Educational Technology Management: Infrastructure and Innovation, a case study from a K-12 private School in Australia.

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This dissertation is submitted to Charles Sturt University in partial fulfilment for the degree of Professional Doctorate in Information Technology

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Dedication:

With the most sincere gratitude to:
Principle Supervisor: Dr Lihong Zheng
Industry Supervisor: Dr Andre Van Zyl
Staff of Charles Sturt University

Dedicated to:
My best friend and father who passed away during the years spent working on this professional doctorate. This work is in part due to your gentle advice and quiet support over the years. Each day you are fondly remembered for who you were. God Bless you dad.

My mother and continuing supporter for all matters involving education, family and life in general. Thank you for all your devoted love and patience over so many years. Also thanks go to my older brother, Stephen, for your ongoing friendship and support during these years of research.

Finally to my lovely and supportive wife and daughters. Thank you for all your love and support over the last few years. To my incredible wife... what a journey! To my daughters in particular... your dad is back!
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Abstract

In order to follow an ICT strategic plan, IT management are required to efficiently assign resources, both monetary and people, to tasks and projects. In an education setting, those projects aligned with the ICT strategic plan can encompass capital required for large ICT infrastructure across an entire educational campus and the smaller innovative projects requiring recurrent budget expenses. This research has set out to find the components, which contribute to both capital and recurrent ICT budgets in order to better understand links with teaching and learning and how technology items are used to create greater learning outcomes for students.

Both of these types of projects require a balance of resources in order to efficiently operate a stable and supportive ICT infrastructure and the use of innovative technology and teaching methods used in the classroom. The ultimate goal is the production and support for greater learning outcomes for students. This thesis includes a mixed-methods approach, using a constructivist ontological stance, to understanding the balance required between ICT infrastructure and innovation in education in a case study set in a K-12 private School in Australia.

This balance often plays out a game of tug-of-war on a continuum of control/slack where accountability for efficiently run ICT infrastructure weighs war with the striving efforts of teaching and learning to foster innovation in an educational context. In the majority of cases, innovation uses technology, which in turn, is supported by the efficient use of ICT infrastructure. However, other factors which help to foster the inclusion of innovation in education, warrant understanding from an IT management perspective, in order to provide greater support for teaching and learning. Furthermore, senior leadership in education would benefit from staff feedback, in terms of whether
the intended innovative technology and learning culture is suitable for fostering and sustaining innovation in the classroom and work place.

In addition, when IT management know of the types of elements fostering innovation in the classroom, technology can be purchased and directed to support this endeavour. To this end, a School Innovation Rating was developed to help decision makers understand how the School culture and potential for the intended new technology would be accepted and utilised by staff. It is hoped that this School Innovation Rating will help guide staff who are responsible for managing budgets.

To increase the chance for transferability and confirmability for other readers of the thesis results, a high level of research rigour was utilised during this research.
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Certificate of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Charles Sturt University or any other educational institution, except where due acknowledgment is made in the thesis. Any contribution made to the research by colleagues with whom I have worked at Charles Sturt University or elsewhere during my candidature is fully acknowledged.

I agree that this thesis be accessible for the purpose of study and research in accordance with the normal conditions established by the Executive Director, Division of Library Services or nominee, for the care, loan and reproduction of theses.

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Signature   
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<th>Explanation</th>
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<tbody>
<tr>
<td>ADFS</td>
<td>Active Directory Federated Services</td>
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<tr>
<td>ADP</td>
<td>Accidental Damage Protection</td>
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<tr>
<td>AIO</td>
<td>All-In-One</td>
</tr>
<tr>
<td>BIIR</td>
<td>Balance of Infrastructure and Innovation Rating</td>
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<tr>
<td>CDP</td>
<td>Cisco Discovery Protocol</td>
</tr>
<tr>
<td>CETL</td>
<td>Centre for Excellence in Teaching and Learning</td>
</tr>
<tr>
<td>CNC</td>
<td>Computer Numerical Control</td>
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<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
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<tr>
<td>DP</td>
<td>Data Processing / Data Projector</td>
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<tr>
<td>DPM</td>
<td>Data Protection Management</td>
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<tr>
<td>DR</td>
<td>Disaster Recovery</td>
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<tr>
<td>GB</td>
<td>Gigabyte</td>
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<tr>
<td>HEFCE</td>
<td>Higher Education Funding Council for England</td>
</tr>
<tr>
<td>ICR</td>
<td>Innovation Culture Rating</td>
</tr>
<tr>
<td>ID</td>
<td>Identification</td>
</tr>
<tr>
<td>ILT</td>
<td>Instructor-Led Training</td>
</tr>
<tr>
<td>iOS</td>
<td>Apple Operating System</td>
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<tr>
<td>IRPT</td>
<td>Innovation Rating Potential for Technology</td>
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<tr>
<td>ISP</td>
<td>Internet Service Provider</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>IWB</td>
<td>Interactive White Board</td>
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<td>JISC</td>
<td>Joint Information Systems Committee</td>
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<tr>
<td>KVA</td>
<td>1000 Volt Amps</td>
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<tr>
<td>LTO</td>
<td>Linear Tape-Open</td>
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<tr>
<td>MAC</td>
<td>Media Access Control</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>MACs</td>
<td>Apple Macintosh Computer</td>
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<tr>
<td>MDM</td>
<td>Mobile Device Management</td>
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<tr>
<td>MVLA</td>
<td>Microsoft Volume Licensing Agreement</td>
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<tr>
<td>NBD</td>
<td>Next Business Day</td>
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<td>OM</td>
<td>Optical Mode</td>
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<td>PCI</td>
<td>Peripheral Component Interconnect</td>
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<td>PD</td>
<td>Professional Development</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Design</td>
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<tr>
<td>RU</td>
<td>Rack Unit</td>
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<tr>
<td>SAN</td>
<td>Storage Area Network</td>
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<tr>
<td>SFP</td>
<td>Small Form-Factor</td>
</tr>
<tr>
<td>SOE</td>
<td>Standard Operating Environment</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language</td>
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<tr>
<td>SSO</td>
<td>Single Sign On</td>
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<tr>
<td>TB</td>
<td>Terrabyte</td>
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<tr>
<td>VLAN</td>
<td>Virtual Local Area Network</td>
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<tr>
<td>VM</td>
<td>Virtual Machine</td>
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<tr>
<td>WAP</td>
<td>Wireless Access Point</td>
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Chapter 1. Introduction

1.1 Background

The responsibility of IT management in any organisation is to efficiently assign resources to tasks and projects in order to implement an overall ICT strategic plan. In an educational setting, those projects often involve enabling innovation for classroom teaching and for the support roles of administration staff. IT management needs to predict future growth based on demands for resources. These can take the form of higher internet bandwidth, greater storage capacity and computing power and faster access to data via wired and wireless connections.

The state of the ICT infrastructure can be determined by comparing progress to a timeline for key ICT strategic plan milestones. In addition, the ICT maturity model developed by Richard Nolan from Harvard University (Nolan, 1973), can guide an organisation in adopting and implementing ICT. The implementation of ICT in any organisation is limited by funding and as Noblitt (1997) states, the introduction and continued maintenance of a technology-based curriculum requires responsible planning.
The importance of planning for IT in education (Kong, 2009) and formulating roadmaps for spending on ICT projects in education (Solar, Sabattin and Parada, 2013) cannot be overstated. To provide responsible support for the needs of teaching and learning, adequate funding is required for ICT infrastructure. How to efficiently manage the purchase of ICT in education at an organisational level has been questioned by Berghout, Nijland and Powell (2011). Constant reviewing of funding and the need for scrutinizing investments in ICT and implementation methods which aim to increase learning outcomes for students is essential. In fact, the pedagogical justifications for using ICT by teaching and learning require regular reviewing as mentioned by Lofstrom and Nevegi (2007). There needs to be clearly defined priorities for ICT spending in education and accurate needs assessment will ensure funding is utilized efficiently (Sofiana and Arifin, 2012).

Research (Fabros-Tyler, 2014; Kreijns, Kirschner and Vermeulen, 2013) has indicated the underpinning of a successful teaching and learning process is the continued investment in both ICT and education training. Time has been identified as crucial for teaching and learning staff to learn how to implement ICT in the classroom. Time is needed for teaching staff to tinker with the ICT equipment, for professional development in using the ICT equipment and for the planning of how to integrate ICT into the curriculum (Beggs, 2000; Becta, 2004; Schoepp, 2005; Hadley and Sheingold, 1993; Jacobsen, 1998).

Research is required to investigate a method of feedback for purchasing decision makers. This feedback or potential rating, will allow the purchase of innovative technology and the correct ICT infrastructure needed to support the innovation, while achieving the highest confidence in the staff making full use of the expensive technology.
Sound budget allocations for ICT infrastructure in educational institutes provides several immediate and long-term advantages. These include efficient use of funding, reduction in sub-optimal learning outcomes and reduction in sub-optimal innovation in the classroom and work spaces. This research intends to investigate how efficiencies can be made in these areas by enhancing the ICT infrastructure needed for stable and efficient running of information technology services and the support of innovational equipment and teaching methods in the classroom. If these efficiencies can be extracted, the School would benefit from better use of funding, students would benefit from higher learning outcomes through higher usage of ICT resources and School staff would benefit from improved methods of content delivery and more satisfaction of using innovative technology.

The following sub-sections describes the research motivations.

1.2 Research Motivations

Rogers (2003) speaks of diffusions of innovations and users of innovative practice (Rogers, 1995), however, research documented in the literature review of this thesis could not uncover examples of this in practice for IT Management in education. Though Noblitt (1997) mentions responsible plans for innovation integration in the curriculum, no indepth studies look at feedback systems providing guidance for technology purchases. It is therefore the aim of this research to fill this gap in the literature, in which the case study examines the ICT infrastructure components required to support an educational facility and the sorts of demands for innovative technology teaching and learning request of IT management.
1.2.1 Research Topic

It is importance to implement ICT infrastructure efficiently and clearly design for responsible ICT planning and implementation for capital and recurrent budgets in any educational organisation. The funding pendulum for ICT infrastructure and innovative technology warrants careful attention. If overspending on ICT infrastructure occurs, there will be insufficient funding for innovation in ICT integration in the classroom. Likewise, insufficient spending on ICT infrastructure required to support classroom devices intended for use in innovative classroom teaching, results in wasted opportunities with new 'shiny' devices left in classrooms and not used effectively. Therefore, a balance is required between funding spent on the end-user device and the ICT infrastructure required to support the successful use and implementation of those devices.

1.2.2 Research objective

The research objective has been to investigate how to improve the expenditure on ICT infrastructure, in order to support an environment, which fosters innovation in education.

This has required a mixed methods approach in which an investigation into improving the expenditure on ICT infrastructure required a quantitative analysis of capital and recurrent budget items while seeking no statistical significance. This has involved a single case study using a single School spanning 5 years of budget information. In addition, investigations using qualitative analysis examined the factors required to foster innovation in an educational environment. These kind of approaches provide a clear understanding on how best to balance ICT infrastructure and innovation in education.
An exploration of the literature was undertaken to deepen the understanding of efficient ICT infrastructure implementation and the factors most likely to foster innovation in education. The research questions are open-ended to allow for other factors in this case study research to develop which may have not been present in the reviewed literature. A thematic analysis has been used to identify any emerging themes, which may have not been expected.

The main research question is:

"How can we improve educational innovation through better budget awareness and planning?"

Since ICT infrastructure and innovation are both related to funding, more investigation has been required to understand where the funding was required for ICT infrastructure and what factors, money and otherwise, drive innovation in education.

The sub research questions, listed in section 3.4 and discussed in more detail in section 6.4, have guided further research. Pivotal to understanding the key factors for fostering innovation in education is the rigorous questions relating to funding of ICT, professional development for teaching staff and time provided for staff to tinker with ICT equipment and incorporate ICT into curriculum planning.

1.2.3 Research Hypothesis

Research participants were asked to rate current and future potential innovative technology. The null hypothesis is the rating of old technology by staff is equal to the rating of new technology by staff. In general, this would mean there would not be a justification for spending funding on the new proposed technology.

