructional influence as a measure of leadership as an organisational quality. *Educational Administration Quarterly. 48*(2), 230-258. http://dx.doi.org/10.1177/0013161X11432925

Jarvinen, P. (2007). Action research is similar to design science. *Quality and Quantity, 41*(1), 37–54.

Jauch, K. (2010). *The perceptions of administrators from Quality award-winning school districts and comparison of student academic achievement in Quality award-winning districts.* Unpublished doctoral dissertation, Northern Illinois University, DeKalb, USA.

Jepsen, D. M. & Rodwell, J. J. (2008). Convergent interviewing: a qualitative diagnostic technique for researchers. *Management Research News, 31*(9), 650-658.

Joseph, M. & Joseph, B. (1997). Service quality in education: A student perspective. *Quality Assurance in Education*, *5*(1), 15-21. http://dx.doi.org/10.1108/09684889710156549

Juran, J. M. (1989). *Juran on Leadership for Quality: An Executive Handbook*. Juran Institute, Wilson, CT.

Juran, J. M. & Gryna, F. M. Jr (Eds). (1988). *Juran's Quality Control Handbook*, 4th ed., New York, NY: McGraw-Hill.

Kanji, G. K. & Malek, A. & Tambi, B. A. (2010). Total quality management in UK higher education institutions. *Total Quality Management, 10*(1), 129-153. http://dx.doi.org/10.1080/0954412998126

Kanji, G. K. & Yui, Y. (1997). Total quality culture. *Total Quality Management, 8*(6), 417-428.

Kaufman, R., & Zahn, D. (1993). *Quality management plus: The continuous improvement of Education.* Newbury Park, CA: Corwin Press.

Krafzig. D., Banke, K. & Slama, D. (2005). *Enterprise SOA: Service-oriented Architecture best practices.* Upper Saddle River, NJ: Pearson Education.

Kuechler, W. L. & Vaishnavi, V. K. (2008). The emergence of design research in information systems in North America. *Journal of Design Research, 7*(1), 1–16.

Kwalwasser, H. (2012). *Renewal: Remaking America's schools for the twenty-first century*. Lanham, Maryland: Rowman & Littlefield Education.

Laevers, F. (1994). *The innovative project experiental education and the definition of quality in education*. Leuven, Belgium: Leuven University Press.

Lambert, L. (2003). *Leadership capacity for lasting school improvement.* Alexandria, VA: Association for Supervision and Curriculum Development.

Lee, T. W. (1999). *Using Qualitative Methods in Organizational Research*. Thousand Oaks, CA: Sage.

Lee, T. W., Mitchell, T. R. & Sablynski, C. J. (1999). 'Qualitative research in organizational and vocational psychology, 1979–1999'. *Journal of Vocational Behavior, 55*, 161–87.

Lincoln, Y. S. & Guba, E. (1985). *Naturalistic Inquiry*. Newbury Park, CA: Sage Publications Inc.

Little, J. W. (2012). Understanding data use practice among teachers: the contribution of micro-process studies. *American Journal of Education, 118*(2), 143-166.

Lujan, H. L. & DiCarlo, S. E. (2006). Too much teaching, not enough learning: what is the solution? *Advances in Physiology Education, 30*(1), 17-22. http://dx.doi,org/10.1152/advan.00061.2005

Luo, M. (2008). Structural equation modeling for High School Principals' data-driven decision making: an analysis of information use environment. *Educational Administration Quarterly, 44*(5), 603-634. http://dx.doi.org/10.1177/0013161X08321506

March, S. T. & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems, 15*(4), 251–266.

March, S. T. & Storey, V. C. (2008). Design science in the information systems discipline: an introduction to the special issue on design science research. *MIS Quarterly, 32*(4), 725–730.

Marsh, J. A., Pane, J. F. & Hamilton, L. S. (2006). *Making Sense of Data-Driven Decision Making in Education: Evidence from Recent RAND Research*. Santa Monica, CA: RAND Corporation, 2006. http://www.rand.org/pubs/occasional_papers/OP170.

Martínez-Lorente, A. R., Dewhurst, F. & Dale, B. G. (1998). Total quality management: origins and evolution of the term. *The TQM Magazine, 10*(5), 378-386.

Mason, S. (2002). Turning data into knowledge: Lessons from six Milwaukee public schools. A paper presented at the *Annual conference of AERA*, New Orleans, April 2002.

Mattson, M. R. (1992). Manual of Psychiatric Quality. American Psychiatric Association. USA.

McLaughlin, M. W. (1990). The RAND change agent study revisited: macro perspectives and micro realities. *Educational Research, 22*(3), 219-232.

McNaught, C., Phillips, R., Rossiter, D. & Winn, J. (2000). *Developing a framework or a useable and useful inventory of Computer-facilitated learning and support materials in Australian universities.* AusInfo, Canberra, ACT.

Medina, R. L. (2010). *The beliefs that school administrators hold about the role of data in driving school improvement*. (Unpublished doctoral dissertation). University of Nevada, Reno.

Metsala, M., Mikkola, H. & Saastamoinen, H. (2008) A user perspective on usability of information systems. In *Proceedings of the 2nd European Conference on Information Management and Evaluation (London, 2008).*

Moretto, L. (2012). *Exploring the nature of the relationship between decision-driven scenarios and decision confidence in high-velocity environments*. (Unpublished doctoral dissertation). The George Washington University, Wahington DC.

Moser, C. A. & Kalton, G. (1979). *Survey Methods in Social Investigation*, 2nd Ed. Gower: Aldershot, 20-61.

Moss, P. A. (2012). Exploring the macro-micro dynamic in data use practice. *American Journal of Education, 118*(2), 223-232. http://www.jstor.org/stable/10.1086/663274

Moss, P. E. & Pence, A. E. (1994). *Valuing quality in early childhood services: new approaches to defining quality*. New York, NY: Teachers College Press.

Nunamaker Jr, J. F., Chen, M. & Purdin, T. D. M. (1991). Systems development in information systems research. *Journal of Management Information Systems, 7*(3), 89–106.

Object Management Group. *Business Process Model and Notation (BPMN) Ver. 2.0*. Web. 2 August 2015. Retrieved from http://www.omg.org/spec/BPMN/2.0/PDF

O'Day, J., Bitter, C., Kirst, M., Camoy, M., Woody, E., Buttles, M., Fuller, B. & Ruenzel,D. (2004). *Assessing California's accountability system: successes, challenges, and opportunities for improvement.* PACE Policy Brief, 4(2). Retrieved 6 May, 2013, vocserve.berkeley.edu/research/pace/reports/PB.04-2.pdf

O'Hear, A. (1989). *Introduction to the Philosophy of Science*. Oxford, UK: Calrendon Press

Oldfield, B. & Baron, S. (2000). Student Perceptions of Service Quality in a UK University Business and Management Faculty. *Quality Assurance in Education, 8*(2), 85-95. http://dx.doi.org/10.1108/09684880010325600

Ostrand, T. (2002). *White-Box Testing*. Encyclopedia of Software Engineering.

Pallant, J. (2013). *SPSS Survival Manual. A step by step guide to data analysis using IBM SPSS* (5th ed.). Sydney, Australia: Allen & Unwin. Sociology Press.

Parasuraman, A., Zeithaml, V. A. & Berry, L. L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing, 4*(4), 41-50. http://www.jstor.org/stable/1251430

Park, V., Daly, A. J. & Guerra, A. W. (2012). Strategic framing: how leaders craft the meaning of data use for equity and learning. *Educational Policy*, (2012). http://dx.doi.org/10.1177/0895904811429295

Park, V. & Datnow, A. (2009). Co-constructing distributed leadership: district and school connections in data-driven decision making. *School Leadership and Management, 29* (5), 477-494. http://dx.doi.org/10.1080/13632430903162541

Peffers, K., Tuunanen, T., Rothenberger, M. & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems, 24*(3), 45–77.

Peters, T. J. & Waterman, R. H. (1982). *In search of excellence*. New York, NY: Harper & Row.

Pierce, R. & Chick, H. (2011). Teachers' intentions to use national literacy and numeracy assessment data: a pilot study. *The Australian Association for Research in Education, Inc., 2011*(38), 433–447. http://link.springer.com/article/10.1007/s13384-011-0040-x

Pries-Heje, J., Baskerville, R. & Venable, J. (2008). Evaluation Risks in Design science research: A Framework. In: *Third International Conference on Design science research in Information Systems and Technology*. Georgia State University, Atlanta.

Prieto, J., Mazuelas, S., Bahillo, A., Fernandez, P., Lorenzo, R. M. & Abril, E. J. (2012). Adaptive Data Fusion for Wireless Localization in Harsh Environments. *IEEE Transactions on Signal Processing, 60*(4), 1585-1596.

Remy, R. (1997). Adding focus to improvement efforts with PM3. *PM Network, July*, 43–47.

Rittel, H. W. J. & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(2), 155-169. http://dx.doi.org/10.1007/BF01405730

Rivkin, S. G., Hanushek, E. A. & Kain, J. F. (2005). Teachers, schools, and academic achievement. *Econometrica, 73*(2), 417–458. http://dx.doi.org/10.1111/j.1468-0262.2005.00584.x

Robertson-Dunn, B. (2012). A problem oriented enterprise architecture approach to wicked problems. In S. Pallab (Eds.), *Enterprise architecture for connected e-government: practices and innovations.* (pp. 57-77). Singapore: National University of Singapore. http://dx.doi.org/10.4018/978-1-4666-1824-4.ch002

Robinson, K. (2013). *Do schools kill creativity?* Retrieved 4, May, 2013. from http://sirkenrobinson.com/?p=595

Rockoff, J. E. (2004). The impact of individual teachers on student achievement: Evidence from panel data. *American Economic Review, 94*(2), 247–252. http://www.jstor.org/stable/3592891

Rodgers, W. M. & Brawley, L. R. (1996). The influence of outcome expectancy and self- efficacy on the behavioral intentions of novice exercisers. *Journal of Applied Social Psychology, 26*(7), 618-634.

Rodriguez, M., Pece, J. P. & Escudero, C. J. (2005). In-building location using bluetooth. In *International Workshop on Wireless Ad-hoc Networks 2005,* Coruna, Spain.

Romeo, G. I. (2006). Engage, empower, enable: Developing a shared vision for technology in education. In D. Hung & M. S. Khine, *Engaged learning with emerging technologies* (pp. 149-175) Dordrecht, The Netherlands: Springer.

Rowley, J. (1998). Quality measurement in the public sector: Some perspectives from the service quality literature. *Total Quality Measurement, 9*(2/3), 321–335. http://dx.doi.org/10.1080/0954412989171

Rossi, M. & Sein, M. K. (2003). *Design research workshop: a proactive research approach*. Presentation delivered at IRIS 26, 9–12.

Sahney, S., Banwet, D. K. & Karunes, S. (2008). An integrated framework of indices for quality management in education: a faculty perspective. *The TQM Journal, 20*(5), 502–519. http://dx.doi.org/10.1108/09544780410523044

Saiti, A. (2012). Leadership and quality management. *Quality Assurance in Education, 20*(2), 110-138. http://dx.doi.org/10.1108/09684881211219370

Sallis, E. (1993). *Total quality management in education*. London: Kogan Page.

Sanders, W. L. & Rivers, J. C. (1996). *Cumulative and residual effects of teachers on future student academic achievement.* Knoxville, TN: University of Tennessee Value-Added Research and Assessment Centre.

Saraph, J. V., Benson, P. G. & Schroeder, R. G. (1989). An instrument for measuring the critical factors of quality management. *Decision Sciences, 20,*810–829. http://dx.doi.org/10.1111/j.1540-5915.1989.tb01421.x

Schildkamp, K. & Kuiper, W. (2009). Data-informed curriculum reform: which data, what purposes, and promoting and hindering factors. *Teaching and Teacher Education, 2010*(26), 482–496. http://dx.doi.org/10.1016/j.tate.2009.06.007

Schön, D. (1983). *The Reflective Practitioner.* New York, NY: Basic Books.

Schwefel, H., Kovacs, I. Z., Jõao, F., Monghal, G. & Malidor, Y. (2005). Enhanced triangulation method for positioning of moving devices. *Proceedings of the 8th International Symposium on Wireless Personal Multimedia Communications*. WPMC, 2005.

Seddon, P. B., Staples. S., Patnayakuni. R. & Bowtell. M. (1999). Dimensions Of Information Systems Success. *Communications of the Association of Information Systems, 2*(3) 20-37.

Sekaran, U. (2003). *Research methods for business, a skill building approach.* India: Willey

Sessions, R. (2007). *A Comparison of the Top Four Enterprise-Architecture Methodologies.* Retrieved from http://msdn.microsoft.com/en-us/library/bb466232.aspx

Sheppard, B . H., Hartwick, J. & Warshaw, P. R. (1988). The Theory of Reasoned Action: A Meta-Analysis of Past Research with Recommendations for Modifications and Future Research. *Journal of Consumer Research, 15*(3), 325-343.

Simon, H. (1996). *The Sciences of Artificial, 3rd ed*., Cambridge, MA: MIT Press.

Simpson, G. H. (2011). *School leaders' use of data-driven decision making for school improvement: a study of promising practices in two California charter schools.* (Unpublished doctoral dissertation). University of Southern California, Los Angeles.

Sniehotta, F. F. (2010). Towards a theory of intentional behaviour change: Plans, planning, and self-regulation. *British Journal of Health Psychology, 14*(2), 261-273.

Spillane, J. P. (2012). Data in practice: conceptualizing the data-based decision-making phenomena. A*merican Journal of Education, 118*(2), 113-141. http://www.jstor.org/stable/10.1086/663283

Stensaker, B. (2007). Quality as a fashion: Exploring the translation of a management idea into higher education. In D.F. Westerheijden, B. Stensaker, & M.J. Rosa (Eds.), *Quality assurance in higher education: Trends in regulation, translation and transformation.* Dordrecht: Springer.

Sterman, J. D., Repenning, N. P. & Kofman, F. (1997). Unanticipated side effects of successful quality programs: exploring a paradox of organisational improvement. *Management Science, 43*(4) 503-521. doi: http://dx.doi.org/10.1287/mnsc.43.4.503

Stinchcombe, A. L. (2001). *When Formality Works: Authority and Abstraction in Law and Organizations.* Chicago: University of Chicago Press.

Stringfield, S., Wayman, J. C. & Yakimowski-Srebnick, M. E. (2005). Scaling up data use in classrooms, schools, and districts. In C. Dede, J. P. Honan, & L. C. Peters (Eds.), *Scaling up success: Lessons learned from technology-based educational improvement* (pp. 133-152). San Francisco: Jossey-Bass.

Sureshchander, G. S., Chandrasekharan, R. & Anantharaman, R. N. (2002). The relationship between service quality and customer satisfaction - a factor specific approach. *Journal of Services Marketing, 16*(4), 363-379. http://dx.doi.org/10.1108/08876040210433248

Taner. M. T., Sezen, B. & Atwat, K. M. (2012). Application of Six Sigma methodology to a diagnostic imaging process. *International Journal of Health Care Quality Assurance, 25*(4), 274–290.

Taylor, S . & Todd, P. A. (1995). Understanding Information Technology Usage: A Test of Competing Models. *Information Systems Research 6*(4), 144–176.

TOGAF® 9.1. The Open Group, n.d. Web. 29 May 2014. Retrieved from http://www.opengroup.org/togaf/

Treece, E. W. & Treece, J. W. (1986). *Elements of Research in Nursing*. Fourth edition. St Louis MO: Mosby.

Tribus, M. (1993). Quality management in education. *The Journal for Quality and Participation, 16*(1), 12-22.

Uline. C. & Tschannen. M. (2008). The walls speak: the interplay of quality facilities, school climate, and student achievement. *Journal of Educational Administration, 46*(1), 55-73. http://dx.doi.org/10.1108/09578230810849817

Vaishnavi, V. & Kuechler, W. (2007). *Design science research methods and patterns: innovating information and communication technology.* NY: Auerbach Publication, Taylor & Francis Group.

Van Aken, J.E. (2004): Management research based on the paradigm of design sciences: the quest for field-tested and grounded technological rules. *Journal of Management Studies, 41*(2), 219-246.

Venable, J. (2006). A Framework for Design science research Activities. In: *Information Resource Management Association Conference (CD)*, Washington, DC, USA. Idea Group Publishing, Hershey.

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the Unified Theory of Acceptance and Use of Technology. *Information Systems Research, 11*(4), 342-365.

Venkatesh, V. & Davis, F. D. (1996). A model of the antecedents of perceived ease of use: Development and test. *Decision Sciences, 27*(3), 451-481.

Venkatesh, V. & Morris, M. G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. *MIS Quarterly*, *24*(1), 115-139.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478.

Venkatesh, V., Speier, C. & Morris, M. G. (2002). User acceptance enablers in individual decision making about technology: Toward an integrated model. *Decision Sciences, 33*(2), 297-316.

Venkatesh, V., Thong, J. Y. L. & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS Quarterly, 36*(1), 157-178.

Wallman, K. K. (1993). Enhancing statistical literacy: enriching our society. *Journal of the American Statistical Society, 88*(421), 1-8. http://dx.doi.org/10.1080/01621459.1993.10594283

Walls, J. G., Widmeyer, G. R. & El Sawy, O. A. (1992) Building an information system design theory for vigilant EIS. *Information Systems Research. 3*(1), 36–59.

Walls, J, G, Widmeyer, G, R. & El Sawy, O, A. (2004) Assessing Information System Design Theory in Perspective: How Useful was our 1992 Initial Rendition? *Journal of Information Technology Theory and Application, 6*(2), 43-58.

Wayman, J. C., Stringfield, S. & Yakimowski, M. (2004). *Software enabling school improvement through analysis of student data* (Report No. 67). Baltimore: Johns

Wiedmer, T. L. & Harris, V. L. (1997). Implications of Total Quality Management in education. *The Education Forum, 61*(4), 314-318. http://dx.doi.org/10.1080/00131729709335276

Winter, R (2008). Design science research in Europe. *European Journal of Information Systems, 17*(5), 470–475.

Welsh, J. & Dey, S. (2002). Quality Measurement and Quality Assurance in Higher Education. *Quality Assurance in Education, 10*(1), 17-25. http://dx.doi.org/10.1108/09684880210416076

West-Burnham, J. (1992) *Managing Quality in Schools.* Longman, Harlow, Essex

Westerheijden, D. F., Stensaker, B. & Rosa, M. J. (2007). *Quality assurance in Higher Education. Trend in regulation, translation, and transformation.* Dordrecht: Springer. http://www.lavoisier.fr/livre/notice.asp?ouvrage=1780271

Wittek, L. & Kvernbekk, T. (2011). On the problems of asking for a definition of quality in education. *Scandinavian Journal of Educational Research*, *55*(6), 671-684. http://dx.doi.org/10.1080/00313831.2011.594618

APPENDIX 1.0

ETHICS CLEARANCE (QUT)

Dear Mr. Wayne Hellmuth and Prof. Glenn Stewart

Project Title: Impacts of PCSchool Behaviour Management System at Padua College

Ethics Category: Human - Low Risk

Approval Number: 1300000611

Approved Until: 01/11/2016 (subject to receipt of satisfactory progress reports)

We are pleased to advise that your application has been reviewed by the Chair, University Human Research Ethics Committee (UHREC) and confirmed as meeting the requirements of the National Statement on Ethical Conduct in Human Research (2007).

I can therefore confirm that your application is APPROVED. If you require a formal approval certificate please respond via reply email and one will be issued.

CONDITIONS OF APPROVAL

Please ensure you and all other team members read through and understand all UHREC conditions of approval prior to commencing any data collection:

Standard: Please see attached or go to www.research.qut.edu.au/ethics/humans/stdconditions.jsp

Specific: None apply

Decisions related to low risk ethical review are subject to ratification at the next available UHREC meeting. You will only be contacted again in relation to this matter if UHREC raises any additional questions or concerns.

Whilst the data collection of your project has received QUT ethical clearance, the decision to commence and authority to commence may be dependent on factors beyond the remit of the QUT ethics review process. For example, your research may need ethics clearance from other organisations or permissions from other organisations to access staff. Therefore the proposed data collection should not commence until you have satisfied these requirements.

Please don't hesitate to contact us if you have any queries. We wish you all the best with your research.

Kind regards

Janette Lamb on behalf of the Chair UHREC

Research Ethics Unit | Office of Research | Level 4 88 Musk Avenue,

Kelvin Grove | Queensland University of Technology

p: +61 7 3138 5123 | e: ethicscontact@qut.edu.au | w: www.research.qut.edu.au/ethics/

APPENDIX 2.0

ETHICS CLEARANCE (APPLICATION DOMAIN)

PADUA
COLLEGE

80 Turner Road
PO Box 111
Kedron QLD 4031

Tel 07 3857 9999
Fax 07 3857 9988

admin@padua.qld.edu.au
www.padua.qld.edu.au

26 August 2013

Mr Wayne Hellmuth
C/Padua College

Dear Wayne

I am writing in relation to your request for permission to study "The impact of PC School BMS at Padua College" during the period of September 2013 to March 2014. After discussing your request with the Senior Leadership Team, I am approving your request to survey and interview staff and students of Padua College with the following conditions.

1. The participation of students and staff is voluntary.
2. A copy of the final product of the research is made available to Padua College.
3. Padua College is under no obligations in relation to the outcomes of the research.

On behalf of the College, I wish you well with your research and I hope that you find it personally rewarding.

Yours sincerely

Robert Out
Rector

APPENDIX 3.0

INTERVIEW QUESTION PROMPTS AND RECORDING SHEET

Round	1				2				3			
Respondent	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Role of data and information systems												
Track academic performance												
Track student behaviours												
Planning												
Data used to inform practice												
External sources e.g., NAPLAN, QCS, ICAS												
Student SIS (summative data)												
Formative data (spreadsheets)												
Anecdotal data (both academic and behavioural)												
Engagement issues with use of IS												
Habit												
Confidence												
Struggling to keep up with rate of change of technology												
Time to learn												
Engagement issues with the use of												
Not a data driven culture												
Validity of Data												
Mistrust of how and why data is being collected e.g. performance based pay												
Legitimacy (why collect data)												
Anecdotal evidence more reliable than data and data systems												
Engagement issues with the use of												
Resistance												
Confidence												
Time to learn												
Quality of data issues												
Too much information												
No systems in place to analyse data												
Not a priority												
Legacy IS quality												
Difficult to use. Too much on screens												
Not practical on a mobile device												

Round	1				2				3			
Respondent	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Mobile App Quality												
Positive - functionality												
Positive – ease of use												
Positive – speed to use												
Positive – feedback to students												
Positive – feedback to and from others												
Negative – limited scope												
App Quality link to Teacher Behaviour												
More reported behaviours												
A richer range of reported behaviours												
Ratio of reported behaviours												
App Quality link to Student Outcomes												
Ratio of + and – comments to outcomes												
Student feedback												
Informed parents												

APPENDIX 4.0

CONSTRUCT DEFINITIONS

Table A4-1 – Construct definitions for the UTAUT scale.

Construct	Definition
Performance expectancy	The degree to which an individual believes that using the system will help him or her to attain gains in job performance.
Effort expectancy	The degree of ease associated with the use of the system.
Social influence	The degree to which an individual perceives that important others believe he or she should use the new system.
Facilitating conditions	The degree to which an individual believes that an organisational and technical infrastructure exists to support use of the system.
Behavioural intention	The degree to which a person has formulated conscious plans to perform or not perform some specified future behaviour.

Table A4-2 – Construct definitions for the IS-impact scale.

Construct	Definition
Individual impact	Individual impact (II) is a measure of the extent to which (the IS) has influenced the capabilities and effectiveness, on behalf of the organisation, of key-users.
Organisational impact	Organizational impact (OI) is a measure of the extent to which (the IS) has promoted improvement in organisational results and capabilities.
System quality	System quality (SQ) is a measure of the performance of (the IS) from a technical and design perspective.
Information quality	Information quality (IQ) is a measure of the quality of (the IS) outputs – namely, the quality of the information the system produces in reports and on-screen.
Satisfaction	Satisfaction with the information system

APPENDIX 5.0

WHITE BOX TESTING

Login Screen

1	PASS	FAIL	Function	Username Textbox accepts text, and the keypad is made available to the user.
			Fail Behaviour	
2	PASS	FAIL	Function	Password Textbox accepts text, and the keypad is made available to the user.
			Fail Behaviour	
3	PASS	FAIL	Function	Login button triggers login.
			Fail Behaviour	
4	PASS	FAIL	Function	Incorrect login triggers appropriate message to the user.
			Fail Behaviour	
5	PASS	FAIL	Function	Authentication with correct details, returns the appropriate student details
			Fail Behaviour	
6	PASS	FAIL	Function	Screen automatically navigates to the Student Details Screen
			Fail Behaviour	

Student Details

7	PASS	FAIL	Function	The student search box, allows text to be entered.
			Fail Behaviour	
8	PASS	FAIL	Function	On ‘Enter’ the search button returns back a list of students, based on the parameter typed in the search box.
			Fail Behaviour	
9	PASS	FAIL	Function	The return list is a transparent box that overlays other controls
			Fail Behaviour	

10	PASS	FAIL	Function	The list control on the left hand side of the screen returns a picture and student name
			Fail Behaviour	
11	PASS	FAIL	Function	The list control is populated with all students in the teacher's current class
			Fail Behaviour	
12	PASS	FAIL	Function	The Bluetooth proximity detector can be 'turned on'.
			Fail Behaviour	
13	PASS	FAIL	Function	Turning on the Bluetooth proximity detector orders the class list according to proximity. The most proximal student has focus, and their details are displayed in the right hand pane of the screen.
			Fail Behaviour	
14	PASS	FAIL	Function	The student details are displayed in the right hand pane of the screen. Details include: Picture, Name, Home Class, Home Teacher, Phone, Medical Alerts.
			Fail Behaviour	
15	PASS	FAIL	Function	Clicking on any student on the left hand list control, gives focus to the student, and the appropriate student details are called.
			Fail Behaviour	
16	PASS	FAIL	Function	Two graphs (My Interactions, All interactions) are visible on the bottom of the right hand pane of the screen. The screens change their appearance based on the number of merits and demerits, of the individual, and all teachers.
			Fail Behaviour	

Student Subjects

17	PASS	FAIL	Function	The screen can be navigated to by clicking on the second tab in the tab bar of the app.
			Fail Behaviour	
18	PASS	FAIL	Function	All subjects and the teachers, for the student, is displayed in a list box.
			Fail Behaviour	
19	PASS	FAIL	Function	Details change based on which student has focus.
			Fail Behaviour	

Student Absences

20	PASS	FAIL	Function	The screen can be navigated to by clicking on the third tab in the tab bar of the app
			Fail Behaviour	
21	PASS	FAIL	Function	All absences for the student are listed.
			Fail Behaviour	
22	PASS	FAIL	Function	Fields include: Date, Percentage of daily absences, Reason, and Code.
			Fail Behaviour	
23	PASS	FAIL	Function	'See Codes' Navigate button appears on the app
			Fail Behaviour	

Student Timetable

24	PASS	FAIL	Function	The screen contains a: 1. Calendar control, 2. List box with the fields: period, subject, room, teacher.
			Fail Behaviour	
25	PASS	FAIL	Function	By clicking on the calendar control, the classes for the student with focus, for a particular day, are returned.
			Fail Behaviour	
26	PASS	FAIL	Function	The calendar control, can also scroll through month by month.
			Fail Behaviour	
27	PASS	FAIL	Function	The data in the list fields change based on the date of the calendar control, and the focus of the student.
			Fail Behaviour	

Add appraisals – positive appraisals

28	PASS	FAIL	Function	Clicking on the search field at the top of the green half of the screen will return back all positive appraisals listed in the database.
			Fail Behaviour	
29	PASS	FAIL	Function	Choosing the positive appraisal in the search lookup places the chosen positive appraisal into the first label in the green shaded area.
			Fail Behaviour	

30	PASS	FAIL	Function	The choice of successive lookups places the choice in the next label underneath.
			Fail Behaviour	
31	PASS	FAIL	Function	Each label has a cross (delete function) on the right hand side of the label, so that the populated label can be cleared.
			Fail Behaviour	
32	PASS	FAIL	Function	When a label is cleared, the choices made in all other labels are shuffled up the order so that there are no gaps between labels.
			Fail Behaviour	
33	PASS	FAIL	Function	One label can be highlighted, and the user can see that the label has focus.
			Fail Behaviour	
34	PASS	FAIL	Function	A student picture can be dragged into the center of the shaded green area.
			Fail Behaviour	
35	PASS	FAIL	Function	The student picture can be highlighted (by pressing on it). The user can see which of the student pictures has the current focus.
			Fail Behaviour	
36	PASS	FAIL	Function	Comments can be typed into the comments textbox.
			Fail Behaviour	
37	PASS	FAIL	Function	When clicking on the comments textbox, the surface keyboard is automated.
			Fail Behaviour	
38	PASS	FAIL	Function	Clicking on the delete button at the bottom of the screen, deletes the students picture from the green target area.
			Fail Behaviour	
39	PASS	FAIL	Function	The notification button sends the user to the notification screen.
			Fail Behaviour	
40	PASS	FAIL	Function	The submit button writes the data to the PCSchool database, and clears all users from the green target area of the screen.
			Fail Behaviour	
41	PASS	FAIL	Function	The submit button sends emails to the targeted recipients.
			Fail Behaviour	

Add appraisals – negative appraisals

42	PASS	FAIL	Function	Clicking on the search field at the top of the red half of the screen will return back all negative appraisals listed in the database.
			Fail Behaviour	
43	PASS	FAIL	Function	Choosing the negative appraisal in the search lookup places the chosen positive appraisal into the first label in the red shaded area.
			Fail Behaviour	
44	PASS	FAIL	Function	The choice of successive lookups places the choice in the next label underneath.
			Fail Behaviour	
45	PASS	FAIL	Function	Each label has a cross (delete function) on the right hand side of the label, so that the populated label can be cleared.
			Fail Behaviour	
46	PASS	FAIL	Function	When a label is cleared, the choices made in all other labels are shuffled up the order so that there are no gaps between labels.
			Fail Behaviour	
47	PASS	FAIL	Function	One label can be highlighted, and the user can see that the label has focus.
			Fail Behaviour	
48	PASS	FAIL	Function	A student picture can be dragged into the center of the shaded red area.
			Fail Behaviour	
49	PASS	FAIL	Function	The student picture can be highlighted (by pressing on it). The user can see which of the student pictures has the current focus.
			Fail Behaviour	
50	PASS	FAIL	Function	Comments can be typed into the comments textbox.
			Fail Behaviour	
51	PASS	FAIL	Function	When clicking on the comments textbox, the surface keyboard is automated.
			Fail Behaviour	

52	PASS	FAIL	Function	Clicking on the delete button at the bottom of the screen, deletes the students picture from the red target area.
			Fail Behaviour	
53	PASS	FAIL	Function	The notification button sends the user to the notification screen.
			Fail Behaviour	
54	PASS	FAIL	Function	The submit button writes the data to the PCSchool database, and clears all users from the red target area of the screen.
			Fail Behaviour	
55	PASS	FAIL	Function	The submit button sends emails to the targeted recipients
			Fail Behaviour	

Student notification screen

56	PASS	FAIL	Function	No emails are selected by default.
			Fail Behaviour	
57	PASS	FAIL	Function	The students email appears under the Student TAB
			Fail Behaviour	
58	PASS	FAIL	Function	The students email can be selected and moved to the right hand pane of the screen
			Fail Behaviour	
59	PASS	FAIL	Function	The student's Dean's emails appears under the Dean TAB
			Fail Behaviour	
60	PASS	FAIL	Function	The Dean's email can be selected and moved to the right hand pane of the screen
			Fail Behaviour	
61	PASS	FAIL	Function	The student's Home Teacher's emails appears under the Home Teacher TAB
			Fail Behaviour	
62	PASS	FAIL	Function	The Home Teacher's email can be selected and moved to the right hand pane of the screen
			Fail Behaviour	
63	PASS	FAIL	Function	The student's Subject Teacher's emails appears under the Subject Teachers TAB
			Fail Behaviour	

64	PASS	FAIL	Function	The Subject Teacher's email can be selected and moved to the right hand pane of the screen
			Fail Behaviour	
65	PASS	FAIL	Function	The student's Co-Curricular Teacher's emails appears under the Co-Curricular TAB
			Fail Behaviour	
66	PASS	FAIL	Function	The Co-Curricular Teacher's email can be selected and moved to the right hand pane of the screen
			Fail Behaviour	
67	PASS	FAIL	Function	The student's Parent's emails appears under the Parent TAB
			Fail Behaviour	
68	PASS	FAIL	Function	The Parent's email can be selected and moved to the right hand pane of the screen
			Fail Behaviour	

Tab bar

69	PASS	FAIL	Function	Tab Bar has 5 tabs
			Fail Behaviour	
70	PASS	FAIL	Function	Each Tab navigates to the appropriate app page
			Fail Behaviour	

APPENDIX 6.0

WEB-SERVICES BLACKBOX TESTING

A6-1.0 Testing Client Description

Fiddler is a web debugging proxy which logs all HTTP(s) traffic between any PC and the Internet. It can be used to debug traffic from many applications that supports a proxy like IE. Fiddler outputs analytics such "total page weight," HTTP caching, and compression. This tool, therefore, can report on web services issues such as performance bottlenecks. Fiddler can be downloaded online from http://fiddler2.com/

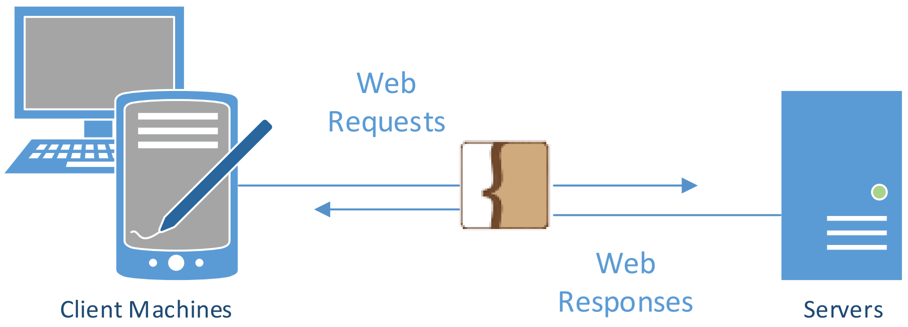


Figure A.1 Basic structure of how web services are tested using the Fiddler Web Debugging Proxy (Fiddler)

A6-1.1 COMPOSING A WEB-SERVICE IN FIDDLER

1.1.1 API Address

The web services are tested by defining the http:// address of the Application Programming Interface (API) e.g. http://203.143.236.47/PCSchoolWebAPI/api/Schools/GetSchools

Request Headers

In the Request Headers you will need to define the Content-Type as either JSON or XML eg. Content-Type: application/xml or Content-Type: application/json

Request Body

Use your missing parameters eg.

```
<Login>
  <UserName>ahernz14</UserName>
  <Password>password</Password>
  <HostAddress>Padua</HostAddress>
</Login>
```

Testing Client

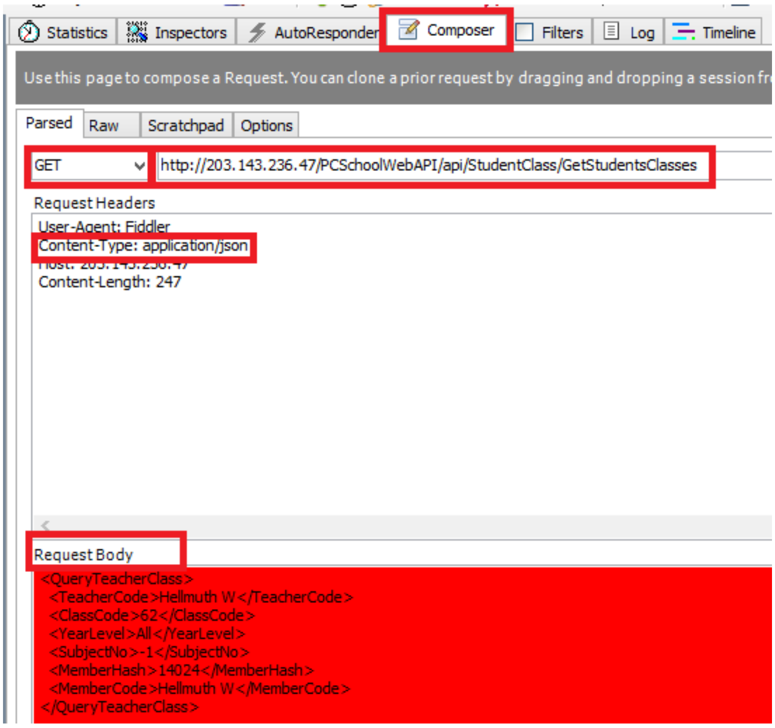


Figure A.2 Design Interface for Fiddler

A6-1.2 GET api/Schools/GetSchools

http://203.143.236.47/PCSchoolWebAPI/api/Schools/GetSchools

JASON HEADERS

n/a

XML HEADERS

n/a

TEST RESULTS

304	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Schools/GetSchools	440	no-cac...	application/...
305	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Schools/GetSchools	221	no-cac...	application/...

TEST SAMPLE OUTPUT

Body

[{"Name":"Dennis School","WebServiceURL":"http://localhost/PCSWebAPI/"},{"Name":"PCSchool - Cloud Based","WebServiceURL":"http://pcschool.dyndns.org/PCSWebAPI/"},{"Name":"Padua College QLD","WebServiceURL":"http://203.143.236.47/PCSchoolWebAPI/"}]

A6-1.3 GET API/AUTHENTICATION/GETAUTHENTICATEDUSERDETAILS

api/Authentication/GetAuthenticatedUser/{LoginName}/{Password}/{HostAddress}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/Authentication/GetAuthenticatedUser?LoginName=ahernz14&Password=password&HostAddress=Padua

JSON HEADERS

{LoginName} = ahernz14

{Password} = password

{HostAddress} = Padua

TEST RESULT

3	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentClass/GetStudentsInCurrentPeriod
6	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentClass/GetStudentsInCurrentPeriod

TEST OUTPUT EXAMPLE

Body

{"SecurityUserId":56,"ActualAccess":"1","ActualCreate":"1","ActualDelete":"1","ActualEdit":"1","MemberId":4280,"Email":"ahernz14@padua.qld.edu.au","UserType":"S|","PatronNumber":4280,"PatronType":"D","MemberCode":"AHERN Z","Template":" ","SecGroups":[{"GroupId":30},{"GroupId":31},{"GroupId":38}],"SecObjects":[{"ObjectID":251,"Access":1,"Create":1,"Edit":1,"Delete":1},{"ObjectID":252,"Access":1,"Create":1,"Edit":1,"Delete":1},{"ObjectID":253,"Access":0,"Create":0,"Edit":0,"Delete":0},{"ObjectID":262,"Access":1,"Create":0,"Edit":0,"Delete":0},

A6-1.4 UDID Update - PUT api/Students/StudentUDIDUpdate/{Id}

http://203.143.236.47/PCSchoolWebAPI/api/Students/StudentUDIDUpdate/{Id}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/Students/StudentUDIDUpdate/4280

JSON HEADERS

```
{
  "UDID": "8889"
}
```

TEST RESULT

648	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/StudentUDIDUpdate/4280	0	no-cac…

TEST OUTPUT EXAMPLE

N/A

A6-1.5 GET CLOSEST STUDENT DATA

api/Students/ClosestStudentData?UDID={UDID}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/Students/ClosestStudentData?UDID=8890&MemberCode=Ahern%20z&MemberHash=4280

NOTE: **MemberHash** is **MemberID** in this instance only.

JSON HEADERS

```
{
  "UDID": "8889",
```

```
    "MemberHash": 4280,
    "MemberCode": "Ahern Z"
  }
```


TEST RESULTS

69	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/ClosestStudentData	2,955	no-cac...	application/...
77	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/ClosestStudentData	3,993	no-cac...	application/...