To show we do not reject the alternative hypothesis, it must be shown the null hypothesis has been rejected. This requires a difference in the mean values of the
ratings, demonstrating the new proposed technology would be considered more innovative to staff if implemented in the educational setting. For this scenario, there would be justification for spending funding on the proposed innovative technology, as staff would consider it worthwhile in promoting and fostering innovation in education.

Therefore, the aim of this research was to prove the alternative hypothesis and demonstrate the proposed new technology and teaching methods would be eagerly supported by staff and therefore provide positive feedback to funding decision makers.

1.2.4 Research Paradigm and Method

The constructivist paradigm (Creswell and Miller, 2000) was used in this research, aiming at building knowledge and seeking understanding of the world in which a phenomenon takes place. In this case, the exploratory research seeks to explore how to efficiently implement an ICT infrastructure, which supports a long term ICT strategic plan to support innovation and creative principles undertaken by teaching and learning in an educational environment. Furthermore, social constructivism makes uses of open-ended questions asked of research participants in order to examine in more detail their participation in a phenomenon, which can only be examined in the context in which it happens. The constructivist paradigm (Creswell and Miller, 2000) works for the qualitative research component as it allows the researcher to fully explore the phenomenon under study. In this case, teaching and non-teaching staff provided different points of view on what technology and teaching methods were considered innovative. In addition, the purposive sampling allowed different opinions on funding, time and training to be collected from varying year levels and departments across the entire School. This provided an exhaustive and thorough examination of viewpoints from staff.
Though the constructivist paradigm (Creswell and Miller, 2000) was used for the quantitative research examination of the ICT infrastructure components, it could also be stated the positivist research paradigm could have been used as there was really only one reality when it came to reviewing these components. Furthermore, this quantitative research component results were deducted from values obtained over the years from 2012 to 2016 and not subjectively inducted from various viewpoints of research participants.

1.2.5 Research case study setting

A case study approach was undertaken in a co-educational K-12 private School in Australia to understand how to balance the funding requirements for an efficient ICT infrastructure, which supports the fostering of innovation in the teaching and learning setting. Research participants in this case study came from 12 School departments and included teaching staff, teaching/management staff and non-teaching staff. Student numbers were approximately 1350 with 150 teaching and support staff.

1.2.6 Researcher’s position

I commenced this professional doctorate at CSU immediately following a Masters in management and information technology also from CSU. It was based on the research work between 2013 to 2017, I developed a curiosity for questioning my own ability to run an efficient IT department. I have been working in the field of IT management for more than 2 decades with vast experience in the practical implementation and maintenance of IT management programs. However, academic study helped to drive questions relating to the improvement in efficiency for planning million dollar budgets for various industries including construction, financial services, engineering and education.
This research was conducted in a School environment in which I was the IT Manager. I have always tried to challenge myself to provide more services and resources for the business I work in and for the staff I share daily work activities.

Therefore, this doctoral journey has been a positive one and has provided great insight into more efficient practices for myself and the School. The distance related study CSU offers in the doctoral programs provided a great opportunity to allow more time for study than previous educational experiences, in which time is wasted during travelling and enforced lectures.

1.2.7 Significance of the research

Given the amount of money spent on ICT infrastructure and ICT related services, the slightest gains made in improvements to overall spending would be welcome. ICT infrastructure sub research question 1 (How can ICT infrastructure expenditure become further optimized?) and sub research question 2 (Is there a justification for ICT infrastructure expenditure?) help to investigate this problem.

With this in mind, highlighting to decision makers the ICT infrastructure components which often require funding for Schools to run efficiently, help to explain why they are needed and how they relate to the end result, which is often the innovative products and services in use by the end users. ICT infrastructure sub-research question 3 (What ICT infrastructure components are considered important for the efficient running of an education environment?) help to investigate this problem.

It is hoped the resulting Innovation Culture Rating (ICR) will guide School leadership in knowing if their proposed ICT strategic plan will improve the use of innovative technology and whether additional support is required to support the key factors, which foster innovation in education. The main sub-research question (Can a
rating be developed which can help educational leadership with fostering innovation?) examines this problem. Furthermore, the IRPT or Innovation Rating Potential for Technology can be used to determine if proposed technology will be accepted and implemented by staff before the purchasing decision has been made. This is investigated by innovation in education sub research question 2 (Do staff rate the potential for new technology and teaching practices higher than older technology and teaching practices in terms of fostering innovation?).

Large amounts of funding can be wasted if the purchasing decisions initiated by senior management, implement technology which is either not supported by inadequate ICT infrastructure or innovative technology is purchased and not fully utilised by staff due to lack of time and training. The innovation in education sub- research question 1 (What factors provide a positive school culture for innovation?) helped to identify how important money time and training are to staff in fostering innovation.

Finally the information researched and gather above will help to answer the main research question (How can we improve educational innovation through better budget awareness and planning?).

1.2.8 Research scope and boundaries

This dissertation was conducted in a case study at one private School in Australia. Due to the limitations of time and resources, a single case study was implemented.

This study does not include a direct focus on what technology is deemed as innovative. Research questions were asked of participants to gain a better understanding of what they thought was considered innovative future technology, with the intention of rating types of technology as a good choice of funding. However, an
exhaustive study was not conducted to determine what technology is considered more innovative.

It also must be noted, different educational facilities may decide to purchase different types of ICT infrastructure depending on budget limitations, geographical location and public/private School decisions. The scope of this case study was defined by the ICT infrastructure and innovative technology present at this School.

The research methodology chosen for this research was mixed-method. A descriptive form of quantitative research was used to investigate the components which made up a typical ICT infrastructure and why funding was directed at certain areas of infrastructure as explained in section 2.1. In turn, how this increase in the maturity of ICT infrastructure, as outlined by the model developed by Richard Nolan in 1973, was utilised to help foster innovation in education. Although this model was not followed in detail, it was used in principle as a guide to linking ICT maturity, with the investment in ICT infrastructure (King and Kramer, 1984) as described in section 2.2.7.

A constructivist ontological stance was established in order to build knowledge and seek an understanding of the world in which ICT infrastructure requirements were balanced against the funding required to foster innovation in education, as described in section 3.2.

The main research question then aims to see how we can improve educational innovation through better budget awareness and planning as described in section 3.4. Several sub questions follow, developing a rating for innovation for School leadership. In addition, key factors which contribute towards an efficiently run IT department and greater innovation fostered in areas of teaching and learning were investigated.
The qualitative research component of the mixed method approach utilised a high level of rigour in order to provide accurate results for the key components fostering innovation in this case study School. These can be found in detail throughout section 3.12.

1.2.9 Research overview

The constructivist paradigm was chosen for this research in order to explore the phenomenon under study in the context in which it occurs. In this case, it was in a private K-12 School in Australia. In addition, the social constructivist paradigm was used to gather a better understanding of how research participants viewed key factors thought to foster innovation in education and how innovative technology could be used to collaborate between students and teaching staff.

The major reason for the pursuit of the professional doctorate was my passion for efficiently running an IT department and acquiring technology and other resources to benefit both teaching staff in their endeavour to increase learning outcomes for students and the non-teaching staff in their support role for the School.

1.3 Thesis contributions

This research has contributed to theory by introducing an Innovation Culture Rating as a way for educational leadership to gauge the likelihood of efficient use of innovative technology and teaching methods. By combining the culture for innovation, as indicated by staff and the staff perception for the potential of new technology, the rating provides a prophetic view of success before a commitment to purchasing technology.

The purpose however, for the metrics of ICR, BIIR and SIRP or "proposed measures" are to aid in the contribution to the body of knowledge by offering an alternative for decision makers in how they manage budgets in the area of ICT infrastructure and
support required for innovation in educational institutes. These proposed measures were created to support a feedback system where money spent on innovative practices could be rated by those users of the technology and practices before they are purchased and implemented, hopefully reducing wastage and non-use of the equipment. It must be noted however, these proposed measures are not measures as this would imply they have been fully established as valid measures.

This research has confirmed previous research for the ICT maturity model (Nolan, 1973) in understanding if an educational organisation is in a state of equilibrium in terms of the ICT infrastructure used to support technology used by staff. In addition, the research highlights the typical ICT infrastructure components required to support teaching and learning outcomes. The research also confirms the key factors thought to foster innovation in education; these being funding, time and training. Research was undertaken to see if staff believed funding for technology and funding for additional release time was adequate. Again, staff were investigated and asked if sufficient time was provided for training with the innovative technology provided to them and whether sufficient professional development was afforded to them in how best to use the innovative technology.

This research also contributes a case study research in which various forms of rigour was used to increase the trustworthiness of the research. These include member checking interview data, direct observations, within method and across method triangulation, methodological triangulation, peer debriefing, audit trails, thick descriptions, negative case analysis, researcher bias, reflexivity journals and prolonged engagement.
1.4 Structure of the dissertation

The dissertation consists of seven chapters. The following paragraphs contains a brief summary of my dissertation.

Chapter 1: Introduction

This chapter is the introductory chapter, which explains the research objectives, research questions and hypothesis that guides the case study research undertaken. An explanation was provided for the case study setting, the position of the researcher and the significance of the research. This was followed by an explanation of the sample study population, the scope and limitation of the research and finally concludes with an overview of the research.

Chapter 2: Literature Review

Chapter 2 identifies many of the concepts found in the literature. This starts with a definition of innovation and responsible innovation implementation. The chapter continues with a description of the ICT maturity model and links the ICT maturity model to the investment in ICT infrastructure. This chapter explains the key factors for fostering innovation in education, which includes professional development, the time required for innovative teaching and the funding required for innovation. The chapter finishes with literature explaining how to balance control and slack or balancing ICT infrastructure with innovation in education, how ICT is a benefit to education and ICT infrastructure's place in implementing ICT in education.

Chapter 3: Research Methodology

Chapter 3 starts with an explanation of the research design and choice of methodology. An explanation was provided of the research paradigms relevant to questions and the
researcher lens used in the research process. All of the research questions are defined in this chapter. Chapter 3 continues with an explanation of the quantitative research approach, including the hypothesis and use of R for windows software. This is followed by an explanation of the qualitative research approach including case study research, confirmability, transferability, interviews and the tools used for conducting interviews, the environment for interviews, an example transcription and thematic analysis. Mixed methods research was explained, followed by research sample size, data collection, data analysis and methods of demonstrating rigour in the research. The chapter finishes with an explanation of ethical considerations.

Chapter 4: Data Analysis – Quantitative

Chapter 4 explains the data analysis using quantitative methods. This starts with an explanation of the background and demand for ICT infrastructure. These demands include internet services, print and copy services, wireless services, storage, backup and DR services, virtual machines and helpdesk support. The chapter continues with the data collection and analysis including ICT infrastructure components and budget items, both capital and recurrent. A question relating to the testing of the hypothesis was explained. All of the hypothesis sub questions and the results from the R for windows software was provided. The chapter finishes with a summary of the quantitative data analysis.

Chapter 5: Data Analysis – Qualitative

Chapter 5 explains the data analysis using qualitative methods. Interview details were explained, including schedule dates and times, duration and transcribed word count. The thematic analysis shows the number of issues raised throughout the interviews and several other questions relating to innovation. The importance of innovation to staff and technology requested by staff were investigated. Main questions relating to the key
factors fostering innovation in education were explored. These include money, time and training. The concept of the Balance of Infrastructure and Innovation Rating (BIIR), Innovation Rating Potential for Technology (IRPT) and School innovation rating (SIR) were explained.

**Chapter 6: Results and Discussion**

Chapter 6 combines the findings into the results and discussion chapter. Explanations for the demands for services were given in the quantitative research section. ICT infrastructure capital and recurrent budget items were discussed. Hypothesis testing for innovation in education was explained. The qualitative research process was discussed including rigour throughout the research and this includes a summary of the results from several of the questions. Key factors for fostering innovation in education, the School innovation rating and direct observations were presented. Finally a summary of the research question findings is provided.

The majority of research participants agreed that additional money, time and training were key factors for fostering innovation in education. These are shown respectively in Figure 5.2.12.1, Figure 5.2.12.2 and Figure 5.2.12.3. 88 percent of participants claim they are not satisfied with the level of money for innovation. 86.4% claiming they are not satisfied with time provided for innovation to flourish and 74.7% claiming they are not satisfied with the amount of training for learning about new innovative technologies and teaching methods.

Additional information regarding these results can be found in chapter 5.

**Chapter 7: Conclusion**

Chapter 7 includes a critique of the research, the significance and implications are addresses and directions for future research are proposed.
1.5 Publications


1.6 Chapter Summary

This chapter laid the foundation for the research by introducing the responsible planning needed for ICT infrastructure in education and the importance of supporting innovation for teaching and learning. Research motivations, objectives, questions and a description of the case study settings have been explained. The methodological underpinnings for the research have been explained with the use of a constructivist paradigm and a mixed methods methodology followed. The researcher's stance, significance of the research, the study population and research limitations have been discussed. A brief breakdown of the dissertation chapters have been provided. Finally, contributions to educational management practice have been discussed.

In the next chapter, the literature review is discussed.
Chapter 2. Literature Review

2.1 Research of ICT Infrastructure and Innovation in Education

The aim of the ICT infrastructure research (ICT infrastructure sub-research question 3) is to highlight the typical components which make up ICT infrastructure and in this case study, reveal the decisions made to increase the maturity of the ICT implemented in an educational organisation. Historical data is used to demonstrate why funding was directed towards particular areas of ICT infrastructure and how those choices help cater for the needs of teaching and learning in fostering innovation in education. As Gil-Flores, Rodriguez-Santero and Torres-Gordillo (2017) states, these are factors at the school level. In addition there are other factors from the teacher's perspective which help to foster innovation in education which Gil-Flores et al (2017) explains, are at the teacher level. Research was conducted from this perspective to obtain those factors most likely to help foster innovation in education.

2.1.1 Definition of Innovation

Rogers (1995) defined an innovation as an idea, practice or object that is perceived by the individual, and diffusion as the process by which an innovation makes its way through a social system. Rogers (1995) stated that innovation is not something adopted
instantly, but over time consisting of a series of actions and decisions. Dytham and Rowell (2015) indicate innovation is looking at ways to work with new groups of people and providing a student voice as opposed to the traditional motivation for researchers in seeking increased funding opportunities and advancing a specific field of knowledge. Innovation is said to be the successful exploitation of new creativity (Gurteen, 1998; Leonard and Swap, 1999; O'Sullivan and Dooley, 2009). Research has derived creativity as the key element for the development of innovation (Chiesa, 2001; O'Sullivan and Dooley, 2009).

Rogers (1995) listed 5 characteristics of innovation. *Relative Advantage* describes the degree to which the innovation is better than the former process. *Compatibility* is the degree to which the innovation is consistent with existing values, experiences and requirements of the adopter. *Complexity* is the degree to which the innovation is easy to use and understand. *Trial ability* is whether the innovation may be experimented with on a limited basis. *Observability* is the degree to which innovation results can be seen by others.

Rogers (2003) developed a theory called diffusion of innovations which describes how new ideas and techniques follow a strict sequence of adopters from innovators, though early adopters, early and late majority and laggards as described by Shaw (2013). Potential users of innovative practice are rarely convinced their attempt at innovation is superior to current alternative methods in place (Rogers, 1995).

### 2.1.2 Responsible Innovation Implementation

Noblitt (1997) mentioned those who propose a wide-scale adoption of a technology-based curriculum will need to find a way to combine innovation with a responsible plan for implementation. Rogers (1995) defined the innovation-decision period as the length of time required to pass through the innovation-decision process. Rogers (1995)
explained the rate of awareness-knowledge for an innovation is quicker than its rate of adoption.

Gilbert and Green (1997) suggests encouraging early adopters in a faculty as peer mentors to increase availability of support services while holding down costs. Wilson (1998) reveals early adopters of technology need to be respectful of faculty who are slow to change and yet eager to learn.

Smith (1996) mentions the use of an interactive technology integration process. This is key to reviewing the effectiveness of technology in teaching and learning. Becker, Ravitz and Wong (1999) describes the importance of the investment made in terms of resources allocated to the internet usage for teaching staff and the measurement of that investment in terms of funding and in units of time.

### 2.2 ICT Maturity Model introduction

The goal for all involved in education is increasing learning outcomes. The ICT Maturity model presents a way to define the ICT infrastructure resource levels required to achieve primary organisational objectives aimed at meeting and exceeding the learning outcomes for students. Education institution managers, teachers and senior academics in developing countries lack ICT planning and infrastructure implementation knowledge. Guidance on this could help make better use of scarce resources, develop in-house skills and cope with rapid technological change by focusing on key organizational objectives. An ICT Maturity Model could provide guidance for achieving these objectives.
2.3 ICT Maturity Model stages

Adopted from Kuznets (1965) was the identification of distinct and empirically verifiable characteristics of change, and detailed specification of the characteristics of succession whereby one stage moves to the next.

The experiences of these firms formed the basis of a "stage theory" of computing growth intended to meet two conditions adopted from Kuznets (1965): identification of distinct and empirically verifiable characteristics of change, and detailed specification of the characteristics of succession whereby one stage moves to the next.

Richard Nolan from Harvard University (Nolan, 1973) hypothesised the adoption of clearly articulated developmental stages by organisations in the adoption of ICT. His initial 4 stages are shown below.

2.3.1 Stage I: Initiation (computer acquisition)

Introduction of computing into the organization to meet basic needs; slow growth in use; beginning of problems caused by computing's role as a "change agent": little management response to these problems; decentralized control; minimal planning. In this stage, few applications are installed, control is lax and planning is almost non-existent. Several low level operational systems in a functional area, typically accounting, are automated.

2.3.2 Stage 2: Contagion (intense system development)

The organization encourages innovation and extensive application of DP technology by maintaining low control and high slack. Development is encouraged (i.e., greater slack), but lack of planning results in systems of poor design quality. Rapid growth in computing use due to top management commitment to exploiting computing potential
plus high expectations among users; rapid rise in costs; top management search for
controls to contain cost growth; beginning of centralization; little increase in planning.

2.3.3 Stage 3: Contagion Control (proliferation of controls)

Stage 3 usually follows a crisis of out-of-control computing expenditure and poorly
planned and executed automation projects. Characterized by rebuilding and
professionalizing the DP activity to give it more standing in the organization. The
services that are provided at this level of maturity include equipment repair and fault-
finding, ensuring data integrity and security procedures such as the implementation of
anti-virus software. The model also encourages the use of technicians to provide user
support and in-service staff development training. Also involves preparation of
multimedia learning resources and use of computers for simulations and experiments
using CD-ROM and DVD-based resources. Cost control measures instituted by top
management; planning now a major priority; computing function centralized; DP
manager's position raised in the organizational hierarchy; priority setting mandatory;
standards established for programming, documentation, and operations; charge out
systems adopted to impose market-like constraints on use; controls often proving to be
too stringent, resulting in failure to exploit the potential of computing or meet user
expectations. Problems from bad design and rising costs create difficulties for users
and management, so control becomes tighter. Users almost give up on getting what
they want, but with the advent of data communications and user terminals they relax
and become tolerant of rising costs they pay through the charge out system. Top
management begins to rethink the management of computing in terms of data resources
rather than computer resources.
2.3.4 Stage 4: Integration (user/service orientation)

Stage 4 involves reassessing the role of computing resources in the achievement of organisational goals. Costs continue to rise rapidly as computing use increases. Database systems are brought in which helps the move toward data resource management. Organisations have both a helpdesk technician service and high-speed Internet access. The Internet access enables classroom teaching of Internet browsing, use of online email services and the use of search engines. In this stage, controls are refined to allow exploitation of computing without runaway costs; planning well established; users more knowledgeable and capable in their uses of computing; operations more rational; economic analyses. An example would be cost benefit analysis used to set priorities for new systems; charge out systems modified to ease restriction on use; system analysts sometimes decentralized to user departments to encourage improved systems development; centralization/decentralization decisions made in light of organizational and business strategy; growth slowing markedly, but new investments bringing greater marginal benefits. Eventually the computer utility and network reach a point where high quality services are being reliably provided to users.

2.3.5 Stage 5: Data Administration management

In a subsequent paper, Nolan (1979) adds two further stages of maturity. Stage 5, Data Administration management, focuses on information flows, storage and management. Focus of computing management turns completely to Data Administration, in which control of computing resources is tight, but slack is maintained in development of systems that bring high, value adding advantages. Technology mediated learning of subject specific critical thinking skills.
2.3.6 Stage 6: Maturity computing resources

Stage 6 precisely mirrors the information flows within the organisation. Maturity, is achieved when the applications portfolio is "complete" (how completion is recognized is not specified), and its "structure 'mirrors' the organization and the information flows in the company". The applications portfolio is completed, and its structure "mirrors" the organization and information flows in the company. Infrastructure required to mainstream e-research and the teaching of advanced (up to postgraduate) critical thinking and reasoning skills.

2.3.7 Linking ICT Maturity Model to investment in ICT Infrastructure

Therefore, the Maturity Model links stages of organisation's ICT development to the potential student learning outcomes. The objective of creating new student learning outcome opportunities becomes the major driver for targeted investment to move from one developmental stage to another. The aim is to link ICT infrastructure investment to primary organisational objectives, expressed in the form of student learning outcomes. I would argue that you cannot completely decouple budgets from being the major driving force propelling organisations through ICT development stages as Bass (2011) states due to the initial and ongoing ICT infrastructure investment.

Bass (2011) sees the Maturity Model as advocating helpdesk technician provision before purchase of broadband Internet connection. This is because technical support can improve the chances of sustainable use of the servers and network infrastructure associated with the higher-speed Internet service. Otherwise, computers are broken, not in use or possibly infected with viruses. Teaching staff typically do not have the skills or resources to repair broken machines.
However, the model can be used to argue that automation of manual processes can only be undertaken when a sustainable support infrastructure is in place. Bass (2011) states, anecdotal evidence of major data loss incidents, for example resulting from virus infections, suggests that reliance on computers for storage of mission-critical data without a support infrastructure would be premature. Again, this highlights the importance of correctly funded ICT infrastructure.

As Bass (2011) mentions, no surveyed institutions demonstrated any institution-wide effort to support the use of ICT for teaching and learning; and restricted these institutions to Level 5, at best. Some faculties are supporting staff members who use technology to support higher learning (Level 5) and yet some departments are still only teaching students generic computer use skills, not linked to any subject-specific pedagogy (Level 2).

The Maturity Model has been designed to discourage some poor practice, for example installing high-speed Internet infrastructure without a proper support environment, or under using installed infrastructure by not linking technology use to subject-specific pedagogy (Bass, 2011).

Bass (2011) notes the Maturity Model does not currently pay sufficient attention to learning support technologies such as e-libraries and e-learning software applications, online social networking and cloud-based applications and services.

King and Kramer (1984) do not believe that one variable, being the change in budgets, can measure important variables such as managerial strategies for growth of computing and the organisations learning curve when dealing with computing. It must be noted that this does not mean Nolan’s hypothesis is useless, however, it does reduce its generalizability. However, the research in this case study identifies the importance
of sufficient funding for both the ICT infrastructure and the factors which help foster innovation in education.

King and Kramer (1984) state the model holds that technological change is the primary driving force behind the growth of computing through the stages. I would add technology changes has meant a more affordable and efficient means for data storage, processing power, ease of DR and recovery of files and folders (hyper-converged solution). However, the introduction of iPads are more in line with new shiny devices than technology that has proven to engage students and increase learning outcomes. This case study reveals teaching and learning decision makers initially want the device for its mobility and large apps database, then leaving teaching staff with no training and the result is devices left uncharged, no additional apps installed and basically unused, which is a significant waste of money.

King and Kramer (1984) identify internal and external knowledge is assumed in the model to possess the power to lead effective and efficient control over the computing resources. How certain policies lead to ICT maturity through integration and data administration is not explained by Nolan. However, training and better computing knowledge can help to make an organisation run more effectively. How though needs to be thought through and planned by each individual organisation with differing needs.

In an effort to improve its recognition of what policies are appropriate, the organization evolves toward a state of improved planning. This means an intensified effort to anticipate the future and develop appropriate controls for the present to improve chances of future satisfaction (King and Kramer, 1984). Forward planning of ICT Infrastructure expenses to create a sustainable model for funding is required. This forward planning needs to occur over several future years, taking into account the
The most noticeable benefit from the Nolan ICT maturity model is the interplay between freedom (innovation) and constraint (efficient use of ICT resources) that produces periodic states of equilibrium.