TEST OUTPUT EXAMPLE

Body

[{"StudentId":4280,"StudentCode":"AHERN Z","UDID":"8889","GivenName":"Zeke","KnownAsName":"Zeke","SurName":"Ahern","FullName":"Ahern, Zeke","Mobile":"0478 029 508","ImageName":"4280.JPG","Nationality":"2311670489","SpecialNeeds":" ","Email":"ahernz14@padua.qld.edu.au","ExamNumber":"13874000011","RegistrationNumber":"5341","StudentAlert":" ","FamilyAlert":" ","Gender":"M","EmergencyContact":"Tom Ahern","EmergencyPhone":"0450 299 374","DoctorName":"Nundah Village

A6-1.6 GET API/STUDENTS/GETSTUDENTIMAGEBYNAME/{ID}

http://203.143.236.47/PCSchoolWebAPI/api/Students/GetStudentImageByName/{Id}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/Students/GetStudentImageByName/Ahern%20Z

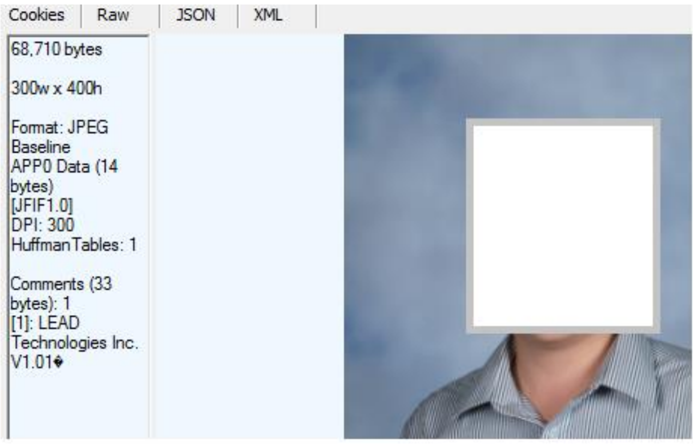
JSON HEADERS

Note - ID, Documentation for ‘Id’. Define this parameter in the request of the URL

TEST RESULT

67	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/GetStudentImageByName/Ahern%20Z

TEST OUTPUT EXAMPLE



A6-1.7 GET API/STUDENTCLASS/GETSTUDENTSINCURRENTPERIOD

http://203.143.236.47/PCSchoolWebAPI/api/StudentClass/GetStudentsInCurrentPeriod?TeacherCode={TeacherCode}&Date={Date}&Time={Time}&Membercode={Membercode}&MemberHash={MemberHash}

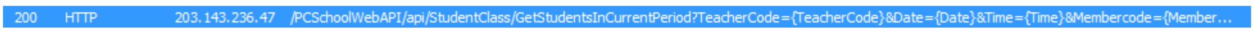
EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentClass/GetStudentsInCurrentPeriod?TeacherCode=hellmuth%20w&Date=18/09/2013&Time=9.10&Membercode=hellmuth%w &MemberHash=14024

JSON HEADERS


```
{
  "TeacherCode": "Hellmuth W",
  "Date": "18/09/2013",
  "Time": "9.10",
  "MemberCode": "Hellmuth W"
  "MemberHash": 14024,
}
```


TEST RESULTS



TEST OUTPUT EXAMPLE

File Edit Format View Help

[{"StudentId":17120,"StudentCode":"AYRES J","FullName":"Ayres, James","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87,"UDID":null},
{"StudentId":10845,"StudentCode":"CASSIDY C","FullName":"Cassidy, Connor","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87,"UDID":null},
{"StudentId":8360,"StudentCode":"FENWICK S","FullName":"Fenwick, Sam (Samuel)","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH

A6-1.8 GET API/STUDENTS/GETSTUDENTS

api/Students/GetStudents?StudentCode={StudentCode}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/Students/GetStudents?StudentCode=a&MemberCode=Hellmuth%20W&MemberHash=14024

JSON HEADERS

```
{
  "StudentCode": "a",
  "MemberHash": 14024,
  "MemberCode": "Hellmuth W"
}
```

TEST RESULTS

99	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/GetStudents	37,804	no-cac...	application/...
119	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/GetStudents	31,657	no-cac...	application/...

TEST OUTPUT EXAMPLE

Body

[{"StudentId":16226,"StudentCode":"ADAMS S","UDID":" ","GivenName":"Sean","KnownAsName":"Sean","SurName":"Adams","FullName":"Adams, Sean","Mobile":null,"ImageName":"16226.JPG","Nationality":null,"SpecialNeeds":null,"Email":null,"ExamNumber":null,"RegistrationNumber":"7648","StudentAlert":null,"FamilyAlert":null,"Gender":null,"EmergencyContact":null,"EmergencyPhone":null,"DoctorName":null,"DoctorPhone":null,"Ambulance":null,"Medicare":null,"BarCode":null,"Age":0.0,"BirthDate":"9/8/2000 12:00:00 AM","CurrentYear":"

A6-1.9 GET API/STUDENTS/GETSTUDENTDETAILS

GET api/Students/GetStudentDetails?StudentCode={StudentCode}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/Students/GetStudentDetails?StudentCode=ahern%20z&MemberCode=Hellmuth%20w&MemberHash=14024

JSON HEADERS

```
{
  "StudentCode": "ahern Z",
  "MemberHash": 14024,
  "MemberCode": "Hellmuth W"
}
```

TEST RESULTS

131	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/GetStudentDetails	2,956	no-cac...	application/...
139	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/Students/GetStudentDetails	3,979	no-cac...	application/...

TEST OUTPUT EXAMPLE

Body

[{"StudentId":4280,"StudentCode":"AHERN Z","UDID":null,"GivenName":"Zeke","KnownAsName":"Zeke","SurName":"Ahern","FullName":"Ahern, Zeke","Mobile":"
029
508","ImageName":"4280.JPG","Nationality":"2311670489","SpecialNeeds":" ","Email":"ahern   @padua.qld.edu.au","ExamNumber":"13874000011","RegistrationNumber":"5341","StudentAlert":" ","FamilyAlert":" ","Gender":"M","EmergencyContact":"Tom Ahern","EmergencyPhone":"045
374","DoctorName":"   Village

A6-1.10 GET API/STUDENTATTENDANCE/GETSTUDENTATTENDANCECODES

http://203.143.236.47/PCSchoolWebAPI/api/StudentAttendance/GetStudentAttendanceCodes

TEST RESULTS

164	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentAttendance/GetStudentAttendanceCodes	1,032	no-cac...	application/...
169	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentAttendance/GetStudentAttendanceCodes	2,415	no-cac...	application/...

TEST OUTPUT EXAMPLE

Body

[{"AttendanceCode":"?","Description":"Unexplained"},
{"AttendanceCode":"T","Description":"Unexplained/Truant"},
{"AttendanceCode":"P","Description":"Present"},
{"AttendanceCode":"L","Description":"Student Late for class"},
{"AttendanceCode":"S","Description":"Sickbay"},
{"AttendanceCode":"I","Description":"Internal School
Appointment"},{"AttendanceCode":"M","Description":"Short-
Term Illness/Medical Reasons"},
{"AttendanceCode":"N","Description":"School Sanctioned
Activity"},{"AttendanceCode":"Q","Description":"Excursion"},

A6-1.11 GET API/STUDENTABSENCE/GETSTUDENTABSENCES

GET
api/StudentAbsence/GetStudentAbsences?StudentCode={StudentCode}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentAbsence/GetStudentAbsences?StudentCode=Ahern Z&MemberCode=Hellmuth W&MemberHash=14024

JSON HEADERS

```
{
  "StudentCode": "Ahern z",
  "MemberHash": 14024,
  "MemberCode": "Hellmuth W"
}
```

TEST RESULTS

219	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentAbsence/GetStudentAbsences	2,427	no-cac...	application/...
225	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentAbsence/GetStudentAbsences	3,777	no-cac...	application/...

TEST OUTPUT EXAMPLE

Body


```
[{"StudentCode":"Ahern Z","DateFrom":"9/2/2013 12:00:00
AM","DateTo":"9/6/2013 12:00:00
AM","Days":0.00,"Reason":"Yr 11
Exams","AbsenceStatus":"X"},{"StudentCode":"Ahern
Z","DateFrom":"8/13/2013 12:00:00
AM","DateTo":"8/13/2013 12:00:00
AM","Days":0.01,"Reason":"","AbsenceStatus":"P"},
{"StudentCode":"Ahern Z","DateFrom":"8/8/2013 12:00:00
AM","DateTo":"8/8/2013 12:00:00
AM","Days":0.01,"Reason":"","AbsenceStatus":"P"},
```


A6-1.12 GET API/STUDENTDISCIPLINE/GETMERITSDEMERITS

GET
http://203.143.236.47/PCSchoolWebAPI/api/StudentDiscipline/GetMeritsDemeritsByParams?StudentCode={StudentCode}&ReportedBy={ReportedBy}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentDiscipline/GetMeritsDemeritsByParams?StudentCode=ahern%20z&ReportedBy=hellmuth%20W&MemberCode=hellmuth%20W&MemberHash=14024

JSON HEADERS


```
{
  "StudentCode": "ahern z",
  "ReportedBy": "Hellmuth W",
  "MemberCode": "Hellmuth W",
  "MemberHash": 14024,
}
```


239	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentDiscipline/GetMeritsDemerits	99	no-cac...	application/...

TEST RESULTS

245	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentDiscipline/GetMeritsDemerits	280	no-cac...	application/...

TEST OUTPUT SAMPLE

GetMeritsDemeritsByParams - Notepad

File Edit Format View Help


```
{"StudentCode":"ahern z","MeritsByMe":5.0,"DeMeritsByMe":1.0,"MeritsTotal":4.0,"DeMeritsTotal":9.0}
```

A6-1.13 POST API/STUDENTDISCIPLINE/POSTDISCIPLINE

http://203.143.236.47/PCSchoolWebAPI/api/StudentDiscipline/PostDiscipline

DisciplineId – will always have a value of 0. This denotes a ‘new record’.

DisciplineType – “M” is positive, “” is negative (i.e., no value)

DisciplineTypeID – value comes from the “ “ web-service.

Where DisciplineType = “M” the Merits value will = “1” and Demerits will = “0”

Where DisplineType = “0” the Merits value will = “0” and the Demerits will = “1”

SubjectNo – value comes from

JSON HEADERS - POSITIVE

```
{
  "DisciplineId": "0",
  "DisciplineType": "M",
  "DisciplineTypeID": "1",
  "StudentKey": "Ahern Z",
  "ReportedBy": "Hellmuth W",
  "Period": "",
  "SubjectNo": "-1",
  "Comment": "This is a sample comment",
  "Merits": "1",
  "Demerits": "0",
  "MemberHash": 14024,
  "MemberCode": "Hellmuth W"
}
```

JSON HEADERS - NEGATIVE

```
{
  "DisciplineId": "0",
  "DisciplineType": "",
  "DisciplineTypeID": "1",
  "StudentKey": "Ahern Z",
  "ReportedBy": "Hellmuth W",
  "Period": "",
  "SubjectNo": "-1",
  "Comment": "This is a sample comment",
  "Merits": "0",
  "Demerits": "1",
  "MemberHash": 14024,
  "MemberCode": "Hellmuth W"
}
```

TEST RESULTS

363	201	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentDiscipline/PostDiscipline

A6-1.14 GET API/STUDENTCLASS/GETSTUDENTSCLASSES

Gets all students in a class

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentClass/GetStudentsClasses?TeacherCode=hellmuth%20w&ClassCode=62&YearLevel=all&SubjectNo=-1&MemberCode=hellmuth%20w&MemberHash=14024

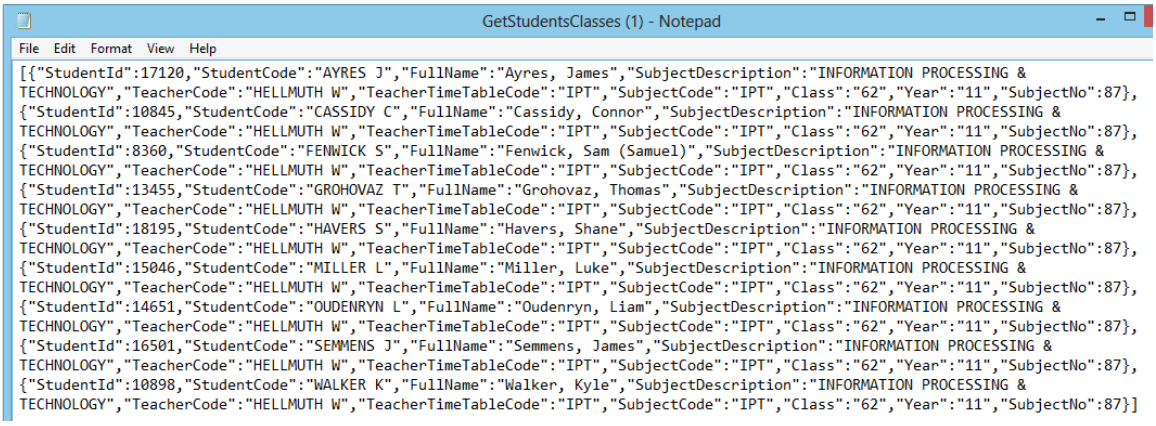
JSON HEADERS

```
{
  "TeacherCode": "Hellmuth W",
  "ClassCode": "62",
  "YearLevel": "All",
  "SubjectNo": -1,
  "MemberHash": 14024,
  "MemberCode": "Hellmuth W"
}
```

TEST RESULTS

254	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentClass/GetStudentsClasses	3,336	no-cac...	application/...
260	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentClass/GetStudentsClasses	2,106	no-cac...	application/...

TEST OUTPUT SAMPLE


GetStudentsClasses (1) - Notepad

File Edit Format View Help

[{"StudentId":17120,"StudentCode":"AYRES J","FullName":"Ayres, James","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":10845,"StudentCode":"CASSIDY C","FullName":"Cassidy, Connor","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":8360,"StudentCode":"FENWICK S","FullName":"Fenwick, Sam (Samuel)","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":13455,"StudentCode":"GROHOVAZ T","FullName":"Grohovaz, Thomas","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":18195,"StudentCode":"HAVERS S","FullName":"Havers, Shane","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":15046,"StudentCode":"MILLER L","FullName":"Miller, Luke","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":14651,"StudentCode":"OUDENRYN L","FullName":"Oudenryn, Liam","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":16501,"StudentCode":"SEMMENS J","FullName":"Semmens, James","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87},
{"StudentId":10898,"StudentCode":"WALKER K","FullName":"Walker, Kyle","SubjectDescription":"INFORMATION PROCESSING & TECHNOLOGY","TeacherCode":"HELLMUTH W","TeacherTimeTableCode":"IPT","SubjectCode":"IPT","Class":"62","Year":"11","SubjectNo":87}]

A6-1.15 GET STUDENT CLASSES

api/StudentSubject/GetStudentSubjectsByParams?StudentCode={StudentCode}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentSubject/GetStudentSubjectsByParams?StudentCode=ahern%20z&MemberCode=Hellmuth%20w&MemberHash=14024

JSON HEADERS

```
{StudentCode} = 4280
{MemberCode} = hellmuth w
{MemberHash} = 14024
```

TEST RESULTS

4	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentSubject/GetStudentSubjectsByParams?StudentCode=ahern%20z&MemberCode=Hellmuth%20w&MemberHash=14024

TEST EXAMPLE OUTPUT

GetStudentSubjectsByParams (3) - Notepad

File Edit Format View Help

[{"StudentCode":"ahern z","SubjectDescription":"RELIGION & ETHICS","TeacherCode":"TAYLOR
M","SubjectCode":"R&E","Class":"11","Year":"11","SubjectNo":6245},{"StudentCode":"ahern
z","SubjectDescription":"ENGLISH","TeacherCode":"MATTHEWS
D","SubjectCode":"ENG","Class":"21","Year":"11","SubjectNo":1},{"StudentCode":"ahern
z","SubjectDescription":"MATHEMATICS B","TeacherCode":"POPPLETON
A","SubjectCode":"MATHB","Class":"31","Year":"11","SubjectNo":37},{"StudentCode":"ahern
z","SubjectDescription":"MATHEMATICS C","TeacherCode":"POPPLETON
A","SubjectCode":"MATHC","Class":"41","Year":"11","SubjectNo":38},{"StudentCode":"ahern
z","SubjectDescription":"ACCOUNTING","TeacherCode":"TAYLOR
M","SubjectCode":"ACCT","Class":"51","Year":"11","SubjectNo":60},{"StudentCode":"ahern
z","SubjectDescription":"PHYSICS","TeacherCode":"YOUNG
S","SubjectCode":"PHYS","Class":"61","Year":"11","SubjectNo":41},{"StudentCode":"ahern
z","SubjectDescription":"MUSIC","TeacherCode":"RIGBY
S","SubjectCode":"MUSIC","Class":"71","Year":"11","SubjectNo":91},{"StudentCode":"ahern
z","SubjectDescription":"ASSEMBLY","TeacherCode":"
","SubjectCode":"ASSEMBLY","Class":"A","Year":"11","SubjectNo":7005},{"StudentCode":"ahern
z","SubjectDescription":"PERSONAL AND LIFE SKILLS","TeacherCode":"LOWRIE
B","SubjectCode":"PALS","Class":"A","Year":"11","SubjectNo":7001},{"StudentCode":"ahern
z","SubjectDescription":"BEHAVIOURAL LEVEL","TeacherCode":"LAVEY G","SubjectCode":"BEHAV LEVE","Class":"BB
HOUSE","Year":"11","SubjectNo":214}]

A6-1.16 GET API/STUDENTEMAIL/GETSTUDENTBASEDEMAIL

GET
api/StudentEmail/GetStudentBasedEmail?StudentCode={StudentCode}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentEmail/GetStudentBasedEmail?StudentCode=ahern%20z&MemberCode=Hellmuth%20w&MemberHash=14024

JSON HEADERS

```
{
  "StudentCode": "ahern z",
  "MemberCode": "Hellmuth W"
  "MemberHash": 14024,

}
```

TEST RESULTS

273	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentEmail/GetStudentBasedEmail	2,386	no-cac...	application/...
299	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentEmail/GetStudentBasedEmail	3,239	no-cac...	application/...

TEST EXAMPLE OUTPUT

GetStudentBasedEmail - Notepad

File Edit Format View Help

[{"Entity":"STUDENT","Code":"AHERN Z","Email":"ahernz14@padua.qld.edu.au","Name":"Ahern, Zeke (AHERN Z)","NameEmail":"Ahern, Zeke (ahernz14@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"LOWRIE B","Email":"blowrie@padua.qld.edu.au","Name":"Mr B Lowrie (PERSONAL AND LIFE SKILLS)","NameEmail":"Mr B Lowrie (blowrie@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"LAVEY G","Email":"glavey@padua.qld.edu.au","Name":"Mr G Lavey (BEHAVIOURAL LEVEL)","NameEmail":"Mr G Lavey (glavey@padua.qld.edu.au)"},{"Entity":"DEAN","Code":"LAVEY G","Email":"glavey@padua.qld.edu.au","Name":"Mr G Lavey (LAVEY G)","NameEmail":"Mr G Lavey (glavey@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"TAYLOR M","Email":"mtaylor@padua.qld.edu.au","Name":"Mr M Taylor (ACCOUNTING)","NameEmail":"Mr M Taylor (mtaylor@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"FIELDS S","Email":"sfields@padua.qld.edu.au","Name":"Mr S Fields (RELIGION & ETHICS)","NameEmail":"Mr S Fields (sfields@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"POPPLETON A","Email":"apoppleton@padua.qld.edu.au","Name":"Ms A Poppleton (MATHEMATICS B)","NameEmail":"Ms A Poppleton (apoppleton@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"POPPLETON A","Email":"apoppleton@padua.qld.edu.au","Name":"Ms A Poppleton (MATHEMATICS C)","NameEmail":"Ms A Poppleton (apoppleton@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"MATTHEWS D","Email":"dmatthews@padua.qld.edu.au","Name":"Ms D Matthews (ENGLISH)","NameEmail":"Ms D Matthews (dmatthews@padua.qld.edu.au)"},{"Entity":"COCURRICULAR","Code":"MATTHEWS D","Email":"dmatthews@padua.qld.edu.au","Name":"Ms D Matthews (FCIP)","NameEmail":"Ms D Matthews (dmatthews@padua.qld.edu.au)"},{"Entity":"HOMETEACHER","Code":"MATTHEWS D","Email":"dmatthews@padua.qld.edu.au","Name":"Ms D Matthews (MATTHEWS D)","NameEmail":"Ms D Matthews (dmatthews@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"MATTHEWS D","Email":"dmatthews@padua.qld.edu.au","Name":"Ms D Matthews (PASTORAL CARE)","NameEmail":"Ms D Matthews (dmatthews@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"RIGBY S","Email":"srigby@padua.qld.edu.au","Name":"Ms S Rigby (MUSIC)","NameEmail":"Ms S Rigby (srigby@padua.qld.edu.au)"},{"Entity":"SUBJECTTEACHER","Code":"YOUNG S","Email":"syoung@padua.qld.edu.au","Name":"Ms S Young (PHYSICS)","NameEmail":"Ms S Young (syoung@padua.qld.edu.au)"},{"Entity":"PARENT","Code":"AHER02","Email":"maria-ahern@live.com","Name":"Mr J & Mrs M Ahern (mother)","NameEmail":"Mr J & Mrs M Ahern (maria-ahern@live.com)"}]

NOTES

Entity = STUDENT means its students details.
Entity = DEAN means it's the dean for student
Entity = HOMETEACHER means it's the home teacher of student
Entity = SUBJECTTEAHER – returns al the subject teachers of the student
Entity = PARENT – returns all the sets of parents possible for the student.