The School in this case study was seen as existing between level 4 and level 6 in terms of the ICT maturity. There could be years where the ICT maturity model for the School could be at level 6, however, other years it could be seen as needing improvement and exist at level 4 or level 5. Teaching and learning are constantly reviewing integration and data management and therefore level 6 is no longer where the ICT maturity level exists. The constant role of IT Management is to refine and improve the ICT maturity in order to keep pace with the ideas of the teaching and learning team.

### 2.3.8 Modern ICT Maturity models and frameworks

Several models and frameworks have been developed in recent years to extend and improve upon the initial work undertaken by Richard Nolan and others. These include the CMMI institute, the ISCAC association and the ITIL framework.

CMMI is the Capability Maturity Model Integration which uses a set of best practices to help organisations to improve their performance and critical business processes. Several journals have highlighted the use of CMMI in improving technology and business processes. A guide to how to support users of CMMI-DEV in software engineering to develop interactive systems has been developed (Goncalves, Oliveira
& Kolski, 2017). Studies have been undertaken in assisting the successful implementation of sponsored CMMI-based SPI initiatives in SMEs (Iqbal, et al., 2015). There is a great need to establish best practice in software development using Agile/Scrum methods, CMMI and Six Sigma processes and to benchmark best practice projects and identify the characteristics of these projects (Pai, Subramanian & Pendharkar 2015). CMMI has recently produced a CMMI Cybermaturity Platform to help improve cybersecurity resilience (Maleh, Zaydi, Sahid, & Ezzati, 2018).

ISACA is the Information Systems Audit and Control Association. In March 2016, ISACA acquired CMMI which advances best practices in people, process and technology. If a person was sceptical of the CMMI acquisition and previous ITIL marketed products, suggestions would indicate these were only successful due to the organisations which found they could market tools to customers rather than for the benefits of the efficiency processes they endorse. The hope though for all IT professionals is for organisations to increase their efficiency for use of technology through the improved capability maturity metrics.

ITIL is the Information Technology Infrastructure Library which includes five core libraries of practices for IT service management. These aim to focus and guide IT services to align with needs of business.

2.4 ICT Infrastructure

Infrastructure refers to the capital budget listed items needed to allow for innovation to take place. If sufficient ICT infrastructure has been established, innovation can be supported, which can include the use of infrastructure such as better interaction with data projectors, end user devices supported with sufficient bandwidth, efficient use of cables and adaptors for connecting with peripherals as examples. Training and professional development help with the efficient use of the ICT infrastructure.
2.4.1 IT cost management

As questioned by Berghout, Nijland and Powell (2011), at an organizational level, can the costs and benefits of management of IT be organized more efficiently? Constantly revisiting any investment in IT is required to scrutinize whether the outcomes have produced the anticipated benefits and costs. Effective budget control requires constant reviewing and the encouragement of competition between suppliers. School-based planning for IT in education is considered crucial for schools in order to improve the quality of education for the 21st century (Kong, 2009). The provision of school IT infrastructure is important for the overall success of teaching and learning. It has been suggested, that planned roadmaps can be used to formulate technology projects and to base budgetary requests tailored to individual schools (Solar, Sabattin and Parada, 2013). Given the lack of adequate ICT infrastructure to support teaching and learning, IT departments will need to find innovative ways to overcome these challenges (Parathnandh, Sing, Laloo, Pillay and Nadesanreddy, 2014). It could be argued, that without sufficient roadmaps and IT planning in schools, budgets will not be allocated sufficiently for creating adequate ICT infrastructure for successfully supporting the needs of teaching and learning.

2.4.2 General ICT Management (Framing ICT)

Many of the traditional assumptions for general ICT management in schools comes from a linear Newtonian model of ICT implementation (Ng, 2010). However, when considering the increased involvement of innovations in education that are demanded of recent ICT infrastructure implementations, the inadequacies of the Newtonian model can no longer be tolerated. A gap in the literature exists for the ICT infrastructure because in the past research has been conducted from a teaching and learning perspective and little has been investigated from the perspective of ICT management.
There are some key areas that need to be considered and should be addressed with regard to enhancing ICT management in schools (Kearns and Sabherwal, 2006). These areas include ICT planning, ICT training, IT budget constraints, ICT support, ICT infrastructure and ICT security.

2.4.2.1 Planning

Pedagogical justifications and implications for using ICT in teaching and learning needs to be revisited regularly (Lofstrom and Nevegi, 2007). In fact, annual ICT planning should allow reflection and feedback on ICT strategic plan progress. ICT Strategic plans should include plans that cover warranty periods and beyond, with the expectation that plans beyond 3 years becomes clouded, with future possibilities less certain. However, this should be a fluid document with plans that are revisited regularly, as ICT tools and classroom teaching environments change.

2.4.2.2 Training

ICT training is one of several indicators that have not been sufficiently provided to school management for solid decision making with respect to ICT management (Morgado and Schmidt, 2012). Vital to the success of the teaching and learning process is a continued investment in ICT and educational training (Fabros-Tyler, 2014). Rohaini (2015) recognizes that formal training is important for knowledge sharing while Kreijns, Kirschner and Vermeulen (2013) mentions that one of the variables that influence teachers likelihood to engage in ICT is computer training. Therefore, each staff member should undertake a personal learning plan endorsed and encouraged by the educational facility. This should be mapped to the school vision and to the needs of teaching staff.
2.4.2.3 Budgets

The inefficient use of ICT budget for schools is the result of budget allocation not being based on accurate need assessment or clearly defined priorities (Sofiana and Arifin, 2012).

2.4.2.4 IT Support

Kreijns, Kirschner and Vermeulen (2013) mention that one of the factors that influence teachers likelihood to engage in ICT is ICT support and their technical ability. In addition, senior school management need to understand the limitations and technical support abilities of ICT staff. Resources and time should be sufficiently allocated for implementation of ICT solutions.

2.4.2.5 Infrastructure

It makes little sense to invest in rapidly aging ICT infrastructure and facilities if there is no human capacity to make use of those investments (Muhoza et al., 2014). School leadership needs to recognize the essentials for improvement of ICT infrastructure and the human resources required to maintain and upgrade these services. It must also be noted, infrastructure can sometimes be described in terms of classrooms, dormitories, laboratories and toilets, since in some countries, basic structural infrastructure components are missing (Barasa, 2014).

2.4.2.6 Security

Due to IT not being agile enough for servicing customers or users, those users may following the path of least resistance without IT involvement, which places an institution or individual data at risk! This is referred to as Shadow IT.
In this school many of the above areas are not considered important and are often neglected which detracts from the ability of ICT infrastructure to enhance innovation. Therefore, it can be proposed that the above categories could possibly form a comprehensive checklist and be regarded as essential elements in the enhancement of ICT management. As (Bocconi, Kampylis and& Punie, (2013) claim, equipping students and teachers with devices are not enough to encourage innovation in education. Hence, it is proposed, the purchase and deployment of ICT devices should take into account planning, suitability, pedagogy, budget constraints, efficient use of resources, encouragement of personalized learning and effective use of data.

2.4.3 Data Management

Data management systems help to improve the decision making process for management staff (Blau and Presser, 2013). School principals can make use of the school data management systems to improve learning outcomes, behaviour management index information, curriculum and other pedagogical data (Blau and Presser, 2013). Sadly, this can be wasted if school leadership ignores the advantages provided by data management and the treasure of information that the process can extract when correctly used. Advanced administration systems can make use of data management systems if the necessary finances are allocated for equipment acquisition, maintenance and upgrading (Prokopiadou, 2012). The improved data communication between teaching staff and parents help to strengthen parent and student involvement and can significantly contribute to the entire school culture (Blau and Presser, 2013). As Tolley and Shulruf (2009) mention, schools across the world collect data, yet few of them effectively utilize this data to improve the quality of the education delivered. After data is collected, it needs to be understood by staff, transformed into useful information and used effectively in the first step towards creating knowledge.
2.4.4 Big Data Analytics

Data is collected about processes and activities that have not been captured before. This is called datafication and refers to the idea that almost anything can be quantified. Since data storage and processing power is cheap, data is collected about everything, just in case it is needed later.

It is the ability to manage data well and extract value from the data, which is critical to any business moving forward (Khatri, 2016). This involves creating a culture of data-driven decision making and providing all employees with the data they need to perform their jobs well. Most employees need small data, however, the data needs to be easy to use and provides them with information they can understand.

It is also important to recognize and embrace data disparity. Not all data will be located in the same place, especially with the embracing of cloud and big data architectures. Businesses need the ability to bring data together from many disparate sources with the intention to tell a story or solve a business problem. This will require information technology departments embracing big data and designing for it.

2.4.5 Knowledge Management

Knowledge management can mean different things to different organizations. For schools it can mean a way of providing constructive feedback in relation to a teachers’ professional practice (Bain and Swan, 2011). Alternatively, knowledge management can involve knowledge learning, knowledge distribution and transformation (Jindal and Tyagi, 2014). Both of these can be used to enhance the professional experience for teachers and support staff in schools. Self-reflection is very important for facilitating improvement for teaching and non-teaching staff in schools. However, the use of knowledge management in terms of professional development for staff within schools
should be a fundamental requirement. An ICT infrastructure enabled platform can provide knowledge acquisition, storage, support for collaboration between stakeholders and fostered real time, integrated systems (Bhusry and Ranjan, 2012). To effectively deploy knowledge management in schools, technology and ICT infrastructure are required (Awang et al., 2011). It is technology, which provides the ability to store, share and transfer information and knowledge. If the correct culture is developed in schools, successful knowledge generating activities can occur. However, barriers to successful knowledge management include time constraints, workloads, weak collaboration and under financed ICT infrastructure.

2.4.6 Obstructive ICT Behaviour

ICT departments answer requests from teaching and learning to facilitate web filtering as part of the school’s duty of care to minors. However, very restrictive web filtering can frustrate students’ online search for information and leave them feeling disengaged. In addition, the schools’ responsibility as digital educators, is diminished and the ‘information poor’ are left impoverished (Hope, 2013). Part of the process of educating middle and senior school students is increasing their own responsibility for making wise decisions with regard to acceptable content research. Compromises need to be made between what is clearly content that is not suitable for under 18 year old students and what allows students under the age of 18 to search for innovative and creative content for the various subjects and projects they encounter throughout their schooling years. The management and continued maintenance of firewalls and the manual overrides for content blocking usually fall into the job responsibilities of ICT department staff. Often the configuration and application of overrides are too complex for teaching staff and therefore require a qualified ICT professional to administer.
However, blame is often associated with the filtering process and teaching and learning view this as obstructive behaviour.

### 2.5 Innovation in Education

To provide ICT infrastructure that supports innovation and creativity in education, IT management need to obtain knowledge of those areas of teaching and learning that can benefit from the use of technology. Innovation is a dynamic and unpredictable social process and an intentional activity, which aims to benefit the innovators and occurs in a specific political, sociocultural, economic, technological and organizational context (Bocconi et al., 2013). It is therefore important to clearly define the specific characteristics and implications of innovation for learning using ICT (Bocconi et al., 2013). In the following paragraphs, some of the main areas, with regard to teaching and learning and IT management are included. It is argued, that for ‘authentic’ collaboration to be achieved between ICT management and ‘teaching and learning’ these essential areas need to be considered. These are factors affecting the ICT infrastructure role in educational innovation.

#### 2.5.1 Financial commitment

Those in management responsible for the purchase of ICT for education, could also claim to add financial commitment to this list as well. Studies by Eren and Kurt (2011) found that ICT training for principals positively influenced their technological leadership behaviour. Vital to the success of the teaching and learning process is a welcoming attitude and positive acceptance of information technology's growing role in education and this also includes a continued investment in IT and educational training (Fabros-Tyler, 2014). Sufficient data collection is required to support decision makers in adopting the best models for improving teaching and learning outcomes.
(Morgado and Schmidt, 2012). This should also include estimates of ICT investments, training required, supervision practices, supplier relationships and negotiations. Often School leadership does not have sufficient indicators for solid decision making with respect to ICT management (Morgado and Schmidt, 2012).

It can also be argued, that the ICT infrastructure needs to be built first, before innovative technology in education can be realised. This will often take the form of servers for processing applications, SAN (Storage Area Network) and NAS (Network Attached Storage) for storage mechanisms, network switches, fibre and copper Ethernet cabling for interconnecting buildings across campus, wireless access points for delivering the promise of device mobility and eventually the delivery of edge devices such as wireless interactive data projectors, tablet devices, AIO (All-in-one) desktops and other innovative new technologies.