A6-1.17 GET API/STUDENTDISCIPLINE/GETDISCIPLINEWORKFLOWS/{ID}

http://203.143.236.47/PCSchoolWebAPI/api/StudentDiscipline/GetDisciplineWorkFlows/{Id}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentDiscipline/GetDisciplineWorkFlows/0

JSON HEADERS

```
0
```

TEST RESULTS

20	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/StudentDiscipline/GetDisciplineWorkFlows/0

TEST EXAMPLE OUTPUT

0 - Notepad

File Edit Format View Help

[{"DisciplineTypeID":294,"Description":"Music-Queensland Catholic Music Festival-Participation","TypeCode":"M"},{"DisciplineTypeID":293,"Description":"Academic-Plagarism-Unknown","TypeCode":" "},{"DisciplineTypeID":292,"Description":"Academic-Non-submission of Assessment-Unknown","TypeCode":" "},{"DisciplineTypeID":291,"Description":"Academic-Non-submission of draft-Unknown","TypeCode":" "},{"DisciplineTypeID":290,"Description":"PC-Behaviour-Student Leadership","TypeCode":"M"},{"DisciplineTypeID":278,"Description":"Academic-Business Invention Convention-Participation","TypeCode":"M"},{"DisciplineTypeID":277,"Description":"Other Sport-UHL Sport Cup -Participation","TypeCode":"M"},{"DisciplineTypeID":276,"Description":"Academic-Kaleidoscope Challenge Participant -Participation","TypeCode":"M"},
{"DisciplineTypeID":275,"Description":"Academic-International Space Design Competition Participant-

A6-1.18 GET ALL SUBJECTS FOR A STUDENT

api/StudentAttendance/GetStudentAttendance?StudentCode={StudentCode}&TimeTableDate={TimeTableDate}&MemberCode={MemberCode}&MemberHash={MemberHash}

EXAMPLE

http://203.143.236.47/PCSchoolWebAPI/api/StudentAttendance/GetStudentAttendance?StudentCode=ahern z&TimeTableDate=8/10/2013&MemberCode=hellmuth w&MemberHash=14024

JSON HEADERS

```
{
  "StudentCode": "ahern z",
  "MemberCode": "Hellmuth W",
  "TimeTableDate": "8/10/2013",
  "MemberHash": 14024

}
```

TEST RESULTS

20	200	HTTP	203.143.236.47	/PCSchoolWebAPI/api/

TEST EXAMPLE OUTPUT

File Edit Format View Help

[{"PeriodDescription":"1 Period 1","SubjectAbbreviation":"MUSIC","SubjectDescription":"MUSIC","Teacher' S Rigby","Class":"71","Room":"MUSIC","Year":"11"},{"PeriodDescription":"2 Period 2","SubjectAbbreviation":"MATHC","SubjectDescription":"MATHEMATICS C","Teacher":"Ms A Poppleton","Class":"41","Room":"SEM3","Year":"11"},{"PeriodDescription":"3 Period 3","SubjectAbbreviation":"MATHB","SubjectDescription":"MATHEMATICS B","Teacher":"Ms A Poppleton","Class":"31","Room":"B5","Year":"11"},{"PeriodDescription":"4 Period 4","SubjectAbbreviation":"PHYS","SubjectDescription":"PHYSICS","Teacher":"Ms S Young","Class":"61","Room":"B8","Year":"11"},{"PeriodDescription":"5 Period 5","SubjectAbbreviation":"R&E","SubjectDescription":"RELIGION & ETHICS","Teacher":"Mr M Taylor","Class":"11","Room":"B2","Year":"11"},{"PeriodDescription":"6 Period 6","SubjectAbbreviation":"ACCT","SubjectDescription":"ACCOUNTING","Teacher":"Mr M Taylor","Class":"51","Room":"B2","Year":"11"}]

APPENDIX 7

DATA DICTIONARY AND DATA STORES

Table A7.1 – Data dictionary

GET SCHOOLS
"Name": "sample string 1",
"WebServiceURL": "sample string 2"

GET AUTHENTICATED USER DETAILS
"UserName":
"Password":
"MemberCode": "sample string 3",
"MemberId": 4280

GET UNIQUE-UDID
“UDID”: "sample string 3",

POST UDID UPDATE
"StudentId":

GET STUDENT DETAILS
"UDID":
"MemberHash":
"MemberCode":
"SurName": "sample string 4",
"KnownAsName": "sample string 5",
"Email": "sample string 6",
"HomeTeacher": "sample string 7",
"HomeRoom": "sample string 8",
"House": "sample string 9",
"Dean": "sample string 10",
"StudentAlert": "sample string 11"

GET STUDENTS (Search Function)
"StudentCode":
"MemberHash":
"MemberCode":
"SurName": "sample string 12",
"KnownAsName": "sample string 13",
"Email": "sample string 14",
"HomeTeacher": "sample string 15",
"HomeRoom": "sample string 16",
"House": "sample string 17",
"Dean": "sample string 18",
"StudentAlert": "sample string 19",

Table A7.2 – Data dictionary

GET STUDENT IMAGE
"StudentCode":
"UDID":
"MemberHash":
"MemberCode":
“StudentImage”: .jpg image

GET MERITS / DEMERITS
"StudentCode":
"ReportedBy":
"MemberHash":
"MemberCode":
"StudentCode": "sample string 20",
"MeritsByMe": 2.0,
"DeMeritsByMe": 3.0,
"MeritsTotal": 4.0,
"DeMeritsTotal": 5.0

GET ALL CLASSES FOR A STUDENT BY PERIOD
"TeacherCode":
"Date":
"Time":
"MemberCode":
"MemberHash":
"UDID": "sample string 21",
"MemberCode": "sample string 22",
"MemberHash": "sample string 23"
"FullName": "sample string 24",

GET SUBJECTS
"StudentCode":
"MemberHash":
"MemberCode":
"TeacherCode": "sample string 25",
"Year": "sample string 26",
"SubjectCode": "sample string 27",
"SubjectDescription": "sample string 28",
"Class": "sample string 29",

Table A7.3 – Data Dictionary

GET ABSENCES
"StudentCode":
"MemberHash":
"MemberCode":
"StudentCode": "sample string 30",
"DateFrom": "sample string 31",
"DateTo": "sample string 32",
"Days": 4.0,
"Reason": "sample string 33",
"AbsenceStatus": "sample string 34"

GET ATTENDANCE CODES
"AttendanceCode": "sample string 35",
"Description": "sample string 36"

GET ALL CLASSES FOR A STUDENT BY PERIOD
"TeacherCode":
"Date":
"Time":
"MemberCode":
"MemberHash":
"UDID": "sample string 37",
"MemberCode": "sample string 38",
"MemberHash": "sample string 39"
"FullName": "sample string 40",

POST DISCIPLINE
"DisciplineId":
"DisciplineType":
"DisciplineTypeID":
"StudentKey":
"ReportedBy":
"Period":
"SubjectNo":
"Comment":
"Merits":
"Demerits":
"MemberHash":
"MemberCode":

Table A7.4 – Data dictionary

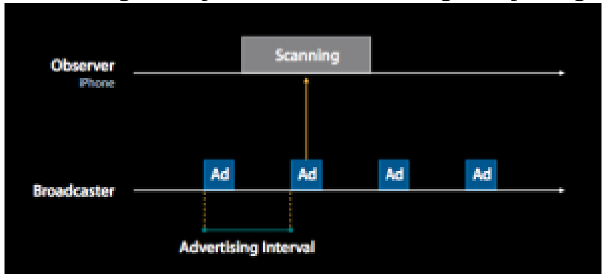
GET DISCIPLINEWORKFLOWS
"StudentCode":
"MemberCode":
"MemberHash":
"DisciplineTypeID": "sample string 41",
"Description": "sample string 42",
"TypeCode": "sample string 43",

EMAILS
"StudentCode":
"MemberCode":
"MemberHash":
"Entity": "sample string 44",
"Code": "sample string 45",
"Email": "sample string 46",

APPENDIX 8

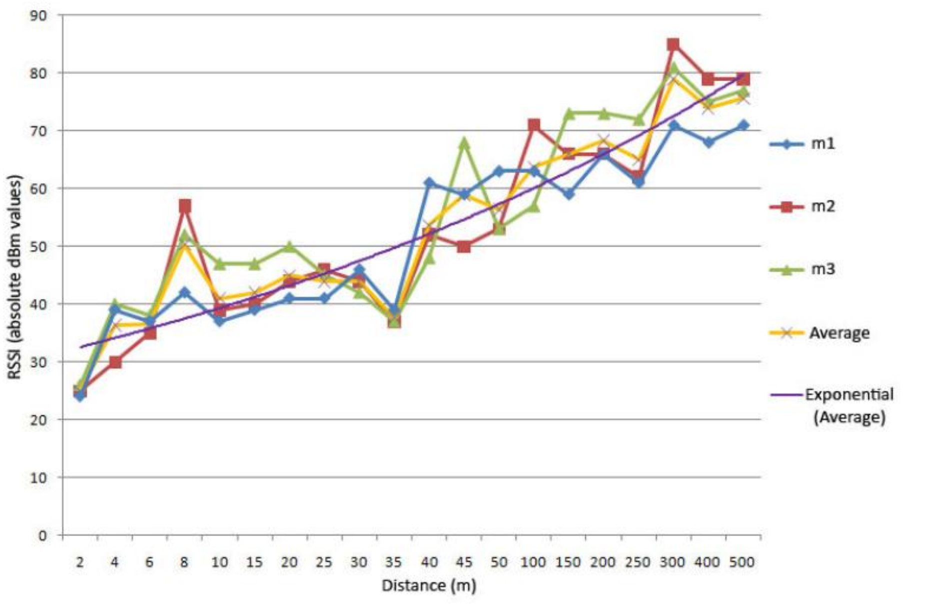
CENTRAL DESIGN REPOSITORY (CDR) FOR NOVEL COMPONENT OF ARTEFACT

Code	Category	Description of Working Issues
WF-1	**WiFi Triangulation Issues**	802.1X is not a common authentication method for all schools. Run into issues with iPAD's and network authentication. Problem with accuracy Mobility of WiFI could be problematic. Routers have to be wired and networked whereas a Bluetooth transponder can be easily made, and shifted with relative ease, making Bluetooth triangulation better over smaller distances. WiFi will have better range depending on type of Bluetooth chip placed in the transponder.
BT-1	**Problem Direction**	With the later versions of iOS devices that support Bluetooth LE, you can obtain the RSSI between it and sensor stations, as well as a UUID for identifying the device. You can also read the MAC address if you're using the right software on your sensor side, but I don't believe that this information is exposed by Core Bluetooth in the same way that RSSI and UUIDs are. **http://stackoverflow.com/questions/13177384/is-it-possible-to-get-bluetooth-mac-and-or-signal-strength-in-ios-6** There are two ways to approach triangulation if using Bluetooth LE. One is to do the triangulation by monitoring the iPhone from a series of placed sensor locations, and the other is to do triangulation on the iPhone itself by reading the signal strength between it and devices that are advertising from known points. The latter can be done by placing a series of LE peripherals in known locations and having them advertise at regular intervals. Within the advertisement information, you could stamp the location of that peripheral in the room. The iPhone could read these advertisements, get the RSSI information from them using the -centralManager:didDiscoverPeripheral:advertisementData:RSSI: delegate method, and triangulate its location. The former approach would be a little more involved. It would require that the iPhone itself be placed into an advertising mode using the new iOS 6.0 support for making the iPhone a Bluetooth LE peripheral. The sensor locations could then pick up the RSSI from them to the iPhone via these advertisement packets, as well as a UUID you generate for the phone. You can also pick up the MAC address of the phone is running the right software on the sensor nodes. A central server would then need to combine these readings to triangulate the iPhone's location.
BT-2	**Bluetooth Framework**	Client/ Server – **In BTLE 4.0, a client is characterised as the device who wants data. This data is processed and presented to the user.** Server (Peripheral) – **In BTLE 4.0, a server is the device who has the data and transmits it.** *Device:* **Is an object that offers an external Bluetooth interface.** **Step 1. Advertising**

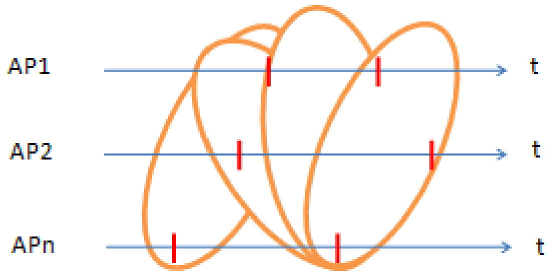
		Advertising is the process of broadcasting data packages, on a set time interval.  **Step 2. Setting up the connection** Once the advertising process is complete, a second Bluetooth device can send a connection request to the broadcaster. Once the connection is made, the observer becomes Central, broadcaster becomes Peripheral. Both devices can then send data to each other. **In iOS5, an iDevice could only be a Central and never a Peripheral, but with the new API in iOS6, iDevices can offer Bluetooth services with their own characteristics. This feature is highly applicable when an iDevice serves as a manager for multiple external Bluetooth devices.**
BT - 3	**Object Model**	**Main objects:** CBCentralManager, CGPeriphealal,CBPeripheralManager,CBCentral **Data objects:** CBService,CBCharacteristic,CBMutableService,CBMutableCharacteristic **Helper objects:** CBUUID,CBATTRequest

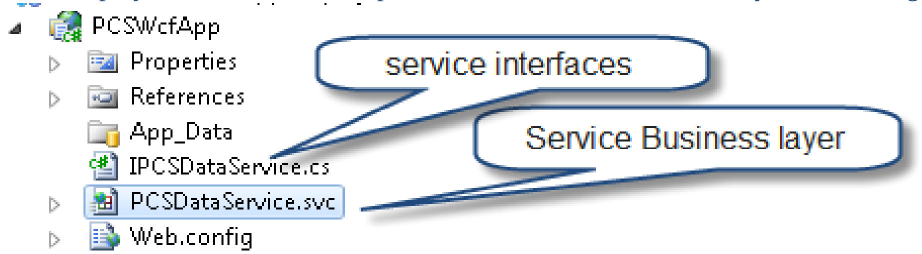
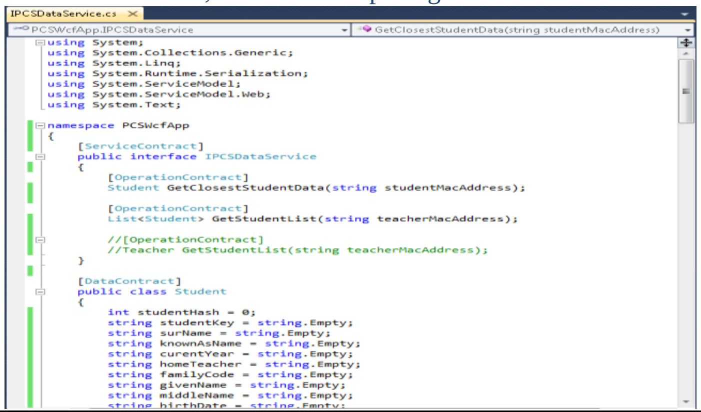
BT- 4	**Setting up Master – Slave Relationship**	**Step 1. Setup CBCentralManager**
		CBCentralManager *manager = [[CBCentralManager alloc] initWithDelegate:self queue:nil];
		
		Step 2. Scan for devices
		NSDictionary *dictionary = [NSDictionary dictionaryWithObject:[NSNumber numberWithBool:YES] forKey:CBCentralManagerScanOptionAllowDuplicatesKey];
		[manager scanForPeripheralsWithServices:nil options:dictionary];
		
		Step 3. Process peripherals
		- (void)centralManager:(CBCentralManager *)central didRetrievePeripherals:(NSArray *)peripherals{
		
		// chose peripheral and connect
		[manager connectPeripheral:[perpherals objectAtIndex:0]options:[NSDictionary dictionary]];
		}
		
		Step 4. Get notified when connection with peripheral is complete and write a value to a characteristic on the peripheral
		- (void)centralManager:(CBCentralManager *)central didConnectPeripheral:(CBPeripheral *)peripheral{
		
		//Write value to a characteristic

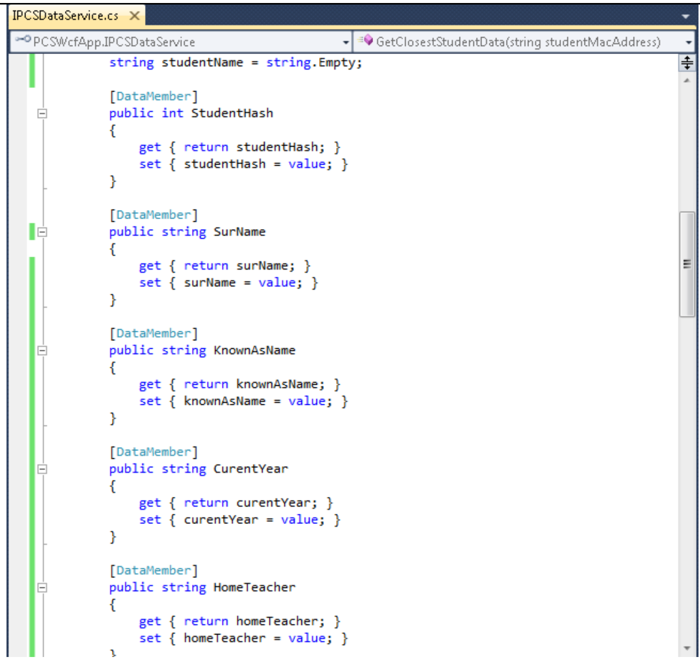
		int i = 1;
		[peripheral writeValue:[NSData dataWithBytes:&i length:sizeof(i)] forCharacteristic:[[service characteristics] objectAtIndex:0] type:CBCharacteristicWriteWithoutResponse];
		}

RS-1	**Determining RSSI Strength**	Use the centralManager:didDiscoverPeripheral:advertisementData:RSSI: delegate method, and then triangulate its location.
RS-2	**RSSI to Distance Conversion**	 Line of best fit for several models of Bluetooth chips and vendors - Indoor Localization Using
RS-3	**Issues with RSSI**	You might need to experiment with the transmission strength to determine what kind of resolution this would provide. The RSSI information is noisy, and in my experience it only seems to resolve to +-30 feet at the normal transmission levels for my peripherals. You may be able to improve upon this with multiple sensor stations and lower transmission strength.
RS-4	**RSSI Bug in iOS 6.0**	There is a bug iniOS 6 where theUDID or Mac address foriOS devicesinconsistentlyreturns a null value... The code has now beenchangedto handle this.. http://web.archiveorange.com/archive/v/lBeBkkzxZ689ulEeGoq4 http://e2e.ti.com/support/low_power_rf/f/538/t/215926.aspx http://lists.apple.com/archives/bluetooth-dev/2012/Sep/msg00106.html
RS-5	**Bluetooth Testing**	**RSSI Signal Testing** See YouTube video - **http://www.youtube.com/watch?v=lIio-q4Wf7U**
TRI-1	**Relevant Bluetooth**	Almaula, V., & Cheng, D. (2012). Bluetooth Triangulator

	Papers	Schwefel, H., Kovacs, I. Z., Jõao, F., Monghal, G. & Malidor, Y. (2005). *Enhanced triangulation method for positioning of moving devices.* ***This one has a particularly strong algorithm that can be used as a starting point for Bluetooth Triangulation.*** Prieto, J., Mazuelas, S., Bahillo, A., Fernandez, P., Lorenzo, R.M. & Abril, E.J. (2012). Adaptive Data Fusion for Wireless Localization in Harsh Environments. IEEE Transactions on Signal Processing, 60(4), 1585-1596. Rodriguez, M., Pece, J. P. & Escudero, C. J. (2005). In-building location using bluetooth. In International Workshop on Wireless Ad-hoc Networks 2005, Coruna, Spain.
TRI-2	**Triangulation Algorithm**	**TECHNICAL DESCRIPTION** Utilising multiple Bluetooth signals, the student radar uses location algorithms that calculates the local position of multiple devices. The algorithm is based on the triangulation method using the Received Signal Strength Indicator (RSSI) received from a device by its neighboring Access Points (AP's). Firstly: the movement is calculated using two stochastic processes: The speed $s = \lvert\vec{s}\rvert$ $\qquad f_{st}(s) = \frac{e(-\frac{(v-s)^2}{2\times\sigma_v^2})}{\int_0^\infty e(-\frac{(v-s)^2}{2\times\sigma_v^2})} . H(t)$ The direction $v = \arg(\vec{s})$ $\qquad f_{vt}(v) = \frac{1}{360}\lfloor H(t+180) - H(t-180)\rfloor$ The coordinates of the AP's emitting Bluetooth signals are determined.

		Secondly: the **Power to Distance** for each AP is calculated knowing the RSSI.  $\widetilde{f_D^{(i)}}\ (d\|Wi) := f_{RSSI}^{(i)}\ (W_i\|d)$ Thirdly: the **Distance to Coordinates** is calculated: $\tilde{f}_{X,Y}^{(i)}\ (x,y\|W_i) := \frac{\tilde{f}_D^{(i)}\ d_{x,y}^{(i)}\|Wi)}{N}$ Finally: **Triangulation** is calculated by obtaining a probability density of the location. $f X,Y\ (x,y) := \prod_{i=1}^{n} f_D^{(i)}\ (x,y\|Wi)$
WS-2	**Web Services** ***Calling Date and Time***	Just starting with PCSchool Web Services development. Few things, when you call the first service, do we need to pass on the 2nd and 3rd argument (date and time). Basically what I need to return is the student data based on the MacID right?

WS-3	**Web Services** ***Calling Date and Time***	We need to pass back the student details based on the Mac ID, but we are passing back only those students that belong to that teacher who owns the Master MacID. The Bluetooth technology picks up the closest student out of this set of students. This eliminates students walking past the class, and other Bluetooth signals. We would need to use time and date to do this I believe. Is this correct?
WS-5	**Creating WCF Test Web Services**	Using WCF web services. Created a project as below which exposes an interface and a business layer that is integrated to a data access layer.  The interface class, where I am exposing the functions and its contracts. 

<table>
<tr>
<td></td>
<td></td>
<td>


The business class where I am doing my call to the data access layer and generating objects
</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td><pre>PCSDataService.svc.cs
PCSWcfApp.PCSDataService | GetClosestStudentData(string studentMacAddress)
using System.Text;
using Spider_Data;
using System.Data;

namespace PCSWcfApp
{
    public class PCSDataService : IPCSDataService
    {
        public Student GetClosestStudentData(string studentMacAddress)
        {
            SpiderData sd = new SpiderData();
            Student student = new Student();
            int iTemp;
            DataSet dsStudent = sd.StudentList(studentMacAddress,string.Empty, string.Empty, string.Empty, false,0,0,string.Empty, str
            if (dsStudent != null)
            {
                foreach(DataRow dr in dsStudent.Tables[0].Rows)
                {
                    int.TryParse(dr["STUDENT#"].ToString(), out iTemp);
                    student.StudentHash = iTemp;
                    student.StudentName = dr["STUDENTNAME"].ToString();
                }
            }
            return new Student;
        }

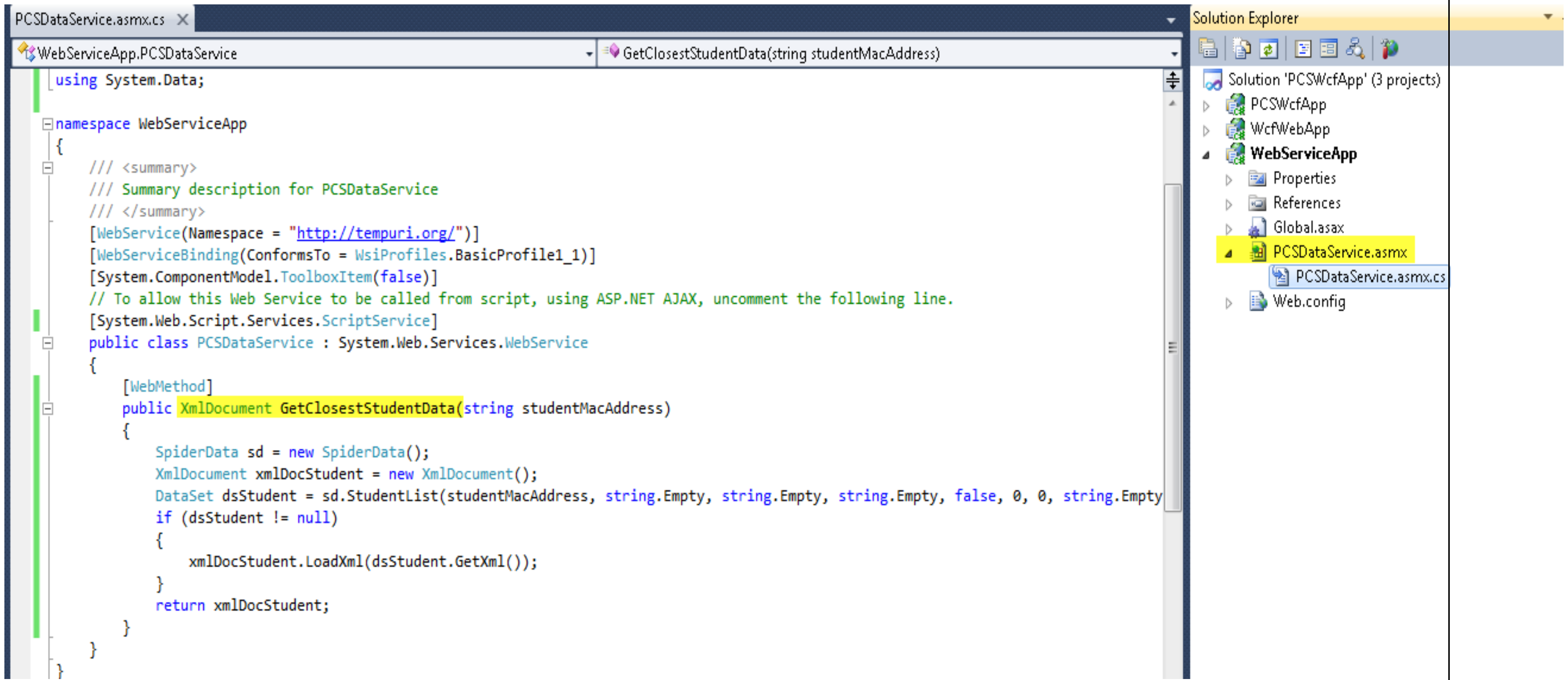
        public List<Student> GetStudentList(string teacherMacAddress)
        {
            List<Student> studentList = new List<Student>();

            return studentList;
        }
    }
}</pre></td></tr>
<tr><td>WS-6</td><td>Checking Web Services with ios6</td><td>I just spoke to a mate who is an integration expert. He said that I do not need to have complicated web services. I just need to use a normal web service, not the WCF standard (according to my understanding you have asp.net web service or WCF web service). This web service you can call straight away no issues. An example framework is attached. I will redevelop the WCF web service accordingly and get back to you for testing on the new web services.
(Working with PCSchool developers)</td></tr>
<tr><td>WS-7</td><td>Location of Web Services</td><td>I will share the entire project (it’s only a testing project) When we are on live mode, we will ensure that this is not a separate project, but something inside spider itself.</td></tr>
<tr><td>S-1</td><td>Security</td><td>Before sending you the source code, we need to discuss the security. All the calls in spider are based on authentication. How are we going to make sure that the calls to this web service are done only by appropriate user?</td></tr>
<tr><td>S-A-2</td><td>Authentication</td><td>Let me briefly discuss the structure of theioscorebluetooth framework. See http://www.icapps.be/corebluetooth-unraveled/for a brief introduction into this framework.

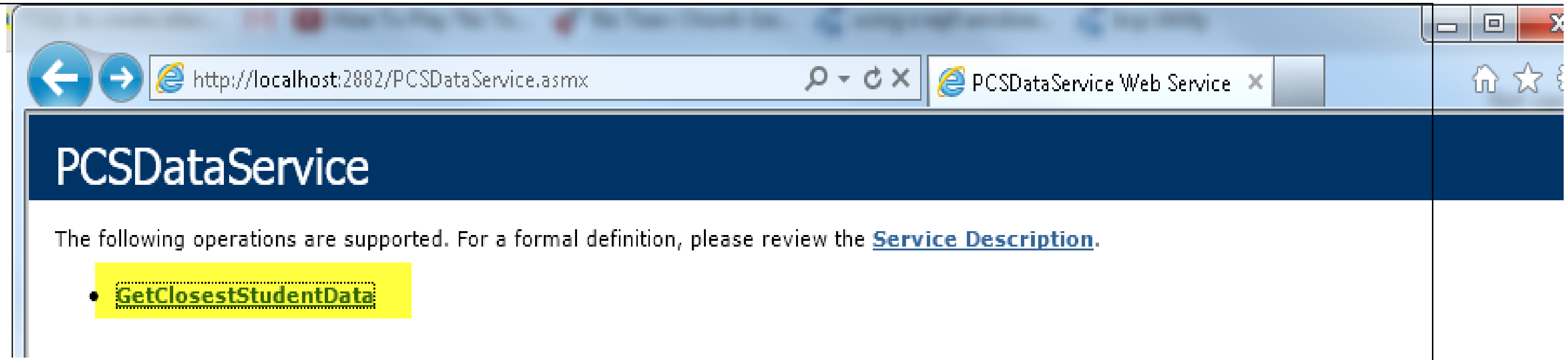
Essentially inios6 we can now set up a master and slave device, in this case a teacher and student device. I am actually developing two types of apps, one app is the teacher app whichI expect will beavailable to download from the "PCSchool" website. I am not sure how you can control this....Up to you...Once downloaded fromPCSchool website, it is a simple process to get the app on to the iPad.The compiled app,is added to yourappfileson iTunes. Then you just sync theidevice to iTunes.</td></tr>
</table>

		The second app sits on the studentiPad and runs in the background. Essentially the student app just advertises the Bluetooth signal and MAC address. We install this appwhen a student brings their device to be connected to theschool wireless network. On the teacher app, at the moment I need to hard code theUDID of the device within the software so that I can test, however, long term the UDID/Mac Addresswill sit within thePCSChool database.Base onUDID we can obviously makemethod calls that are based on theUDID of the device. In a sense theUDID itself will act as the authentication.(I wish to lean this way, as the crucial element of this software, is the time it takes to access, view or enter data. I am trying to keep this process as lean as possible). I am not sure if this will fit with your authentication model. Thegreat thing about theweb servicesis that we are not exposing the full database when using this'open' authentication model'. The downside to this is that security to the information contained within the web service, depends on teachers not losing or misplacing their iPad. My view was that if theiPAD is reported missing, we remove theUDID against the user in PCSchool, and, therefore, the information from the web service cannot be obtained.
S-A-2	**Authentication**	So in summary: a)Whenever the request is send for student information, we will be passing 2 arguments – student's MacID, and teacher's MacID. b)Based on teacher's MacID, we need to find out the teachers credentials c)Based on student's MacID we need to find out the students information Is that right? If that is the case, this requires lot of changes in the business logic. What I would suggest is that we start off with a new web service where teacher will just pass on their MacID, and based on that, I can return you the code and member# of user. You can store it in the iPad and whenever you make any request, pass these 2 extra arguments to me, and then we will not require a lot of changes in business logic layer. I believe that this would work…
S-A-3	**Authentication**	Just finished some discussion on the app development and what we will need to do further is: a) Somehow the app needs to know the url for the web service b) Somehow the UUID has to be registered in pcschool database, otherwise someone has to be type it in manually c)Somehow the authentication has to be completed. We thought of the following ways: In pcschool.net website, we will give an xml which will have a list of schools and their spider URL's Students when they download the app and run it, the app should give them a list of schools from this web url (a generic hardcoded one) Once the selection is done, the app will store the url for the web service Then student gets another interface where they can enter their username and password When they try to submit this information, app will pass on the UUID, and we will store it. This will work fine for teacher or for student

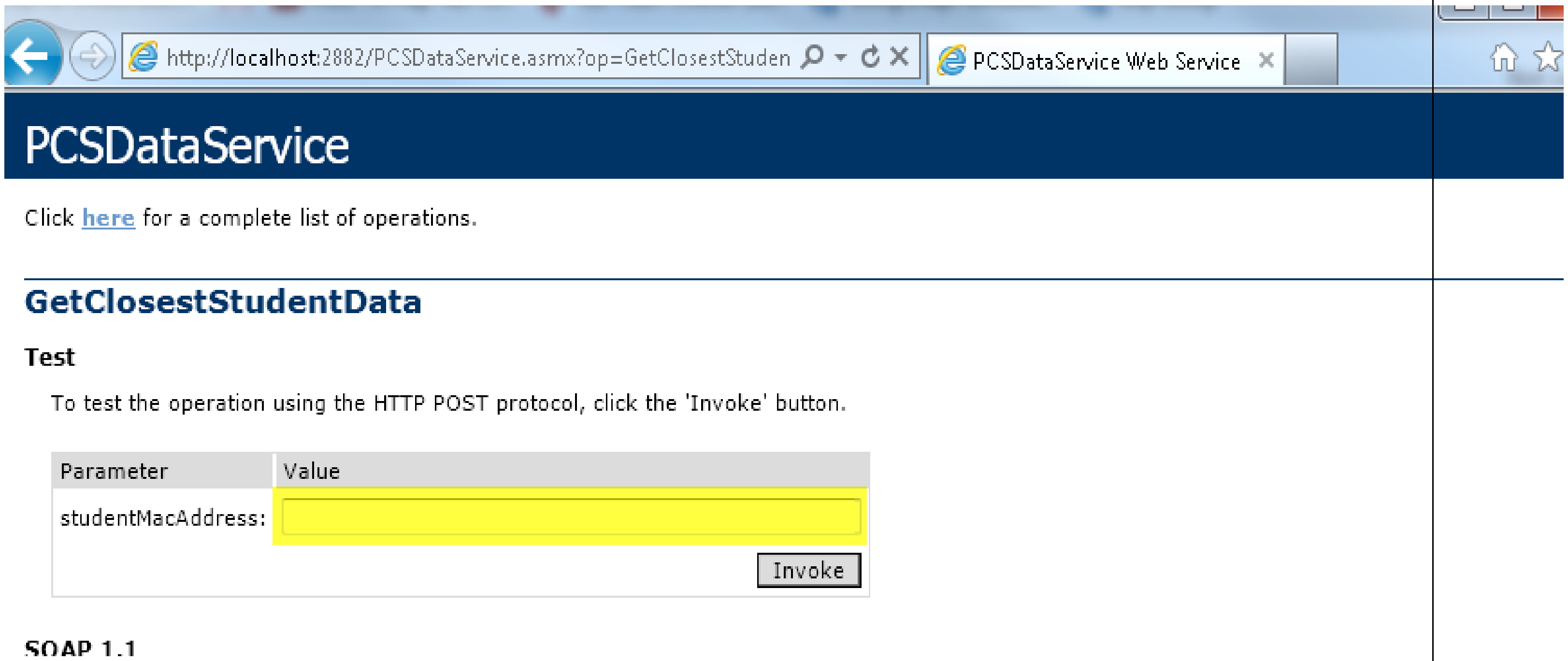
<table>
<tr><td></td><td></td><td>Based on the dynamic web service url, we will authenticate the user and return back their credentials like SSUSERID, MEMBER#, USER CODE
Whenever you make any future calls, pass back this MEMBER#, USERODE and SSUSERID, which are part of our authentication on every call</td></tr>
<tr><td>S-A-4</td><td>Pilot Web-Service Structure</td><td>Hi Guys, Please find the web services that I have been working on. I have just created one, and once I have the approval from you, I will do the rest. I have to make some changes in the stored procedure side of it, but this should work regardless.



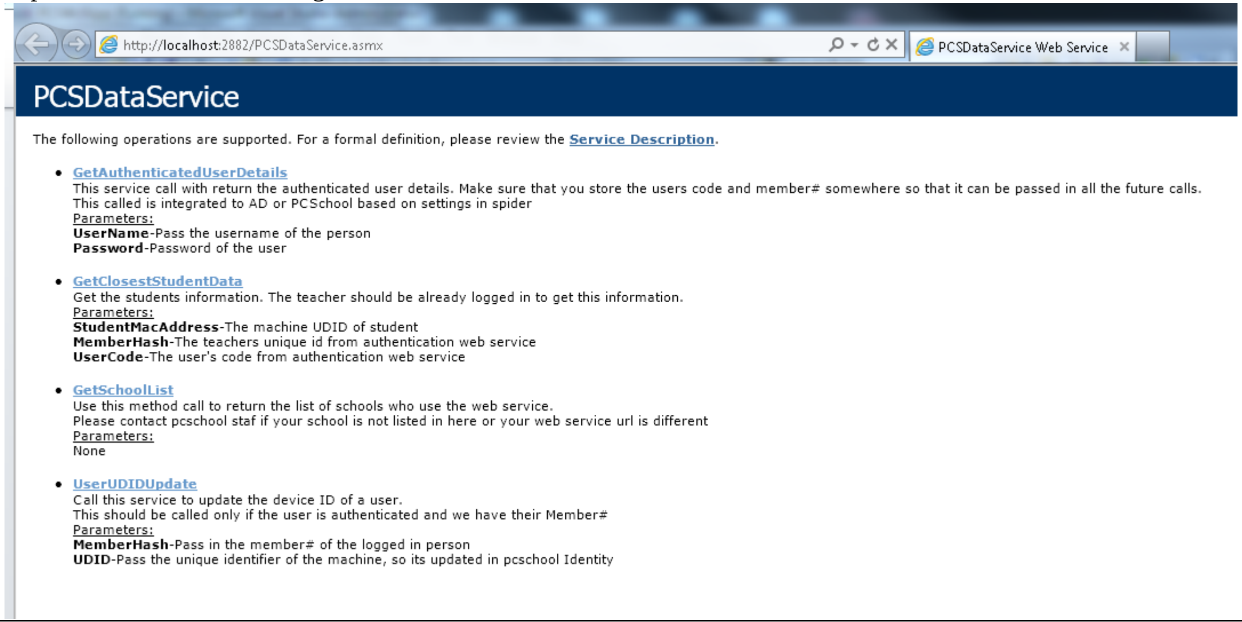
Once you access the web-service you will get the below screen</td></tr>
</table>