2.5.2 Personal Entrepreneurship

Personal entrepreneurship is considered as the cornerstone for stimulating the innovative use of ICT in education. Teachers, who exercise personal entrepreneurship experiment with ICT applications, research how to use ICT in their classrooms and reflect on their achievements and shared ideas with colleagues. Educational facilities should endeavour to create environments that encourage personal entrepreneurship (Drent and Meelissen, 2008). Supportive conditions for personal entrepreneurship include collaborative and cooperative teacher communities, opportunities for self-reflection for teachers and time for the creation of settings to experiment with innovative technology. These are all considered teacher level factors.
2.5.3 Teachers becoming Action Researchers

While the teaching level factors are important, more attention should be given to school level factors. The school level factors include parent and community support, accessibility to the ICT infrastructure, availability of time to devoted towards ICT experimentation (Laurillard, 2008), the availability of experienced ICT support staff and ICT training for teaching staff. Great pedagogy achieves great learning outcomes and the key activities in the learning process include listening, reading, articulating, practicing, experimenting, exploring, producing and reflecting. Teachers become action researchers in order to identify the problems encountered in education and find the best technological solution (Laurillard, 2008). However, it is very easy to make the mistake of attempting to fit a form of technology, which may be a great solution for a specific problem, to a problem that education does not have (Laurillard, 2008). This effectively purchases technology for the sake of buying the latest product, when that product does not provide the ideal solution for the educational problem that teachers have encountered.

2.5.4 Life-long learning

Lifelong learning ensures that students leaving school can contribute towards value-added industries, which are capable of producing high-tech and knowledge-intensive products (Lim, 2007). Students need to acquire the skills to seek new information, to think critically, and to show initiative in order to meet the challenges of our modern, fast-changing world. The best way to support this process is to make effective use of ICT in schools. Furthermore, the principal's role is critical in the successful integration of ICT in schools (Wijesekera, 2008). The right combination of ICT usage and pedagogical strategies aid students in higher-order thinking. ICT usage can help to
develop students who are creative, versatile and open in their perspectives. These will be the students of the future, who think laterally and achieve lifelong learning.

2.5.5 Ability-driven education

An ability-driven education aims to develop and encourage the abilities and potential of every student (Lim, 2007). This type of education requires a reduction in the curriculum content, reduction in the reliance on high-stakes assessment systems, the integration of multidisciplinary ICT programs and the inclusion of alternative pathways.

2.5.6 Individual learning styles

If an education facility chooses to engage in the use of an LMS (Learning Management System), it can become very difficult to assess how students behave and learn in a course compared with the traditional face-to-face classroom activities (Graf and Liu, 2009). If teachers and students are aware of individual learning styles, the chance to enhance teaching and learning outcomes for students increases, through better support of the identified individual learning styles. It is therefore extremely important for the ICT infrastructure to support easy and fast access to the educational LMS, so teachers and students can engage in course contents that cater for the individual needs of students. It must also be stated, that the tools encompassing an LMS can only reach their full potential, if teachers are provided adequate ICT training in the new technologies (Georgouli, Skalkidis and Guerreiro, 2008). Ferdig (2006) mentions that those ICT technologies implemented in teaching and learning must be pedagogically sound. Those ICT tools, purchased for educational purposes, need to be driven by the need to improve pedagogy in schools.
There is a reciprocal relationship between innovation and education where education can foster innovation and innovation is needed to improve education (Bocconi et al., 2013). Framing ICT-enabled innovation for learning raises the question of 1:1 Computing, versus 1:1 learning (Bocconi et al., 2013). It can be argued that with less than a 1:1 ratio of devices to students, problem solving becomes more difficult and inquiry is practically impossible, since access to search engines and the internet in general, is not available to them. Furthermore, the students cannot take advantage of technologies such as social media, blogging, forums, LMS usage and other individual web based products (Bocconi et al., 2013). Alternatively, when students share a device between them, communication and collaboration are being encouraged and they are able to retrieve information together (Bocconi et al., 2013). Moreover, there should be no doubt that simply equipping students and teachers with devices is not enough to encourage innovation in education and may not always constitute best practice (Bocconi et al., 2013).

2.5.7 Supportive School Leadership

Research has indicated there is a link between teacher’s perception of supportive school leadership and their perceptions of beneficial technology use (Perrotta, 2013). Teaching staff will not feel encouraged to explore, experiment and test technology in the classroom, if either the technology is outdated or insufficient time is provided for research and design in the classroom. Implementing the latest technology increases pressure on ICT budgets and requires real commitment to ICT infrastructure by school principals and boards.

Additionally, it has been found, unless School leaders acquire technology knowledge and skills and use this technology whenever possible for their own duties, they cannot perform effectively as technology leaders in the school (Ng, 2010). Those
principals with a tendency to perform technology leadership practices and a school culture which experiences team learning, can heavily influence the level of ICT integration processes in Schools (Anderson and Dexter, 2005). (Banoglu, Vinderlinde and Cetin, 2016) noted Turkish principals with a higher usage of internet technologies, displayed a higher level of technology leadership.

2.5.8 Integration of ICT

The integration of ICT with modern teaching methods in classrooms can be a very effective pedagogical tool, even for general usage of ICT (Shabnam and Nokhbezare, 2013). In fact, when technology is permitted to work alongside modern teaching methods and does not replace them, it becomes a new style of pedagogy (Crandall, Lim and Ro, 2010). ICT is becoming an indispensable part of education and a fundamental tool that links to national development and the key factor for increased economic and social development (Muhoza et al., 2014). The success of ICT integration depends on both the availability of technology and the design of pedagogical practices (Sofiana and Arifin, 2012). Inadequate infrastructure, lack of training and personal expertise and weak technical support, are frequently cited challenges that prevent teachers from using technology fruitfully in the classroom (Ng, 2010). ICT enables educational innovations by interconnecting and supporting teachers, students and vast quantities of informational resources from around the world (Kreijns et al., 2013).

Another aspect of ICT enabled learning is the use of blogs in delivering classroom course content. When teaching staff make use of blogs, they help to integrate ICT into their classrooms and encourage developing ICT skills for the teachers (Goktas and Demirel, 2012). This in turn, provides authentic learning opportunities to integrate ICT into daily routines. Additionally, this builds the confidence of teaching staff to use several ICT applications, in order to create truly collaborative spaces for learning and
provides the opportunity for self-reflection. Committed leadership and curriculum plans are important for deploying ICT. However, providing easy access to ICT and providing affordable and quality hardware and network infrastructure are important prerequisites to the seamless integration of ICT (Lim and Tay, 2013).

2.6 Key findings for innovation in education

2.6.1 Professional development in education

Policymakers and stakeholders are recognizing the role of ICT as a key enabler of innovation in education and training and for learning in general (Bocconi et al., 2013). Teaching staff require constant updating of their ICT skills in order to meet the demands of future learners. In particular, older teachers, need to learn these new ICT skills to help transform their pedagogy (Jordan, 2011). This places a high importance on the professional ICT development and training provided by educational organizations. It can now be argued that ICT training is as important for teaching staff delivering increased teaching and learning outcomes as traditional pedagogical training. While teachers enjoy learning about new technologies, they are often left alone to explore and experiment themselves, when insufficient training is provided and often without sufficient time to test the new technologies in their classroom settings. Boorboor, Jafari and Zarrabian, (2013) states that one of the most important requirements of 21st century teachers is the knowledge required to utilize technological methodologies, alongside traditional pedagogical methodologies in education. In addition, schools containing teaching staff with high levels of ICT training also benefit the IT services department, due to lower numbers of helpdesk tickets and support related requests.

Institutions around the world are embedding ICT within their learning and teaching strategies and linking its use and development with a wide range of other
institutional changes, including expansion of student numbers, widening participation, a stress on lifelong learning, and measures for cost efficiency (Conole, 2002; McNaught and Kennedy, 2000).

A significant body of evidence of successful use of ICT to support learning also exists in the form of published case studies and articles. Alexander, McKenzie and Geissinger (1998) evaluated the outcomes of many projects that used ICT to support learning in Australia. They identified a range of factors likely to lead to successful outcomes but also reported on projects that were not successful in achieving the desired learning outcomes (Alexander, McKenzie, and Geissinger, 1998).

In the United Kingdom, for example, the Higher Education Funding Council for England (HEFCE) has attempted to establish good practice in setting human resources strategies. HEFCE recommends that such strategies must “meet specific professional development and training objectives that not only equip staff to meet their current needs but also prepare them for future changes, such as using new technologies for learning and teaching” (HEFCE, 2002, p. 47).

A report commissioned by the United Kingdom’s Joint Information Systems Committee (JISC) on the development and use of virtual learning environments in medical schools makes a wide range of recommendations including the idea that “support, training and incentives for academics may be necessary to ensure that systems are populated with appropriate content across the curriculum” (Cook, 2001, p. 9).

The analysis by Collis et al. (2000) draws into sharp focus the difference between institutional visions for the use of ICT to support learning and the reality in observable practice. The vision for intended professional development, must be matched by actual training, which is regular and appropriate.
Kuznets (1966) explains we need to ensure we have documented and categorised the need for professional development and direct support of end users, otherwise, the importance and reasons for funding may be overlooked. Kuznets (1966) articulates the two areas of direct staff support and support for professional development overlap greatly and can reasonably be represented as different points on a continuum. There is a place for both direct support via helpdesk IT support and the creation and use of differing types of PD from both the technological (IT Services department) and the pedagogical (teaching and learning) areas.

Shephard 2004 states there is a need for modelling and categorisation of activities that provide direct support and development services for ICT in education. Otherwise, organisations are not likely to either fund or implement these activities.

Many teachers in higher education feel themselves pressured to use ICT to support student learning, and express concern that these developments are proceeding more rapidly than educational research might justify, and without access to adequate or appropriate support or development opportunities (Shephard, 2004).

The combined work of direct support and professional development of teaching staff, have been mentioned in work by Warren (2002) and Green et al (2003).

As Daniel (1996) explains, “A clear focus on professional development is key to the successful deployment of new technology in teaching”. Shephard (2004) indicates the general environment for the use of ICT for learning and teaching is apparently both complex and changing. Furthermore, Shephard (2004) adds the analysis also suggests that extensive support mechanisms are in place but that these focus primarily on supporting professional development, rather than providing specific and direct support to individual teachers. More one-on-one training is required to effectively integrate
sustainable ICT training for individual teachers and for the way in which they can make use of ICT in delivering better learning outcomes for students.

Once the development of new technology teaching methods are recognised as a legitimate and valuable academic activity, it is easier to provide the incentives to do it well (Daniel, 1996).

Kirkpatrick describes “a university-wide programme of academic staff development which sought to familiarise staff with information technologies (IT) and their appropriate use in teaching and learning” (Kirkpatrick, 2001). Of course, the programme at Charles Sturt University, Australia, also attempted to support staff as they adjusted to changing practices, but a recorded emphasis was on staff development. The programme’s focus was the development of flexible learning opportunities for students. As mentioned by Kirkpatrick (2001), previous studies involving supporting staff at Charles Sturt University in Australia, with changes in practice due to new technologies, observed a preference by staff for individual support, however, this was seen as unsustainable.

Templeton (2001) described the range of technical support required. In general, technical support is required at an advanced level and it needs to be continuous and with high levels of coordination and cooperation among a variety of university departments and support sectors. Again, the emphasis is on regular PD.

Inglis et al., (1999) identify zones of expertise, expertise in information technologies, expertise in instructional design as well as subject expertise. Prime need is for teamwork with different members of the team contributing different areas of expertise. This is where there should be a combination of direct support delivered by IT Services and professional development delivered by teaching and learning.
Watson (2003) describes the situation in one Australian university where learning resources are prepared by learning support teams working with academic staff. Again, this highlights the need for teamwork and combination of skills and expertise from non-teaching professionals and academic staff.

Gilbert, based in the USA, addresses the issue as a “visionary answer” to the question of why bother to make increased educational uses of IT? He produces a distinctly traditional answer; “So that teachers, learners and academic support professionals believe they share responsibility for improving teaching and learning.” However, he adds, “But they know that those with knowledge, experience, and wisdom—especially the faculty, both individually and collectively—retain the ultimate responsibility for guiding learning” (Gilbert, 2001).