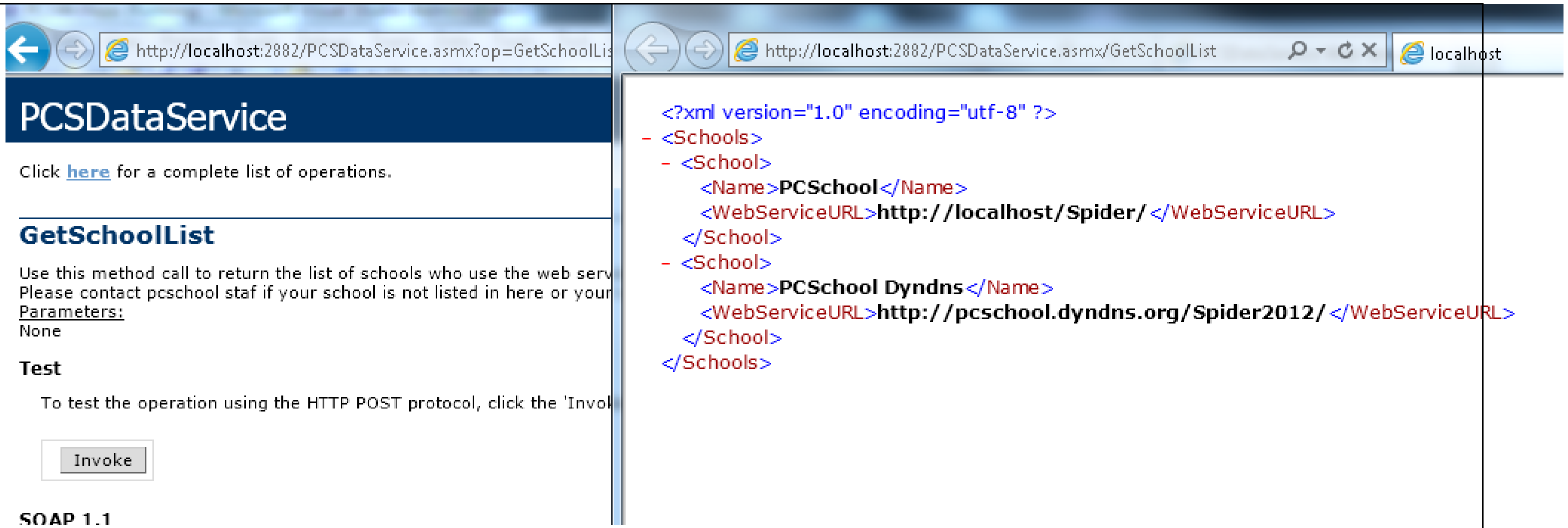


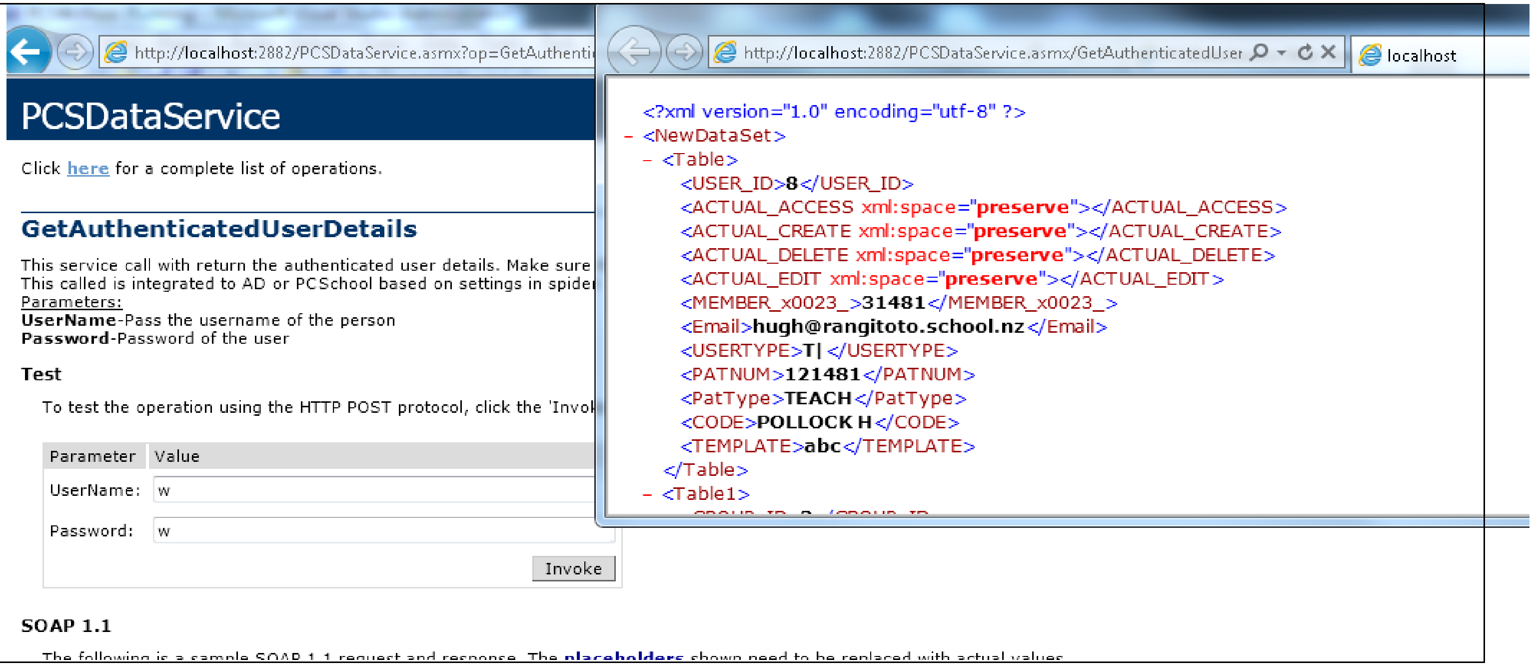
Once you invoke the function:



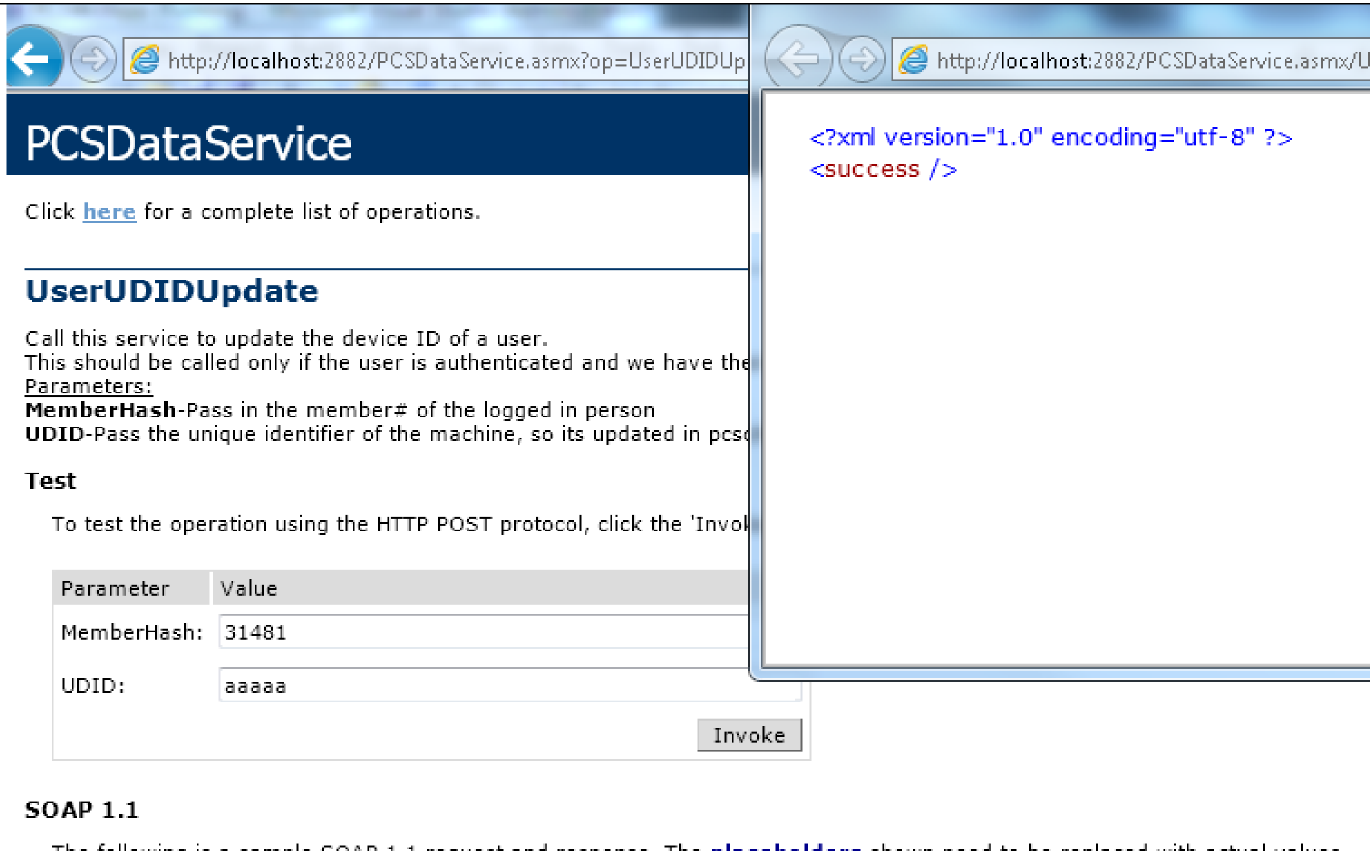
		Once you enter the mac address, you will get the following data: http://localhost:2882/PCSDataService.asmx/GetClosestStudentData localhost <?xml version="1.0" encoding="utf-8" ?> - <NewDataSet> - <Table> <fullname>Abbott, Grace</fullname> <cor_title>Mr & Mrs W R Abbott</cor_title> <cor_address>25 Montgomery Avenue</cor_address> <cor_address1>Rothesay Bay</cor_address1> <cor_town>Auckland</cor_town> <cor_post_code>0630</cor_post_code> <cor_res_add>25 Montgomery Avenue</cor_res_add> <cor_res_add1>Rothesay Bay</cor_res_add1> <cor_res_town>Auckland</cor_res_town> <res_pcode>0630</res_pcode> <age>20.70</age> <birth_date>1992-03-12T00:00:00+10:00</birth_date> <current_year>12</current_year> <home_class>0</home_class> <home_room>B.2</home_room> <home_teacher>R PLACE</home_teacher> <house xml:space="preserve"></house> <dean>COPE G</dean> <emerg_contact xml:space="preserve"></emerg_contact> <emerg_phone>0272749132</emerg_phone> <doc_name>browns bay med centre</doc_name> <doc_phone xml:space="preserve"></doc_phone> <ambulance>Y</ambulance> <medicare xml:space="preserve"></medicare> <father>Mr Abbott, Wayne</father> <dad_home_phone>479 2687</dad_home_phone> <dad_buss_phone>0275 749 355</dad_buss_phone> <dad_mobile>0275 749 355</dad_mobile> <dad_email>wayne.abbott@gen-i-co.nz</dad_email> <dad_job xml:space="preserve"></dad_job> <dad_workplace xml:space="preserve"></dad_workplace> <dad_domicile>Y</dad_domicile> <dad_status>Father</dad_status> <dad_emerg xml:space="preserve"></dad_emerg> <dad_emerg_ph>0275 749 355</dad_emerg_ph> <mother>Mrs Abbott, Andrea</mother>
S-A-5	**UDID Retrieval**	My mistakeUDID can be retrieved programmatically in ios6. Yes, this all sounds good, but we store all credentials in Active Directory. Will this work with spider? **http://ios.biomsoft.com/2011/10/28/how-to-replace-the-udid/** **http://stackoverflow.com/questions/4270200/how-can-i-retrieve-the-udid-on-ios**
S-A-6	**AD Integration**	Yes spider is sensitive to AD and we can even make our authentication in web service sensitive to AD
S-A-7	**Final Web-Service Contract**	If you are all happy at PCSchool, I will start creating the web services that we were talking about. Web service that returns

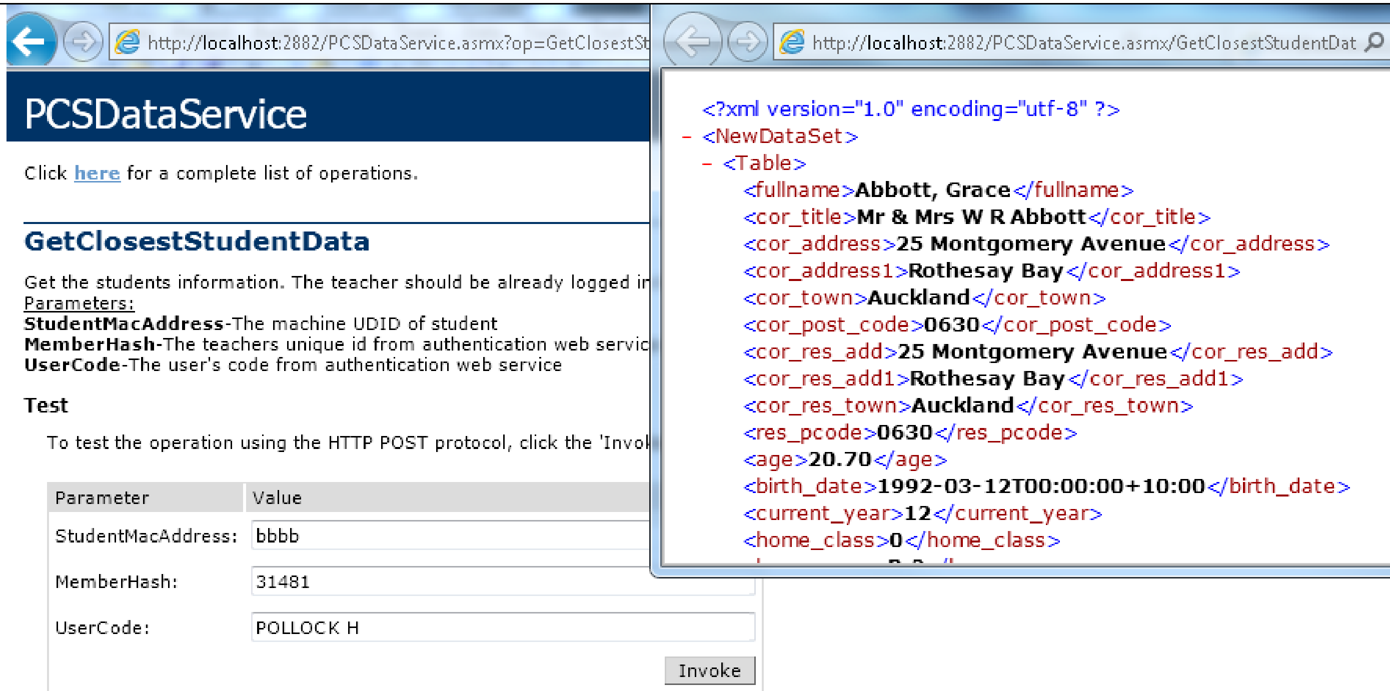
		all the schools The login web service call – connected to AD Store back the UUID to the pcschool – web service The web service call to return student details Once I have these 4 working, I will send you the source code (but again as a sample project)
LWS-1	**Installing Web Services on PC School Server**	A preview of how its working is attached below. 


http://localhost:2882/PCSDataService.asmx?op=GetSchoolLis
PCSDataService
Click here for a complete list of operations.
GetSchoolList
Use this method call to return the list of schools who use the web serv
Please contact pcschool staf if your school is not listed in here or your
Parameters:
None
Test
To test the operation using the HTTP POST protocol, click the 'Invok
Invoke
SOAP 1.1
http://localhost:2882/PCSDataService.asmx/GetSchoolList
localhost
<?xml version="1.0" encoding="utf-8" ?>
- <Schools>
- <School>
<Name>PCSchool</Name>
<WebServiceURL>http://localhost/Spider/</WebServiceURL>
</School>
- <School>
<Name>PCSchool Dyndns</Name>
<WebServiceURL>http://pcschool.dyndns.org/Spider2012/</WebServiceURL>
</School>
</Schools>

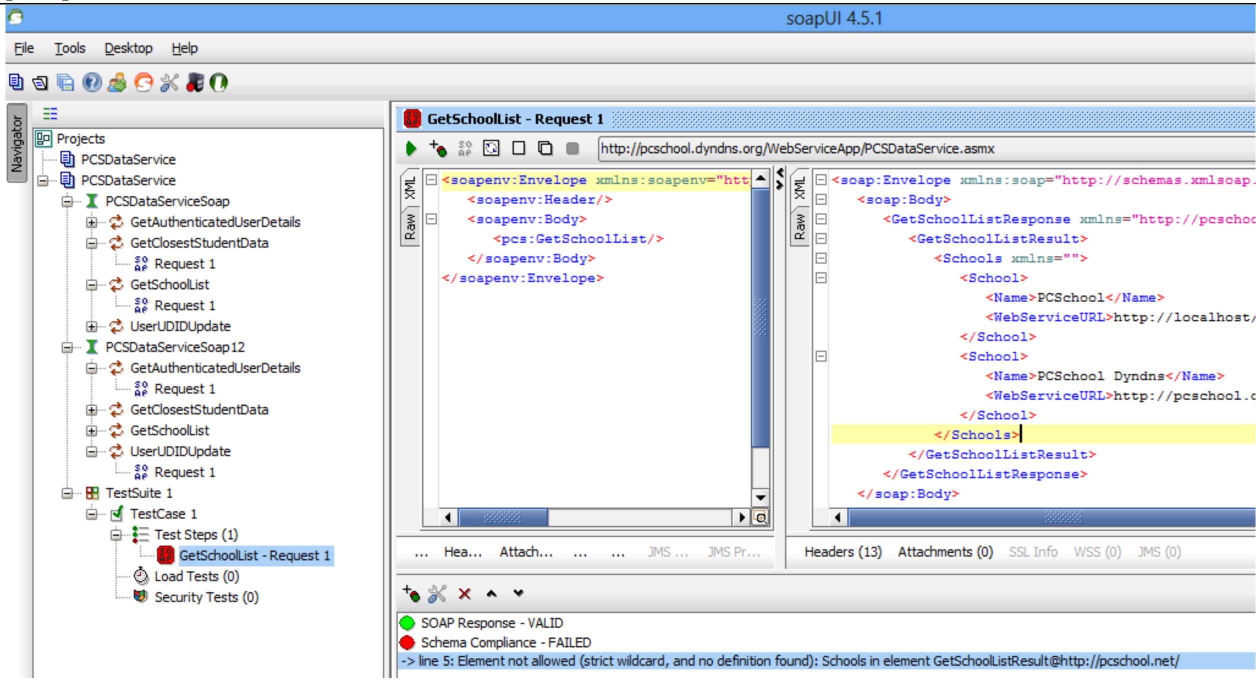
		

http://localhost:2882/PCSDataService.asmx?op=GetAuthenti
PCSDataService
Click here for a complete list of operations.
GetAuthenticatedUserDetails
This service call with return the authenticated user details. Make sure
This called is integrated to AD or PCSchool based on settings in spider
Parameters:
UserName-Pass the username of the person
Password-Password of the user
Test
To test the operation using the HTTP POST protocol, click the 'Invok
Parameter
Value
UserName:
w
Password:
w
Invoke
SOAP 1.1
http://localhost:2882/PCSDataService.asmx/GetAuthenticatedUser
localhost
<?xml version="1.0" encoding="utf-8" ?>
- <NewDataSet>
- <Table>
<USER_ID>8</USER_ID>
<ACTUAL_ACCESS xml:space="preserve"></ACTUAL_ACCESS>
<ACTUAL_CREATE xml:space="preserve"></ACTUAL_CREATE>
<ACTUAL_DELETE xml:space="preserve"></ACTUAL_DELETE>
<ACTUAL_EDIT xml:space="preserve"></ACTUAL_EDIT>
<MEMBER_x0023_>31481</MEMBER_x0023_>
<Email>hugh@rangitoto.school.nz</Email>
<USERTYPE>T|</USERTYPE>
<PATNUM>121481</PATNUM>
<PatType>TEACH</PatType>
<CODE>POLLOCK H</CODE>
<TEMPLATE>abc</TEMPLATE>
</Table>
- <Table1>

		http://localhost:2882/PCSDataService.asmx?op=UserUDIDUp PCSDataService Click here for a complete list of operations. UserUDIDUpdate Call this service to update the device ID of a user. This should be called only if the user is authenticated and we have the Parameters: MemberHash-Pass in the member# of the logged in person UDID-Pass the unique identifier of the machine, so its updated in pcs Test To test the operation using the HTTP POST protocol, click the 'Invok Parameter Value MemberHash: 31481 UDID: aaaaa Invoke SOAP 1.1 http://localhost:2882/PCSDataService.asmx/U <?xml version="1.0" encoding="utf-8" ?> <success />

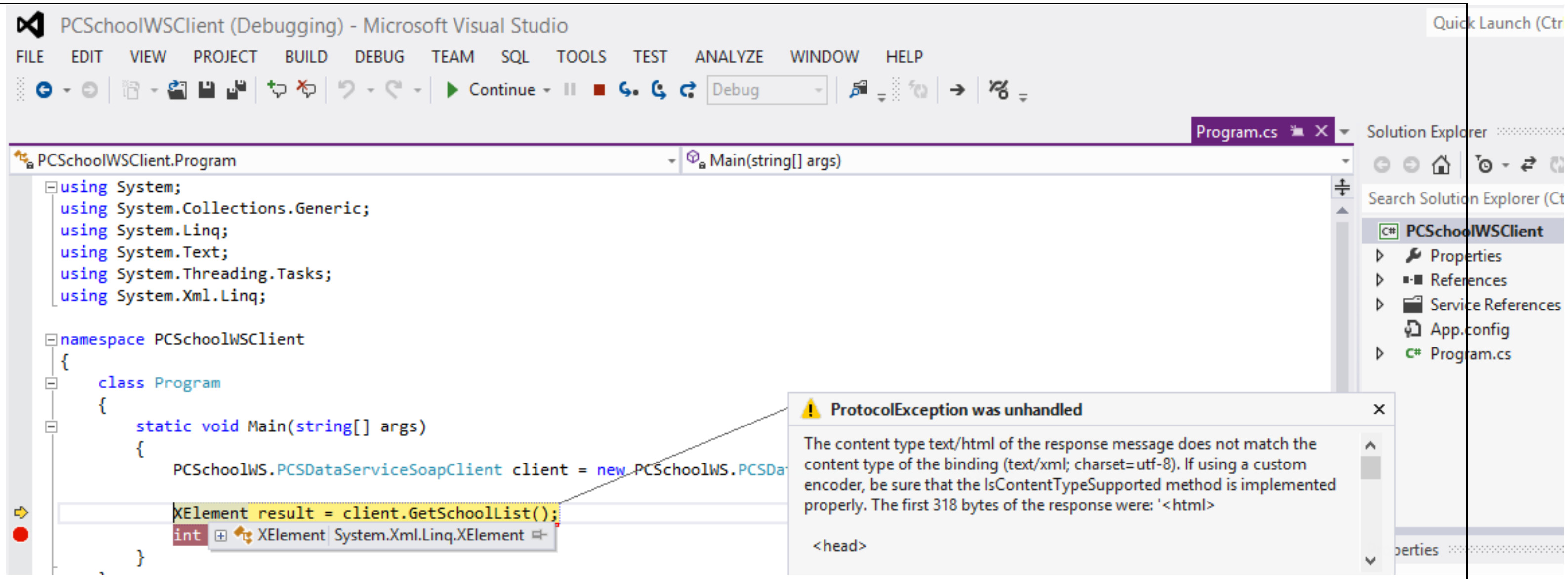


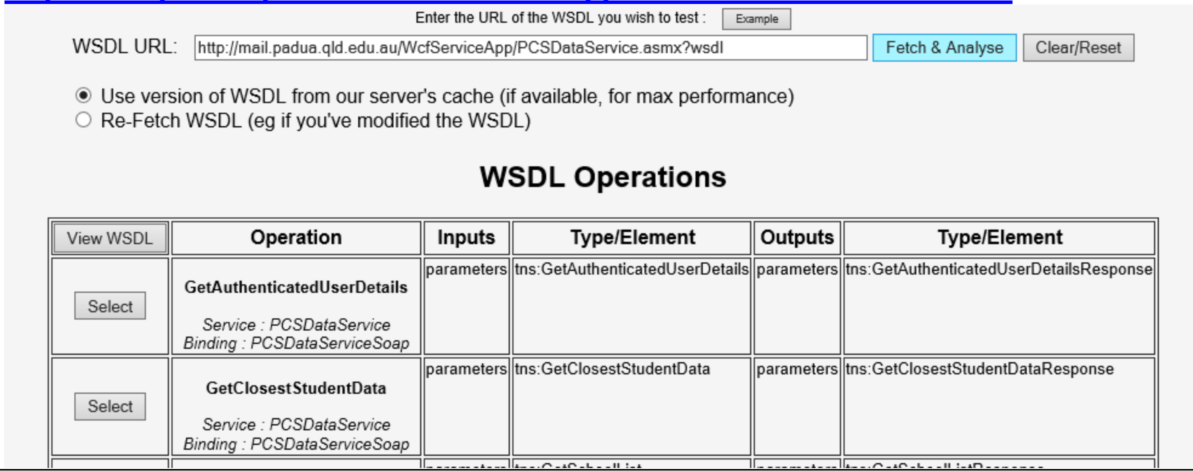
WD-01	**Web -Services on Padua Servers**	I have finished all of my codingto consumethe first 4 web services. I have been trying to deploy the web services you have written, however, I have run into some problems. Our application server here runningPCSchoolis 2003 (Plans to change this at Christmas) runningIIS 6. Microsoft tells me that we will have to deploy the web services using Microsoft Web Deploy. I have installed this but have been trying to troubleshooting why theMsDepSvc Service is not appearing in IIS. Any ideas??
WD-02	**Web -Services on Padua Servers**	Just copy the folder to your IIS and convert that to an application and then you can use it. I Just released it to our INTERNET url and here it is. **http://pcschool.dyndns.org/WebServiceApp/PCSDataService.asmx**
WD-03	**Web-Services on Padua Servers**	This thing is still not behaving nicely, which is strange as the install is exactly the same.
SP-1	**Spider Update**	**Correspondence with PCSchool** Tell me, what's the version of spider you are having? *Ver 2012.09.10*

<table>
<tr><td></td><td></td><td>That too should be updated as we are using the same business libraries and SP's.
We have the functionalities mentioned below working good. Once your spider is updated, I can release these (as the business logic is entirely dependent on spider DLL and SP's.</td></tr>
<tr><td>SP-2</td><td>Spider Update</td><td>Currently we need to upgrade the IIS on the PCSchool Server (pad-fps-02), but this is not a VM. It on the physical box in the server room. It's also running Windows 2005. The latest version of IIS requires 2008. Rama can you create a new VM for me (2008 R2). We will need to name it (pad-fps-03). Leave all of the shares on fps-02. Once this is done, I will do the new install of PCSchool Spider on pad-fps-03.</td></tr>
<tr><td>TC-01</td><td>Test Client 1</td><td>

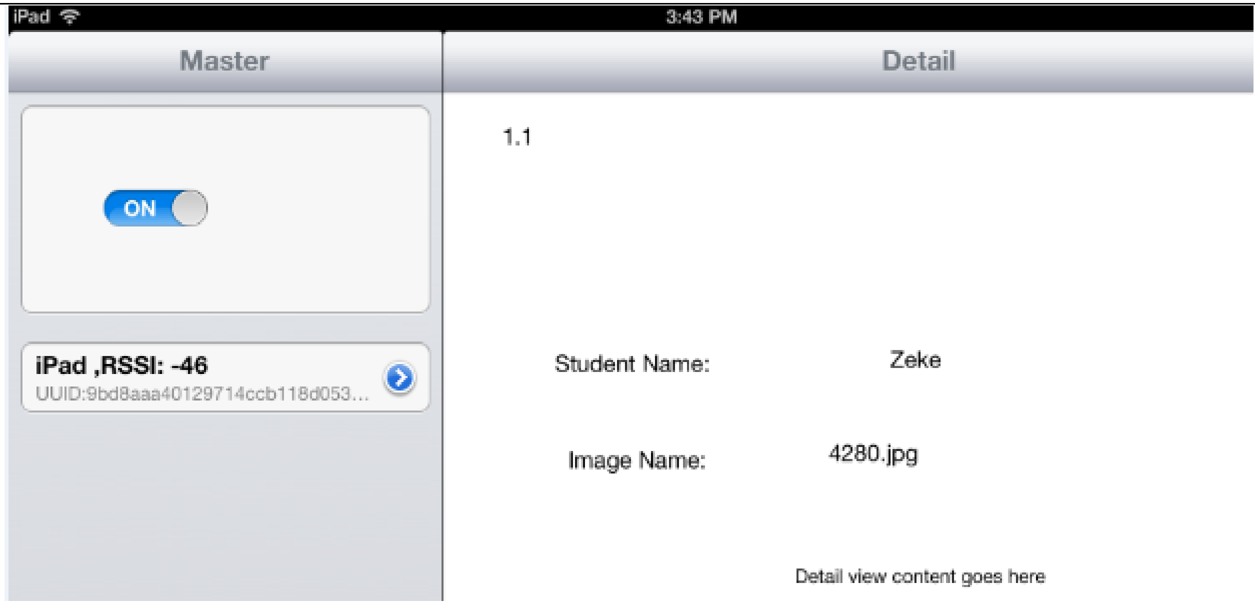
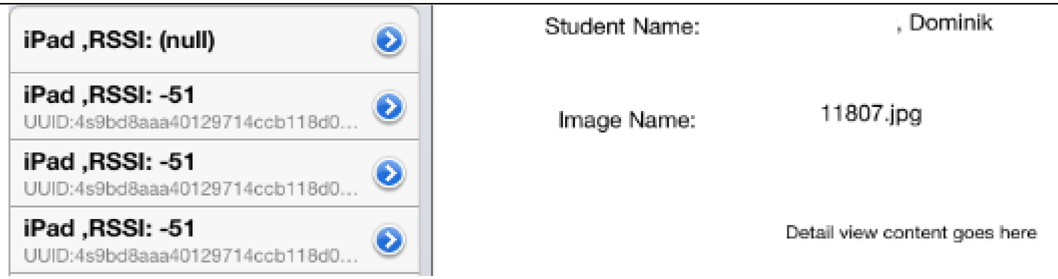
Error when testing services in SOAPUI</td></tr>
<tr><td>TC-01</td><td>Issues</td><td>I think this can be related to the SoapUI program. It might be generating its own schema as the web service that we use is not schema dependent.
See http://sourceforge.net/apps/trac/ogsa-dai/wiki/soapUI</td></tr>
</table>

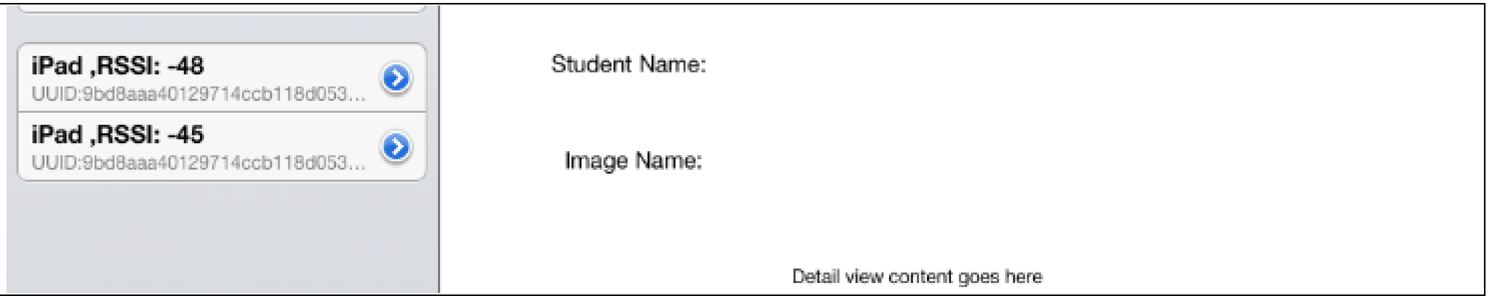
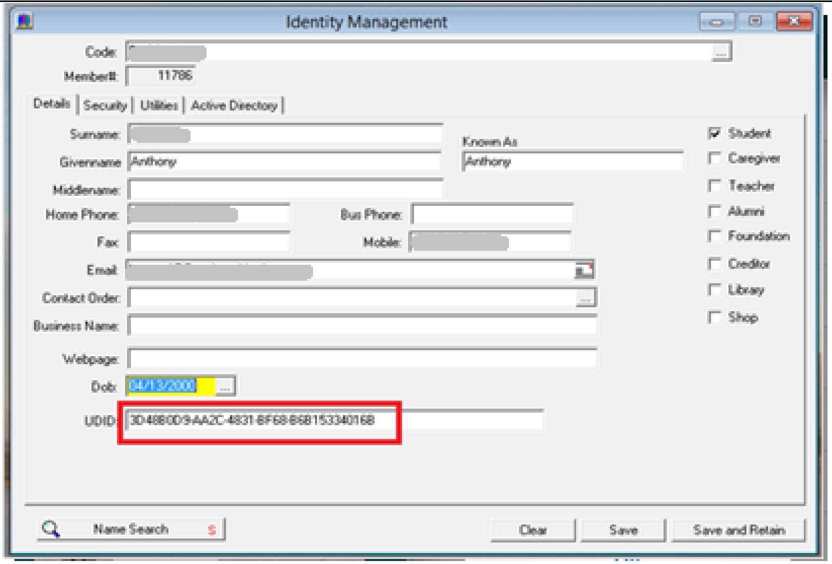
		XML validation
		
		You can right-click on SOAP request or response XML and select Validate to validate whether the XML is legal or not.
		
		When I do this on the SOAP response to a ListResources operation I get
		
		`line 4: Invalid xsi:type qname: 'xsd:string' in element ...`
		
		The line is:
		
		`<ns1:resourceID xsi:type="xsd:string"`
		`  xmlns:ns1="http://ogsadai.org.uk/namespaces/2007/04/service/types">`
		`  DataRequestExecutionResource`
		`</ns1:resourceID>`
		
		Invoking Check WS-I Compliance of the response passes. There's a similar report from a soapUI user. I'm not sure why this occurs.
		
		When I Validate the XML of a GetResourceProperty SOAP response I get:
		
		`line 4: Element not allowed (strict wildcard, and no definition found)`
		
		The line is:
		
		`<ns1:SupportedActivities xmlns:ns1="http://uk.org.ogsadai.resource.activities">`
		`  <ns2:activity name="uk.org.ogsadai.GenericTupleTransformActivity"`
		`    xmlns:ns2="http://ogsadai.org.uk/namespaces/2007/04/types"/>`
		
		This error, from a Google search, arises from within the XMLBeans package used by soapUI. The problem here arises from the fact that there is no XML Schema for namespace `http://uk.org.ogsadai.resource.activities` or the `SupportedActivities` element - these XML fragments are constructed in-code in OGSA-DAI. A similar problem, from a non-OGSA-DAI user is reported here .

TC-01		 Built my own web client using Visual Studio 2013. Error is still showing. Service down??
TC-01	**Access Issues**	Hi Dennis, **http://pcschool.dyndns.org/WebServiceApp/PCSDataService.asmx** Service appears to be down. Hi Wayne, All sorted. Just restarted the router.
TC-02	**Test Client 2**	TESTING CLIENT - RESULTS **http://validwsdl.com/**

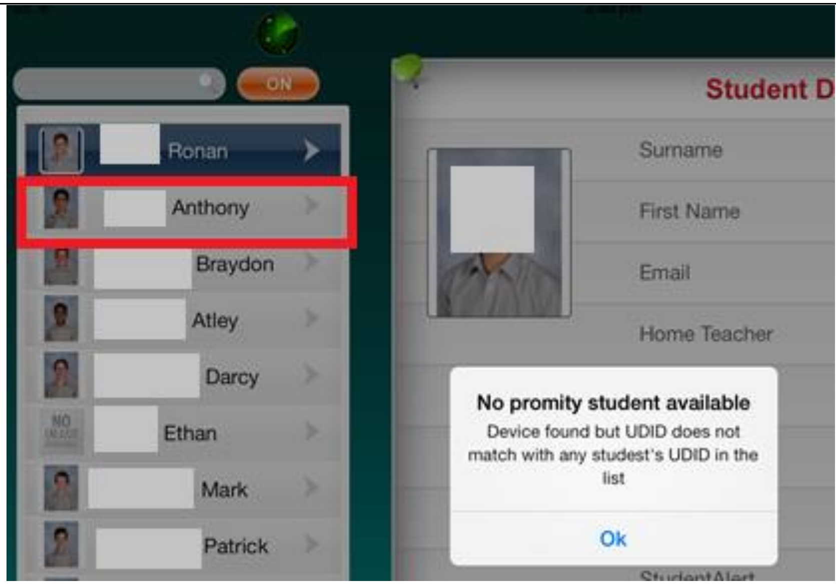
		
TC-02	**WSDL**	All Web Services are listed using; http://mail.padua.qld.edu.au/WcfServiceApp/PCSDataService.asmx?wsdl 
iOS-1	**Development**	Development specification document is completed. Analysis of existing “student behaviour management” applications is completed Business Case is completed Test Use Case Analysis is completed
iOS-2	**UDIDs**	UDID’s for iPads stored for testing purposes 9bd8aaa40129714ccb118d053c6d59b2e53865b **Slave iPad** 86dff27abf92cf6adfc318fd12a6e2317b2dd18 **Master** iPad These will be needed for testing purposes until the finished app is on the Apple App Store.

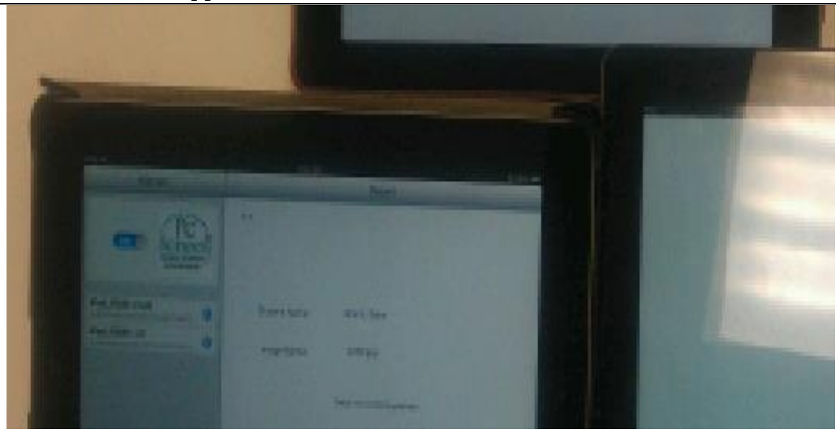
iOS-3	**Data Migration of Merits and Demerits**	253 Merit Music Senior Strings Participat 254 Merit Music Intermediate Concert Band Participat 255 Merit Music Percussion Ensemble Participat Development of the Behaviour metadata. Need to be able to tag when data is written from the app rather than from the legacy IS for testing purposes. Place an extra field in the SQL table for this.
iOS-4	**Proximity Functions**	**<u>FUNCTION 1</u> (Proximity Detector) – Determine closest student iPAD to Teacher iPAD**  **STEP 1 –** Determine the MAC Addresses of all users on the network **STEP 2 –** Determine MAC Address of the teacher, holding the iPAD with our application on it. **STEP 3** – Using a Bluetooth triangulation algorithm determine which iPAD (Mac Address) is closest to the teachers iPAD (Mac Address) **STEP 4** – Return the name and photo from the database of the student with the closest iPAD MAC Address to the teacher's iPAD MAC Address. This is done through Web Services to our local DB. **STEP 5** – This functionality can be turned on and off using a switch. **FUNCTION 2 – Return Class List** **STEP 1 –** Determine MAC Address of the teacher, holding the iPAD with our application on it. **STEP 2** – Return Teacher ID **STEP 3** – Return all students for that teacher at that time. This is done through the use of web services. It will look up all students in the class and return then to a list. The missing parameters will be the system time and date. **STEP 4 –** If the proximity detector is turned on highlight the student who is closest to the teacher in that list. **FUNCTION 3 – STUDENT SEARCH** **STEP 1 –** The proximity detector is turned off. **STEP 2** - Look up the DB using web services, to return the picture and details associated with that student.

iOS-5		 Working with single device
iOS-6		 Code problem. Need to identify and write over option in list after each signal poll.