There should be a shared responsibility for improving teaching and learning, as Gilbert (2001) mentions, so that teachers, learners and academic support staff are all involved.

2.6.2 Time needed for innovative teaching

For most teachers, and whether support is available to help them or not, innovation generally requires time to develop new skills and to engage with the technology (Shephard, 2004).

2.6.2.1 Time in general

Many researchers have mentioned there needs to be more time allocated to integrating ICT into the classroom teaching process. Dillion, Osborne, Fairbrother and Kurina (2000) highlighted 86-88% of primary and secondary science teachers surveyed
indicated lack of time as the most significant constraint to using ICT. Beggs (2000) mentions time as a critical resource for faculty, however, highlights time as a premium with technology. Becta (2004) more specifically identified the lack of time for teachers pertaining to internet research time for exploring content and preparing lessons, practising with the technology, dealing with technical problems and receiving adequate training. Schoepp (2005) identifies lack of time as one of several widespread barriers to integrating technology into teaching and learning. Rarely, are teachers provided the time or encouragement to reflect on their beliefs about learning, or consider implementing new learning programmes (Newhouse, 1999). Hadley and Sheingold (1993) States that integration is both a process and an approach that takes time. As Jacobsen (1998) explains, one of the most immediate changes for faculty is the additional amount of time needed to deal with issues relating to learning new technologies, dealing with technical issues and developing new materials.

This need for more time appears urgent for many countries and educational facilities. Sicilia (2006) found teachers in Canada lack time for planning lessons integrating with technology, exploring internet sites and reviewing various educational software. A survey conducted by Spotts and Bowman (1993) at Western Michigan University demonstrates that faculty have different needs, however, highlights again the need for time to learn about technology and to become comfortable with using the technology. This again supports Geoghegan's (1994) viewpoint. Pajo and Wallace (2001) have identified one of the chief barriers to web-based technology by Massey university teachers was the time required in learning how to use web-based technology, the time provided to develop appropriate courses and the time associated with using and monitoring this form of technology in teaching.
Ertmer, Paul, Molly, Eva and Denise (1999) highlights time as one of those extrinsic, first-order barriers to technology integration. As opposed to second-order, intrinsic barriers such as changing the beliefs teaching staff have of classroom practices. These are both considered barriers to change as described by (Brickner, 1995) which extended the original concept of first and second order change mentioned by (Cuban, 1993 and Fullan and Stiegelbauer, 1991). A lack of time is reported as an issue for providing additional teacher training in using new technologies. Rogers (2000) refers to the barriers to successful technology adoption as having internal and external sources. The internal sources refer to the attitude and perception of the teacher. External sources includes access to adequate hardware or funding issues, the sufficient presence of technical personnel and a sufficient program for staff development. In addition, Rogers (2000) states barriers crossing both internal and external sources include time and funding and often the unique culture of the organisation. Snoeyink and Ertmer (2001) state the most common extrinsic first-order barrier to technology integration is lack of time for teachers.

2.6.2.2 Time for instructional guidelines

Hirschbuhl and Faseyitan (1994) and Nantz and Lundgren (1998) suggest it takes time to learn the technology, however, it takes even more time to formulate instructional materials to utilize the technology. Sammons (1994) agrees the lack of time in developing the instructional guides as a major barrier to the adoption of instructional technology. Beaudin (2002) found teachers in catholic education in Canada lack enough time to develop instruction that uses computers. Byrom and Bingham (1998) identifies lack of teacher time also as a barrier for technology integration and this includes the time to experiment with new technologies, plan lessons using technology or attend technology courses. Anderson, Varnhagen, and Campbell (1998) indicated
reduced teaching load as an important incentive to developing instructional materials for use of technology.

2.6.2.3 Release time

Brace & Roberts (1996) included in their campus-wide strategies, the use of funding for release time for training staff and providing them with time for playing with technology. Redmann and Kotrlik (2004) mentions there is a lack of release time for teachers to learn how to use the new technology. Rogers (2000) refers to teaching staff developing new technical skills as an individual level barrier and the "fear factor" is the panic endured by teaching staff in trying to learn newer technologies and integrate them into classroom teaching without sufficient release time.

Hadley and Sheingold (1993) mention technology creates opportunities for teacher development, however, this also takes time. It is also stated there is not enough time for teachers to prepare computer-based lessons, or enough time in the school schedule for computer-based instruction. Bariso (2003) found a lack of time to learn and practice (ILT) technology skills as well as inconvenient training timetables as some of the major factors for demotivating staff to attend training in an outer London further education College in 2000. Al-Alwani (2005) reports the lack of time in teaching in Saudi Arabia is a barrier to effectively integrating ICT and is due to the busy schedules.

2.6.2.4 Time for training and technical support

Drape (2010) states innovation technology is often introduced but not adopted for a number of reasons including training, self-efficacy, time to plan and learn the new technology and technical support for troubleshooting. Additional factors, including training, self-efficacy and time are noted as reasons why agriculture teachers struggle to integrate instructional technology (Redman and Kotrlik, 2004). Bingimlas (2009)
includes effective professional development, sufficient time and technical support as requirements for effectively integrating ICT into the classroom. Classroom teachers make use of technology to supplement their current curriculum deployment, however, with sufficient time, teachers will take students beyond the current outline of the curriculum (Hooper and Rieber, 1995). Teachers cannot magically utilize technology without training, guidance and models. Those teachers who started in the profession before the introduction of personal computers would have non-existent training on how to use this form of technology (Kopp and Ferguson, 1996). Armstrong (1996) outlines the time consuming process of finding faculty staff interested in transforming their academic vision into integrating technology into the classroom. This process includes administrator funding, instructional designers, technical support for the intended technological infrastructure and continuous technical support during the deployment of the technology.

2.6.2.5 Time to understand what teachers want

The key to achieving technology integration is to study teachers and understand what makes them use computers as explained by Marcinkiewicz (1993). Snoeyink and Ertmer (2001) reiterate what teaching staff do not wish to see a substitute teacher take one or more of their classes while they were undertaking technology training.

Pelgrum (2001) refers to the barriers to integrating ICT as material and non-material. Material are the physical computers or sufficient licenses of software. The non-material conditions include insufficient knowledge on the part of teachers, difficulty with integrating ICT in classroom instruction and the educational faculty not providing sufficient time for teachers (Pelgrum, 2001). Hadley and Sheingold (1993) state teachers use of classroom technology increases as they gain experience in using
technology to deliver content and generally use more applications more often and more flexibly.

2.6.3 Money needed for funding innovation

2.6.3.1 Reasons for funding innovation

Many researchers have various reasons for funding innovation. Several researchers indicate lack of funding as a barrier to successful integration of technology. Fabry and Higgs (1997) state the focus should be on money to help integrate technology into the teaching-learning process. George (2000) indicates the primary barrier in incorporating technology is funding. Green (1998) states intuitions have not prepared for the sustained investment in financial resources. Schoepp (2005) refers to the lack of equipment as a top rated barrier to technology integration. Ertmer, et al., (1999) includes funding as one of the barriers to integrating technology into classrooms. Rogers (2000) reminds us of the requirement for sufficient funding in terms of purchasing technology and providing sufficient numbers of technical support personnel otherwise this becomes a serious barrier to integrating ICT into the classroom. Duffield (1997) noted the lack of classroom teaching equipment due to lack of funds as a key barrier to ICT integration in the classroom. Anderson, Varnhagen, and Campbell (1998) identified the largest barrier to ICT integration in faculties is funding.

Teacher development, training and instruction suffer when insufficient funding is provided. Hadley and Sheingold (1993) state there is a need for financial support for the technology in creating opportunities for teacher development. Anderson, Varnhagen, and Campbell (1998) explain funding is required to provide time, training and proven instruction on how to use new technology.

Funding for ICT infrastructure is critical to enabling many facets of innovation to flourish. Lu, Chin-Chung and Wu (2015) acknowledge the need for constructing
sufficient ICT infrastructure, which will enable the promotion of ICT in education. Integrating computer technologies into education requires successful development of ICT infrastructure (Akbaba-Altun, 2006). Maddux (1999) states computers need to exist in classrooms for ICT integration to happen which requires funding. It has been found, that laptop and tablet computers and mobile phones are increasingly considered as useful in education (Prensky, 2001). These types of devices all depend on sufficient ICT infrastructure. To overcome the lack and limitations of the ICT infrastructure, the necessary financial resources should be provided (Goktas, Gedik, and Baydas, 2013).

Many countries around the world have identified the need for sufficient funding for innovation in education and business. In an interview with the Australian Financial Review in January, Elizabeth Blackburn, Brian Schmidt, Peter Doherty and Barry Marshall, all well renowned scientists were scathing in their assessments of innovation funding in Australia. Millard & Hargreaves (2015) state the challenge for HEFCE (Higher Education Funding Council for England) is to identify a means in which innovations in teaching and learning can be streamlined and embedded into everyday operations. A study undertaken by Mitran and Mohan (2016) illustrates Romania must invest in their own research, teaching and innovation activity, instead of using and importing technology developed in other countries. European Union's Horizon 2020 programme has confirmed funding approval for EU research funding which reassures applicants from the UK's research and innovation community from April 2016 to April 2021 (M2Presswire, 2016). Demmou and Worgotter (2015) indicate private spending on innovation is very low and Russia underperforms in terms of scientific outputs and patents. At this point in time, many argue that most innovation should take place and yet it is a time of cutting back expenditures for many educational facilities (Millard and Hargreaves, 2015). Research undertaken by Savignac (2006) indicates financial
support is essential for improving the likelihood of undertaking innovative projects and increased innovation performance.

Research undertaken by Saad, Guermat and Brodie (2015), indicate a direct relationship between the level of funding towards higher education students and the level of national innovation and knowledge performance. This increase in educated human capital drives the opportunities for innovative practice and enterprise ventures. Part of the successful innovation management resources includes funding for effective human resources. Cooper and Kleinschmidt (2007) mention an effective human resources strategy would require funding for recruitment processes, training and retention schemes. One of the main success factors for innovation management success identified by researchers such as (Johnston and Bate, 2007; Copper and Kleinschmidt, 2007) was innovation resources. These resources include innovation funding for acquiring technology and the number of innovative projects undertaken by the organisation (Metrick and Yasuda, 2011). Shic et al., (2015) highlights the importance of bringing together scientists, engineers and business owners in identifying promising technologies and creating innovative products. A new generation of scientist-entrepreneurs are needed to research autism, technology development and accessibility.

2.6.3.2 Where was funding spent

Funding for innovation should be efficient and accountable. Saarela, Jokela, Niinikoski, Muhos and Leviäkangas (2016) claim moderate public funding provides significant value creation and innovation benefits. Lajoie and Bridges (2014) mention the value of an innovation needs to be valued against the maturity of the innovation and the organisation's tolerance for risk. According to Fenn and Raskino (2008) it is possible to adopt an innovation based on hype before the true value of the innovation
is known. Lajoie and Bridges (2014) state decision making processes should include not just the value of the innovation, but also the time and resources required to see the innovation achieve its goal for the organisation.

Funding for CETLs (Centres for Excellence in Teaching and Learning) across 54 Universities in England was used to improve learning spaces, to purchase hi-tech simulation equipment and mobile technology with its related infrastructure (Millard and Hargreaves, 2015)

Kniest (2016) states the Australian government has changed the way funding for research in universities has been allocated by encouraging a more collaborative approach with industry and end users.

2.6.3.3 Ways to fund innovation

Innovation management is key to funding and wisely dispersing money for innovation integration. (Kowant, Long and Rasli, 2015) mention innovation management as one of the core components of business success by enhancing an organisation's competitive advantage. Molero and Garcia (2008) claim an appropriate innovation management practice in an organisation can promote a positive innovation environment and ultimately improve innovation performance.

Complex technology is vulnerable to disruptive innovations and companies may lose their competitive position in a world where some countries depend heavily on high-technology export markets, which is the case with Finland (Nieminen, Loikkanen and Pelkonen, 2016). Slovenia is looking to encourage R&D by promoting the partnerships between partners who can provide increased connectivity with R&D networks (Martin, Pahor and Jaklic, 2015). Djeflat (2015) mentions one of the barriers to successful innovation in some countries is the weak absorptive capacity of R&D
funding. This can be caused by lack of basic or advanced infrastructure, lack of incentive systems in place or lack of effective partnerships. Increases in R&D funding may not result in additional R&D projects, instead, these can be attributed to increases in academia salaries.

Tugend (2016) mentions Chancellor Gray-Little in June 2016 stated that the University of Kansas had reviewed all of the business operations including technology, purchasing and maintenance and had saved millions. President Napolitano from the University of California saved money by streamlining systems at the University such as payroll (Tugend, 2016). Professor Clifton Forbes from the University of Wisconsin-Madison mentions bringing together people from many areas to solve the issues of funding and a culture of complaint (Tugend, 2016). Van Geenhuizen, Taheri and Soetanto (2014) mention there is a gap in the literature concerning the relationships of academic spinoff firms with their parent university which influence their ability to attract funding for innovation activities. There is more chance of attracting funding for innovation when there is a high density of university and non-university contacts, the relationship between contacts is high and the overall size of the network contacts is large (Van Geenhuizen, Taheri and Soetanto, 2014). Perhaps, Schools can look at ways to improve relationships with suppliers so products can be tested in return for reduced product prices or other incentives to use and advertise their products. In addition, increased network of external suppliers and building relationships can help with reducing costs with the supply of products and ongoing maintenance and operating costs (Van Geenhuizen, Taheri and Soetanto, 2014).

Nastase, Badea and Badea (2015) state available funding for universities is based on a competitive demonstration of their research providing social and economic benefits to the community as an innovative-entrepreneurial university. Da Silva (2015)
states that research, science and innovation start in education. Da Silva (2015) argues for more funding for research considering Brazil has produced more research publications than Mexico, Argentina, Chile, Columbia and Venezuela combined over the years from 2008 to 2010. This comes at a time where Brazil is looking to reduce funding to research.

Cooley (2015) states policy innovation and diffusion theory has been applied in the area of performance higher education funding such as the study undertaken by Dougherty et al., (2013) across the states of Florida, Illinois, Missouri, South Carolina, Tennessee and Washington in the United States of America. This research looks into the impact of both horizontal transmission of policy ideas from state to state and the vertical transmission of policy ideas from federal to state and state to federal. In Australian private Schools, funding is controlled by the individual School, however, the policy for funding is formulated by the School board in conjunction with the headmaster and implemented by the headmaster and various management positions.

New Hampshire Business Review (2015) enables funding for innovative projects by attracting private donors to foster innovation in the colleges in New Hampshire. Funding is allocated by a panel composed of venture capitalists, entrepreneurs and business leaders. However, Millard and Hargreaves (2015) state organisational culture and strong leadership will do more to incentivise change than funding alone. Being cash poor does not mean that we cannot be innovation rich (Millard and Hargreaves, 2015). To support innovators, funders should be innovative in their funding approaches and look at alternate models that could include funding students rather than staff (Millard and Hargreaves, 2015).
2.6.4 Summary of key factors

Many researchers agree there are three main factors for fostering innovation in education, funding, training and time. Green (1998) states institutions have not prepared for the sustained investment in time, support and financial resources needed. George (2000) indicated that the primary barrier in incorporating technology in the teaching-learning process is the lack of expertise, time, and funds. Schoepp (2005) also identifies the lack of time, lack of equipment or funding and lack of training as top rated barriers to technology integration. Fabry and Higgs (1997) confirmed we must focus time, money and resources to integrating technology into the teaching-learning process. Ertmer, et al., (1999) states that researchers have identified barriers to integrating technology into classrooms, which includes funding for equipment, training and time. Anderson, Varnhagen, and Campbell (1998) identified the largest barrier to ICT integration in faculties is funding and the second largest barrier being lack of time to learn technologies. Bingimlas (2009) states not one component is sufficient to provide good teaching, however, the presence of all components increases the likelihood of integrating ICT into the classroom.

Duffield (1997) claims that teachers mostly teach as they were taught and this is especially true when times are tough and students are difficult. The suggestions made are to teach all subjects with technology integrated rather than think of technology as a subject on its own. Time was noted as a key barrier for consultants providing instructions to teachers on how to use technology. As Duffield (1997) states, the barriers encountered in integrating technology into classroom teaching was equipment, training and of course, time. Administrative support for supervising computer usage and financial support for the technology are also highlighted. Hadley and Sheingold (1993) state teachers gain some training with on-site consultants and at conferences or
workshops, however, this is often in their own time. It is also important for a School structure and culture to allow teachers to be given enough time to learn new technologies and for encouragement to provide a professional and experimental approach to their work.

Anderson, Varnhagen, and Campbell (1998) quote a university professor as saying "I believe that irresponsible expenditures on new technology and innovation consume valuable resources (dollars, staff and faculty time). I believe that all new initiatives should be monitored and evaluated from a cost benefit point of view". Anderson, Varnhagen, and Campbell (1998) quote a faculty member, stating "instructors need time to learn and experiment with new materials and methods, instructors need guidance on how to use new materials and methods effectively, and they need examples that illustrate the range of productive possibilities for changing instruction".

2.6 Balancing Control and Slack / Balancing ICT Infrastructure with Innovation in Education

Nolan (1973) summarised the implications of the model by stating that control is lax in stages 1 and 2, reaction to out-of-control spending is overdone in stage 3 and refined and effective in stage 4. The final stage 4 - Maturity is an equilibrium state in which computing growth is brought under control by appropriate management actions, and persisting until new technological changes upset the equilibrium. Therefore the control environment was introduced to ensure efficient use of computing resources and the slack environment was characterized by a lack of control over spending more than was needed. In other words, a control environment would nurture efficiency but constrain innovation; a slack environment would nurture innovation but allow inefficiencies.
In this case study, this would be interpreted as IT Services trying to manage budgets and ensure ICT infrastructure is running efficiently, while the slack environment is decision makers from Teaching and Learning fostering innovation through over spending, which in this case study, with an unfortunate lack of funds and resources to sustain a stable environment.

Gibson and Nolan (1974) first suggest the possibility that the end state of maturity is not in fact an end state, but rather an equilibrium state. King and Kramer (1984) state there is a dialectical relationship between freedom and constraint in the control of computing that leads to certain states of equilibrium. One of the main aims of this case study research was to identify the factors which bring an organisation's ICT maturity to an equilibrium state by exploring and understanding how to balance ICT infrastructure with innovation in education or balancing control and slack.

As King and Kramer (1984) so wisely state, policies must be chosen from some point on the "control" to "slack" continuum but from where should they be chosen in any given instance? Most policies for computing management are probably reactive, developed in response to problems experienced with computing. For management to be proactive, management needs to anticipate when policies using greater control or greater slack are needed. In later versions, the Nolan maturity model was modified to accept greater control in some variables and greater slack in others. The preferred state results from balance between slack and control for each major policy variable.

2.7 How ICT is a benefit to education

As described by Rabah (2015), the primary goal of educational technology as applied to pedagogical contexts is to facilitate the teaching/learning process. Research undertaken by Rabah (2015), indicate participants highlighted the following challenges: lack of supporting school leadership, inconsistent investments in ICT
equipment, infrastructure and resources, inflexibility of funding, the need for additional professional development and support and incorporation of technology in evaluations and curricular plans. Rabah (2015) goes on to explain the classroom ‘micro-level’ issues can only be fully appreciated after having taken into consideration the entire perspective in which educational technology is situated such as the school’s infrastructure, vision and mission.

According to the participants of research undertaken by Rabah (2015), the main benefits of ICT integration are higher student engagement levels and enhancement of the learning process. These results resonate with the recent study by Karsenti and Collin (2012). Their survey of 2,712 students from grades 3 to 11 and 389 teachers regarding their perceptions of the use of laptops in elementary and secondary schools in Québec English Schools shows that the perceived use of available laptops appears to be particularly conducive to student learning.

Rebah (2015) has mentioned that ICT has a positive effect on the academic achievement of special needs pupils.

Means and Olson (1997) thus advise educationalists to have a clear vision before investing and spending money. In addition, this vision should not be a solid hand press from top to bottom. It should go in many directions with various stakeholders involved in building the vision, including teachers, board members and IT consultants (Costello, 1997). Ertmer, et al., (1999) claims: "A vision gives us a place to start, a goal to reach for, as well as, a guidepost along the way". Therefore, the budget for ICT integration in an educational institution should translate into consistent investments that include equipment, infrastructure and support services. According to Papert (1993), when technology enters classrooms, it "weaves itself into the learning process in many more ways than its original promoters could possibly have anticipated".
If educators do not buy into the pedagogical value of various technologies, they will remain just fashionable add-ons in our curricula. Salomon (1993) claims: “No tool is good or bad in itself; [technology’s] effectiveness results from and contributes to the whole configuration of events, activities, contents, and interpersonal processes taking place in the context in which it is being used.”

Rabah (2015) mentions that teachers can incorporate ICT into curriculum programs gradually by investing a lot of time, careful planning and collective effort. Several examples have been stated by Anderson and Dexter (2003).

2.8 ICT infrastructure's place in implementing ICT in education

Some studies fail to include the importance of ICT systems for effective ICT in education deployment and implementation. An example is the SITES 2006 study by Plomp, Pelgrum and Law, (2007) which is based on the pedagogical practices of teachers’ ICT application in teaching. However, their ICT indicators do not make clear each country’s readiness for ICT in education because the study emphasized teachers’ roles as the main part of ICT application in schools, and de-emphasized system-level measurement for effective ICT in education.

There are three elements involved in implementing ICT in education: learners, teachers, and curriculum, which includes teaching and learning materials, all of which directly affect education (Lee, Hong and Ling., 2001; Park et al., 2001). However, it is also important to highlight supportive elements, such as policy for ICT application in education, infrastructure for delivering the service, and other related educational services.

The following framework is suggested for ICT implementation. This framework has been suggested by the researcher based on the work experiences
encountered during the last 5 years working in the School in this case study. However, the details of this framework include contributions from the literature examined by the researcher during this case study investigation.

- Curriculum planning by Teaching and Learning
- Policy making by Risk and Compliance
- Infrastructure planning by IT Professionals in IT Services based on 1 and 2
- Budget planning for ICT infrastructure decisions and support of fostering innovation
- Human resources align appropriate training for staff at regular intervals
- IT Services utilise planning and HR to facilitate ICT infrastructure training
- Teaching and learning to test implementation of ICT in curriculum

The following chapter explains the methodology used throughout this research.

2.9 Summary of Literature Review

The following table summarizes the information gathered from the literature review in understanding what created a stable ICT infrastructure with adequate levels of innovation. In addition, the table continues with a new ICT Strategic Plan to show the sorts of demands placed on the ICT infrastructure by teaching and learning with the goal of achieving higher levels of innovation. This in turn highlights key factors thought to foster innovation in education including funding, time and training. The research needs to examine these key factors in this case study to see if these factors are deemed important by staff.
Table 2.9 ICT infrastructure components supporting innovation

<table>
<thead>
<tr>
<th>ICT Infrastructure item</th>
<th>Funding</th>
<th>Time</th>
<th>Training</th>
<th>Achievement</th>
<th>Innovation Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous ICT strategic plan components (Acceptable only)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage (SAN)</td>
<td>High</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Medium</td>
</tr>
<tr>
<td>Server CPU processing power</td>
<td>High</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Medium</td>
</tr>
<tr>
<td>Print Services</td>
<td>High</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Medium</td>
</tr>
<tr>
<td>Wireless Services</td>
<td>Medium</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Medium</td>
</tr>
<tr>
<td>Data Projectors</td>
<td>Medium</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Low</td>
</tr>
<tr>
<td>Network bandwidth and security measures</td>
<td>Medium</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Medium</td>
</tr>
<tr>
<td>End user tablet devices</td>
<td>High</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Medium</td>
</tr>
<tr>
<td>New ICT strategic plan components (Push for Innovation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage (Hyper-convergence solution)</td>
<td>High</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Very High</td>
<td>High</td>
</tr>
<tr>
<td>Server CPU processing power</td>
<td>High</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Print Services</td>
<td>Medium</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Wireless Services</td>
<td>High</td>
<td>Demanding</td>
<td>Acceptable</td>
<td>Very High</td>
<td>High</td>
</tr>
<tr>
<td>Wireless Interactive Data Projectors</td>
<td>High</td>
<td>Demanding</td>
<td>Unacceptable</td>
<td>Very High</td>
<td>Very High</td>
</tr>
<tr>
<td>Network bandwidth and security measures</td>
<td>High</td>
<td>Demanding</td>
<td>Unacceptable</td>
<td>Very High</td>
<td>Very High</td>
</tr>
<tr>
<td>End user tablet devices</td>
<td>High</td>
<td>Demanding</td>
<td>Unacceptable</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

In general, with increases in innovation requested by Teaching and Learning, come demands for more funding, time for tinkering with the new technology and appropriate and regular training with the technology. In this case study, these factors were investigated to see if teaching and non-teaching support staff considered these key factors important in achieving higher levels of innovation in the classroom and work place.
3.1 Research Design – Choice of Methodology

The research methodology chosen for this research paper is case study using both quantitative and qualitative research methods. However, the ICT infrastructure research method is a descriptive form of quantitative research in which no statistical significance is expected (Morgan, Gilner and Harmon, 1999). The research methodology chosen for the innovation in education aspect is case study research. This research method has gained acceptance in the field of IS (Dube and Pare, 2003). Case research is studying a phenomenon which is broad and complex and when a holistic in-depth investigation is required. Case research is also appropriate when the phenomenon under study cannot be studied outside of the context in which it occurs (Benbasat, Goldstein and Mead, 1987).