<table>
<tr><td></td><td></td><td>
</td></tr>
<tr><td>iOS-7</td><td></td><td>

The app is writing the UDID to the database, but is not picking up the UDID on the poll. Check code.</td></tr>
</table>

<table>
<tr>
<td>iOS-8</td>
<td></td>
<td>

Version 6.01 – Apple have fixed the issue for the UDID null value return.</td>
</tr>
<tr>
<td>iOS-9</td>
<td></td>
<td>
Now working with multiple devices.</td>
</tr>
</table>

APPENDIX 9

IS-IMPACT / UTAUT SCALE

SEND YOUR COMPLETED RESPONSE DIRECTLY TO wayne.hellmuth@qut.edu.au

Impacts of PCSCHOOL BMS at Padua College

A survey conducted by the
Queensland University of Technology (QUT)

<u>**Introduction:**</u> Over the past several years PCSchool together with Padua College have invested significant resources into the PCSChool Behaviour Management systems (BMS). The impact of the BMS is now being experienced across all levels of Padua College. ***All staff at Padua College are being contacted and encouraged to participate in this survey regardless of whether or not you have had direct involvement with the BMS.***

<u>**Purpose of the Survey:**</u> The purpose of this survey is to identify the impacts of the <u>PCSchool Behaviour Management System</u> to Padua College (*henceforth simply referred to as the 'BMS'*. This survey is being conducted as a joint research project between PCSchool, Padua College and QUT.

We seek to learn from your experiences with the BMS at Padua College. Insights into your experiences with the BMS will be valuable in highlighting where future educational IT researchers, and others, should be focusing their attention, today and in future. Analysis of negative impacts will provide the basis of strategies for improvements. Positive impacts may be replicated or extended in your own or other agencies.

<u>**Confidentiality**</u> - This survey is not anonymous, but is **confidential**. Your responses are sent directly to the research team. For data integrity purposes, the research team must be able to associate your demographic details (Title, Role, and Duration of employment etc.) with your survey responses. Detailed results of the survey will be confidential to the research team. No names will be entered into the research database. Neither Padua College nor any agency nor any other group will receive a copy of your survey details. If you have any concerns regarding the ethical conduct of this research, you can contact the Secretary of the Queensland University of Technology's Human Research Ethics Committee on (07) 3864 2902 or email ethicscontact@qut.edu.au.

<u>**General Instructions for Completing and Returning the Questionnaire**</u>

It will take you approximately 10-15 minutes to complete.

Please return the completed questionnaire by **September 12, 2013**. This may be done by resaving the document once completed and sending as an email attachment to wayne.hellmuth@qut.edu.au. Alternatively, if you prefer, the instrument can be completed online at http://www.google.com or can be posted or faxed as below. If you have any queries concerning the questionnaire, please do not hesitate to contact me or the Supervising Researcher – Professor Glenn Stewart

Professor Glenn Stewart
Science and Engineering Faculty
Information Systems, BPM
Queensland University of Technology
Tel: 3138 9480 (voicemail) Fax: 3138 9390
E-mail: g.stewart@qut.edu.au

Mr. Wayne Hellmuth, Doctoral Student
Science and Engineering Faculty
Queensland University of Technology
GPO Box 2434, Brisbane 4001
Mobile: 0488200388
E-mail: wayne.hellmuth@qut.edu.au

PLEASE ANSWER ALL QUESTIONS.

Name:	
Role at Padua College:	
Years working in your current Role:	
Age:	
Gender:	
Years at Padua College:	
Department:	
If you want to receive a copy the preliminary findings of this study please provide your *email address*	

In one or two sentences, please describe your current job role, and where applicable, any involvement you have had with the PCSchool Behaviour Management System (BMS).

IMPORTANT INSTRUCTIONS FOR COMPLETION

The questions are grouped within the following categories for ease of understanding: A) Individual Impacts, B) Organisational Impacts, C) Information Quality, D) System Quality, and E) Satisfaction. Your answers should relate to your own experiences and perceptions of the current PCSchool Behaviour Management Module system in the role you act in. Responses to the questions can be selected by clicking **one** check box per question. 'Comment' fields have been included at the end of each section. Feel free to include here any further views you have on the PCSchool Behaviour Management module on this survey.

<u>Category A:</u> **Individual Impacts** are concerned with how the current **PCSchool BMS** has influenced your **individual performance.** This section seeks to assess whether PCSchool has helped you in your role in managing the behavior of students (e.g.): ability to interpret information accurately, understanding of information and work related activities in your current role, decision making effectiveness, and overall productivity.

		Strongly Disagree			*Neutral*			*Strongly Agree*
1	I have learnt much about Behaviour Management through the presence of the PCSchool BMS.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
2	PCSchool BMS enhances my awareness and recall of job related information.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
3	PCSchool BMS enhances my effectiveness in the job	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
4	PCSchool BMS increases my productivity	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

Comments

<u>Category B:</u> **Organisational Impacts** refer to impacts of PCSchool BMS at a broader level. Here we are interested in (e.g.): costs of organisational resources dedicated to run PCSchool BMS, number of applications replaced / introduced, changes in staff requirements, and changes in administrative processes, due to the introduction of PCSchool BMS.

		Strongly Disagree			*Neutral*			*Strongly Agree*
5	PCSchool BMS is cost effective	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

SEND YOUR COMPLETED RESPONSE DIRECTLY TO wayne.hellmuth@qut.edu.au

		1	2	3	4	5	6	7
6	The PCSchool BMS has resulted in reduced staff costs	☐	☐	☐	☐	☐	☐	☐
7	The PCSchool BMS has resulted in cost reductions (*e.g. paperwork, administration expenses, etc.*)	☐	☐	☐	☐	☐	☐	☐
8	The PCSchool BMS has resulted in overall productivity improvement	☐	☐	☐	☐	☐	☐	☐
9	The PCSchool BMS has resulted in improved outcomes or outputs	☐	☐	☐	☐	☐	☐	☐
10	The PCSchool BMS has resulted in an increased capacity to manage a growing volume of behaviour related activity.	☐	☐	☐	☐	☐	☐	☐
11	The PCSchool BMS has resulted in better positioning for *Padua College.*	☐	☐	☐	☐	☐	☐	☐
12	The PCSchool BMS has resulted in improved ways that behaviour is managed	☐	☐	☐	☐	☐	☐	☐

Comments

<u>Category C:</u> **Information Quality** is concerned with the relevance, timeliness and format of reports, and the accuracy of information generated by the PCSchool_BM_Module. Here the focus is on the quality of the PCSchool_BM_Module outputs: namely, the quality of the information the system produces in reports and on-screen.

		Strongly Disagree 1	2	3	*Neutral* 4	5	6	*Strongly Agree* 7
13	Information available from the PCSchool BMS is important	☐	☐	☐	☐	☐	☐	☐
14	The PCSchool BMS provides output that seems to be exactly what is needed	☐	☐	☐	☐	☐	☐	☐
15	Information needed from the PCSchool BMS is always available	☐	☐	☐	☐	☐	☐	☐
16	Information from the PCSchool BMS is in a form that is readily usable	☐	☐	☐	☐	☐	☐	☐
17	Information from the PCSChool BMS is easy to understand	☐	☐	☐	☐	☐	☐	☐
18	Information from the PCSchool BMS appears readable, clear and well formatted	☐	☐	☐	☐	☐	☐	☐
19	Though data from the PCSchool BMS may be accurate, outputs sometimes are not	☐	☐	☐	☐	☐	☐	☐
20	Information from the PCSchool BMS is concise	☐	☐	☐	☐	☐	☐	☐
21	Information from the PCSchool BMS is always timely	☐	☐	☐	☐	☐	☐	☐
22	Information from the PCSchool BMS is unavailable elsewhere	☐	☐	☐	☐	☐	☐	☐

Comments

SEND YOUR COMPLETED RESPONSE DIRECTLY TO wayne.hellmuth@qut.edu.au

		1	2	3	4	5	6	7
6	The PCSchool BMS has resulted in reduced staff costs	☐	☐	☐	☐	☐	☐	☐
7	The PCSchool BMS has resulted in cost reductions (*e.g. paperwork, administration expenses, etc.*)	☐	☐	☐	☐	☐	☐	☐
8	The PCSchool BMS has resulted in overall productivity improvement	☐	☐	☐	☐	☐	☐	☐
9	The PCSchool BMS has resulted in improved outcomes or outputs	☐	☐	☐	☐	☐	☐	☐
10	The PCSchool BMS has resulted in an increased capacity to manage a growing volume of behaviour related activity.	☐	☐	☐	☐	☐	☐	☐
11	The PCSchool BMS has resulted in better positioning for *Padua College.*	☐	☐	☐	☐	☐	☐	☐
12	The PCSchool BMS has resulted in improved ways that behaviour is managed	☐	☐	☐	☐	☐	☐	☐

Comments

<u>**Category C:**</u> **Information Quality** is concerned with the relevance, timeliness and format of reports, and the accuracy of information generated by the PCSchool_BM_Module. Here the focus is on the quality of the PCSchool_BM_Module outputs: namely, the quality of the information the system produces in reports and on-screen.

		Strongly Disagree 1	2	3	*Neutral* 4	5	6	*Strongly Agree* 7
13	Information available from the PCSchool BMS is important	☐	☐	☐	☐	☐	☐	☐
14	The PCSchool BMS provides output that seems to be exactly what is needed	☐	☐	☐	☐	☐	☐	☐
15	Information needed from the PCSchool BMS is always available	☐	☐	☐	☐	☐	☐	☐
16	Information from the PCSchool BMS is in a form that is readily usable	☐	☐	☐	☐	☐	☐	☐
17	Information from the PCSChool BMS is easy to understand	☐	☐	☐	☐	☐	☐	☐
18	Information from the PCSchool BMS appears readable, clear and well formatted	☐	☐	☐	☐	☐	☐	☐
19	Though data from the PCSchool BMS may be accurate, outputs sometimes are not	☐	☐	☐	☐	☐	☐	☐
20	Information from the PCSchool BMS is concise	☐	☐	☐	☐	☐	☐	☐
21	Information from the PCSchool BMS is always timely	☐	☐	☐	☐	☐	☐	☐
22	Information from the PCSchool BMS is unavailable elsewhere	☐	☐	☐	☐	☐	☐	☐

Comments

SEND YOUR COMPLETED RESPONSE DIRECTLY TO wayne.hellmuth@qut.edu.au

		1	2	3	4	5	6	7
42	Overall, the PCSchool BMS system related knowledge has been managed satisfactorily.	☐	☐	☐	☐	☐	☐	☐

Comments

		1	2	3	4	5	6	7
	OVERALL …							
54	….the impact of the PCSchool BMS on the *role I act in* has been positive.	☐	☐	☐	☐	☐	☐	☐
55	….the impact of the PCSchool BMS on *me* has been positive.	☐	☐	☐	☐	☐	☐	☐

Comments

		1	2	3	4	5	6	7
UTUAT								
Performance Expectancy								
56	I find the PCSchool BMS useful in my daily life.	☐	☐	☐	☐	☐	☐	☐
57	Using the PCSchool BMS helps me accomplish Behaviour Management more effectively.	☐	☐	☐	☐	☐	☐	☐
58	Using the PCSchool BMS increases my productivity.	☐	☐	☐	☐	☐	☐	☐
Effort Expectancy								
59	Learning how to use the PCSchool BMS is easy for me.	☐	☐	☐	☐	☐	☐	☐
60	My interaction with the PCSchool BMS is clear and understandable.	☐	☐	☐	☐	☐	☐	☐
61	I find the PCSchool BMS easy to use.	☐	☐	☐	☐	☐	☐	☐
62	It is easy for me to become skillful at using the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
Social Influence								
63	People who are important to me think that I should use the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
64	People who influence my behavior think that I should use the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
65	People whose opinions that I value prefer that I use the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
Facilitating Conditions								
66	I have the resources necessary to use the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
67	I have the knowledge necessary to use the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
68	The PCSchool BMS is compatible with other technologies I use.	☐	☐	☐	☐	☐	☐	☐
69	I can get help from others when I have difficulties using the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
Hedonic Motivation								
70	Using the PCSchool BMS is fun.	☐	☐	☐	☐	☐	☐	☐

SEND YOUR COMPLETED RESPONSE DIRECTLY TO wayne.hellmuth@qut.edu.au

		1	2	3	4	5	6	7
71	Using the PCSchool BMS is enjoyable.	☐	☐	☐	☐	☐	☐	☐
72	Using the PCSchool BMS is very entertaining.	☐	☐	☐	☐	☐	☐	☐
Habit								
73	The use of the PCSchool BMS has become a habit for me.	☐	☐	☐	☐	☐	☐	☐
74	I use the PCSchool BMS daily as a classroom tool.	☐	☐	☐	☐	☐	☐	☐
75	I must use the PCSchool BMS.	☐	☐	☐	☐	☐	☐	☐
Behavioral Intention								
76	I intend to continue using the PCSchool BMS in the future.	☐	☐	☐	☐	☐	☐	☐
77	I will always try to use the PCSchool BMS in my daily life.	☐	☐	☐	☐	☐	☐	☐
78	I plan to continue to use the PCSchool BMS frequently.	☐	☐	☐	☐	☐	☐	☐
Use								
Please choose your usage frequency for each of the following:								
79	Look up Students Personal Details	☐	☐	☐	☐	☐	☐	☐
80	To make negative reinforcements against a student	☐	☐	☐	☐	☐	☐	☐
81	To make positive reinforcements against a student	☐	☐	☐	☐	☐	☐	☐
82	To view a student's Timetable	☐	☐	☐	☐	☐	☐	☐
83	To view a student's Classes	☐	☐	☐	☐	☐	☐	☐
84	To view a student's Absences	☐	☐	☐	☐	☐	☐	☐

End of Survey – Thank you for your participation

APPENDIX 10

CONVERGENT INTERVIEWS

Interview Start Process

1. Welcome / Thanks to the interviewee
2. Purpose of the Research
    a. The purpose of this research is twofold. The first purpose is to propose better architectures for education software. The second purpose is to examine how effective this architecture is within a functioning bit of software within a school.
3. Purpose of the Interview
    a. The purpose of this interview is to gain an understanding from you, your perceptions on the role of software and data in the management of Education.
4. Explain the Confidential Nature of the Interview
    a. This interview is confidential. Anything you say is confidential. All responses are coded. No one will be able to identify you from your responses.
5. Sign and Informed Consent Form

Opening Question

1. In this interview, I am seeking your opinion on how the school as a whole works together to achieve the goals and visions of the College. What is the role of data and software in education?

Prompt Questions

1. In terms of how information / communication flows to and from the House Guardians to Teachers and back to House Guardians. How effective is this? Problems you experience?
2. Do you see the use of an IS to facilitate Behavioural Management as important in the overall scheme of pastoral care Management?
3. The results that were found with the surveys on the existing legacy software showed that motivation to use IS software is low, however, they used the software because they felt compelled to use the software. We also found that staff on the legacy IS, that staff were still likely to make negative comments rather than positive comments. What are your feelings on these results?
4. What are your perceptions of the new Mobile Management App?
    a. Is it useable in the classroom?
    b. Has it changed the way that you record behaviours about students?
    c. If you have made more positive comments about a particular student, do you feel that your relationship with that student has improved?
    d. Has it improved communication with Stakeholders?
    e. Do feel that it provides information to you about how well you are conducting behavior management.

APPENDIX 11

PARTICIPANT INFORMATION FOR QUT RESEARCH

Queensland University of Technology Brisbane Australia	**PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT** **– Interview –**

Impacts of PCSchool BMS at Padua College

QUT Ethics Approval Number 1300000611

RESEARCH TEAM

Principal Researcher: Wayne Hellmuth, Doctoral student, (QUT)
Associate Researcher: Professor Glenn Stewart, (QUT)

Description

This project is being undertaken as part of a Doctoral Degree for Wayne Hellmuth.

The purpose of this project is to seek to learn from your experiences with the BMS at Padua College. Insights into your experiences with the BMS will be valuable in highlighting where future educational IT researchers, and others, should be focusing their attention, today and in future. Analysis of negative impacts will provide the basis of strategies for improvements. Positive impacts may be replicated or extended in your own or other agencies.

You are invited to participate in this project because you have either direct or indirect experience with the PCSchool Behaviour Management System (BMS).

Participation

Your participation will involve an audio recorded interview at Padua College or other agreed location that will take approximately 30 minutes of your time. Questions will include questions such as:

1. Please explain why it has been difficult for you to learn how to use the PCSchool BMS.
2. Please talk through what key functionality you see as a problem with the PCSchool BMS.

Your participation in this project is entirely voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT or with Padua College. If you do agree to participate you can withdraw from the project at any time without comment or penalty. Any identifiable information already obtained from you will be destroyed.

Expected benefits

It is expected that this project will directly benefit you. Feedback from the survey will be used to further inform software improvements within the education realm.

To recognise the contribution of participants should they choose to participate, the research team is offering participants (Padua staff only) the chance to win one of twelve gold class movie vouchers. Staff members will receive one entry into the draw for each survey they complete, and for each interview they participate in. A maximum of four entries can be earned. The draw for the Gold Class tickets will be conducted on a Wednesday afternoon staff meeting in June 2014.

Risks

There are no risks beyond normal day-to-day living associated with your participation in this project.

QUT provides for limited free counselling for research participants of QUT projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please contact the Clinic Receptionist of the QUT Psychology Clinic on 3138 0999. Please indicate to the receptionist that you are a research participant.

QUT provides for limited free counselling for research participants of QUT projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please contact the Clinic Receptionist of the QUT Psychology Clinic on 3138 0999. Please indicate to the receptionist that you are a research participant.

PRIVACY AND Confidentiality

All comments and responses will be treated confidentially unless required by law. During the course of the interview, all respondents will have the opportunity to verify their comments and responses prior to final inclusion. Once the audio recording has been transcribed, all audio recordings are destroyed. Please note that non-identifiable data collected in this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

Only the researcher and supervisor will see survey and interview results. Padua and its staff will be able to access the reports from the project, however, all data will be presented in a way that does not identify students or staff individually.

Consent to Participate

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate.

Questions / further information about the project

If have any questions or require further information please contact one of the research team members below.

Professor Glenn Stewart	**Wayne Hellmuth, Doctoral Student**
Science and Engineering Faculty Information Systems, BPM Queensland University of Technology	Science and Engineering Faculty Queensland University of Technology GPO Box 2434, Brisbane 4001
Tel: 3138 9480 (voicemail) Fax: 3138 9390	Mobile: 0488 200 388
E-mail: g.stewart@qut.edu.au	*E-mail: wayne.hellmuth@qut.edu.au*

Concerns / complaints regarding the conduct of the project

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on [+61 7] 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

Queensland University of Technology Brisbane Australia	**CONSENT FORM FOR QUT RESEARCH PROJECT** **– Interview –**

Impacts of PCSchool BMS at Padua College

QUT Ethics Approval Number 1300000611

RESEARCH TEAM CONTACTS

Professor Glenn Stewart
Science and Engineering Faculty Information Systems, BPM
Queensland University of Technology
GPO Box 2434, Brisbane 4001
Tel: 3138 9480 (voicemail) Fax: 3138 9390
E-mail: g.stewart@qut.edu.au

Wayne Hellmuth, Doctoral Student
Science and Engineering Faculty
Queensland University of Technology
GPO Box 2434, Brisbane 4001
Mobile: 0488200388
E-mail: wayne.hellmuth@qut.edu.au

STATEMENT OF CONSENT

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time, without comment or penalty.
- Understand that you can contact the Research Ethics Unit on [+61 7] 3138 5123 or email ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project.
- Have discussed the project with my child and what is required of them if participating. (Only if parental/guardian consent required – see Chapter 4.2 of the National Statement).
- Understand that the project will include an audio recording.
- Understand that non-identifiable data collected in this project may be used as comparative data in future projects.
- Agree to participate in the project.

Please tick the relevant box below:

☐ I agree for the interview to be audio recorded.

Name	Signature	Date

Media Release Promotions

From time to time, we may like to promote our research to the general public through, for example, newspaper articles. Would you be willing to be contacted by QUT Media and Communications for possible inclusion in such stories? By ticking this box, it only means you are choosing to be contacted – you can still decide at the time not to be involved in any promotions.

☐ Yes, you may contact me about inclusion in promotions.

☐ No, I do not wish to be contacted about inclusion in promotions.

Please return this sheet to the investigator.