3.2 Research Paradigms relevant to questions

For this study, case study research’s versatility allows for any philosophical perspective including positivist, interpretivist, constructivist or critical. A mixed methods approach was used to obtain descriptive quantitative data from the examination of ICT infrastructure information and qualitative data from exploring open-ended, in-depth questions asked of teaching and learning staff for the extraction of ideas for innovation.
in education. A convergent parallel mixed methods approach will be used to merge the quantitative and qualitative data aimed at producing a comprehensive analysis of the research problem.

In terms of researcher positioning, I saw myself in this study operating from a constructivist ontological stance, aiming to build knowledge and seek understanding of the world in which the requirements of ICT infrastructure are required to be balanced against the pursuit of innovation in education by teaching and learning staff. The decision for approaching the research from a constructivist perspective was largely based on prior research experience and epistemological stance. Social constructivism aims to use open-ended questions of participants in order to explore their life settings and the subjective meanings derived from their responses which can be negotiated socially through the participants’ interaction with others. Inquirers generate a theory or pattern of meaning from the information and findings from their research.

3.3 Researcher Lens

Due to the unique circumstance, the research will be undertaken with a professional lens and a personal lens. Having worked in the school as the IT Manager, the professional lens focuses on the ICT infrastructure elements. As a parent of two daughters enrolled at the school and having a wife working as a Junior School Teacher at the same school, the personal lens focuses on elements associated with the innovation in education aspect.

It was believed the personal lens provided the researcher with an opportunity to extract richer information and deeper meanings from participants as they felt comfortable providing responses to research questions.
3.4 Research Questions

Main research question

How can we improve educational innovation through better budget awareness and planning?

Main sub question

Can a rating be developed which can help educational leadership with fostering innovation?

The proposed Balance of Infrastructure and Innovation Rating (BIIR) is defined as follows:

\[ \text{Innovation Culture Rating (ICR)} = \text{BIIR} \times \text{IRPT} \]

Where BIIR is Balance of Infrastructure and Innovation Rating (BIIR) and IRPT is Staff Innovation Rating Potential for Technology (IRPT)

Specially,

Innovation Culture Rating includes a rating (No=1 or Yes=0) for the following 3 factors...

- Money required for Innovation (Questions 6, 10, 16, 18 and 19) [Value range 0.0 to 1.0]
- Time required for Innovation (Questions 6, 9, 16 and 19)
- Professional Development needed for Innovation (Questions 8, 17 and 19)

Innovation Rating for Innovation is Q20 from the qualitative research with a rating for old versus new technology [Value range 0.0 to 10]
ICT Infrastructure sub research question 1

How can ICT infrastructure expenditure become further optimized?

ICT Infrastructure sub research question 2

What ICT infrastructure components are considered important for the efficient running of an education environment?

Innovation sub research question 1

What factors provide a positive school culture for innovation?

Innovation sub research question 2

Do staff rate the potential for new technology and teaching practices higher than older technology and teaching practices in terms of fostering innovation?

The null hypothesis to be tested is that the average of the two groups of data (old technology innovation rating and the new technology innovation rating) are not different to each other.

A two-sided t-test using R for Windows, and a one-sided t-test using R for Windows will be used to accept or reject the null hypothesis.

In order to provide answers to the research questions above, data was collected using several methods. The descriptive statistical data collected from 5 years of ICT infrastructure budgets provided a background for how the budgets were spent in terms of major capital and recurrent item purchases. Explanations would then follow explaining why those items were purchased and how they would relate to improving the chances for fostering innovation in education. These budget components can be seen in Appendix A for Capital budget items and Appendix B for Recurrent budget items.
To examine how best to foster innovation in education for teaching and learning, in-depth, open-ended interviews were undertaken of 25 staff members. These research questions can be seen in Appendix C for teaching staff and in Appendix D for non-teaching support staff. Note that the decision was made to include non-teaching support staff in these questions as they support and maintain the school systems, which in turn allow teaching staff to perform their jobs. Support staff also make use of technology in their role each day in the school.

### 3.5 Quantitative Research

#### 3.5.1 The Quantitative research approach

As mentioned by Creswell (2013), quantitative research is an approach used to test objective theories. The aim is to view the relationship between variables which are measured by instruments in order for numbered data to become analysed using statistical procedures. In addition, theories are tested deductively and mechanisms are put in place to guard against bias, exploring alternative explanations and providing a pathway for replication of the findings and generalisability of the data.

In this research a descriptive form of quantitative research is undertaken to explore the components that make up a typical capital infrastructure budget. In addition, a longitudinal study is used to examine trends in this data over a 5 year period, from 2012 to 2016. No statistical significance is sought during this quantitative research study.

Question 20 of the research questions was broken up into 5 sub questions. Each question asked for a rating out of 10 for questions relating to technology or teaching method which was seen as old versus new. Question 4 relates to teaching method. These are shown in the Table 3.5.1.
Table 3.5.1 Research questions for rating new and old methods of technology and teaching methods.

<table>
<thead>
<tr>
<th>Q20 Sub-Questions</th>
<th>How would you rate the following innovative tools?</th>
<th>Rating out of 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Non-touch enabled laptops</td>
<td>x/10</td>
</tr>
<tr>
<td></td>
<td>Touch enabled laptops</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Standard data projectors</td>
<td>x/10</td>
</tr>
<tr>
<td></td>
<td>Wireless data projectors</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Desk with displays/books/3D models</td>
<td>x/10</td>
</tr>
<tr>
<td></td>
<td>zSpace augmented reality device</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Explicit teaching</td>
<td>x/10</td>
</tr>
<tr>
<td></td>
<td>Heutagogy self-directed learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LMS Individual learning styles accommodated</td>
<td>x/10</td>
</tr>
<tr>
<td>5.</td>
<td>Standard data for students via TASS</td>
<td>x/10</td>
</tr>
<tr>
<td></td>
<td>Big data analysis</td>
<td></td>
</tr>
</tbody>
</table>

The old technology or teaching methods were in current practice. New proposed technology was spoken about during DigiTal committee meetings between IT Services staff and teaching and learning staff. These were also identified by conversations between the IT Manager and various vendors throughout the year. These were explained to each research participant before they provided a rating. This way, they understood what they were currently using and the advantages and disadvantages of each old and new technology!
3.5.2 Hypothesis

The aim is to prove that the means of both innovative technology ratings are different. For this to happen, the null hypothesis needs to be proven invalid and the alternative hypothesis needs to be proven true. That is, there is a difference in the means of the ratings, showing that staff consider the new innovative technology as more innovative than the older technology. This requires a p-value less than the significance value of 0.05. R for Windows software was used to determine this value.

3.5.3 R for Windows software

R for Windows is an integrated suite of software facilities for data manipulation, calculation and graphical display. This software was used in this research for the implementation of statistical techniques. The aim was to investigate whether the means of ratings for old and new innovative technology and teaching methods are different. The results are shown in section 4.2.3 to prove the null hypothesis or alternative hypothesis as stated in section 1.2.3.

3.6 Qualitative Research

3.6.1 The qualitative research approach

Qualitative research is a complex and evolving field of enquiry as stated by Agostinho (2005). Denzin and Lincoln (2008) have concluded it is embarrassing as to the number of choices now available to researchers investigating qualitative research studies. Compared with conventional scientific research, the field of qualitative research has a relatively short history, however, it is an evolving line of inquiry (Erlandson, Harris, Skipper and Allen, 1993). Agostinho (2005) identifies qualitative research as an umbrella term under which research is conducted in a natural setting to investigate social or human issues. It has also been used with case studies (Merriam, 1998),
ethnography (Goetz and LeCompte, 1984), grounded theory (Neuman, 2004), phenomenology (Lancy 1993) and naturalistic inquiry (Lincoln and Guba, 1985).

3.6.2 What is qualitative research?

As stated by Tesch (1990) and Sandelowski (1993) qualitative research is an artistic endeavour which requires a soulful and imaginative approach to assessing its quality. Denzin and Lincoln (2008) specify "qualitative researchers study things in their natural settings, attempting to make sense of, or interpret phenomena in terms of meanings people bring to them". Caelli, Ray and Mill (2003) recommend "each qualitative approach needs to be evaluated in a manner that is congruent with its epistemological and methodological origins". In fact, research studies which identify the philosophical stance or paradigm used to frame their work, such as post-positivist, critical theory or social constructivist as mentioned by Creswell and Miller (2000) and Morrow (2007) helps to guide the reader in understanding the epistemological position of the researcher and the methods used to answer research questions (Drisko 1997). Leitz and Zayas (2010) state quantitative research may administer a standardised instrument to measure a variable with close-ended items developed and tested for their ability to produce valid and reliable data. However, qualitative research employs data collection strategies such as in-depth interviews, participant observations and archival reviews as mentioned by Polkinghorne (2005). As described by Leitz and Zayas (2010), qualitative research is not generalizable according to the quantitative standards. Instead, a purposive sample of participants are chosen who have experienced the phenomenon being studied. Due to the exhaustive nature of the in-depth investigations smaller numbers of participants exist in qualitative research than in quantitative research (Polkinghorne, 1995).
3.6.3 Comparison with quantitative research

This research is undertaken with a mixed-methods approach. The quantitative research component examines the ICT infrastructure funding from a purely descriptive standpoint, not looking to provide any statistical significance. However, the qualitative research component is used thoroughly throughout the research, investigating what fosters innovation in education.

Leitz and Zayas (2010) state quantitative research may administer a standardised instrument to measure a variable with close-ended items developed and tested for their ability to produce valid and reliable data. In this research, qualitative research approaches include data collection strategies such as in-depth interviews, interview transcriptions, thematic analysis, member checking, peer debriefing, audit trails, the maintenance of a reflexivity journal and several triangulation methods to increase the rigour of the research. Cutcliffe and McKenna (1999) and Carter and Porter (2000) recognise the quality of qualitative research cannot be judged comparatively with the validity and reliability often associated with quantitative research. As illustrated by Bogdan and Biklen (2007) and Lincoln and Guba (1986), qualitative studies differ from quantitative studies since they make use of inductive rather than deductive processes and they consider experiences within context rather than controlling variables as in an experiment. Evaluating quantitative studies involves examining the level of reliability and validity of the measurement procedures, the internal validity is established through the design of the study and the external validity is the degree to which sampling procedures will allow for generalizability as described by Creswell (2002), Lincoln and Guba (1986) and Rubin and Babbie (2010). Agostinho (2005) states that before considering if a piece of research is or is not qualitative, one needs to
acknowledge whether the discussion is happening at the paradigm, method or technique level.

3.6.4 Case study research as a choice of qualitative research

Case study research is useful for the study of a phenomenon in its natural context (Stake 1995, Yin 2003). Stake (2000) mentions case study research is not solely qualitative research. Lancy (1993) states that case study research does not adhere to the qualitative paradigm. Lincoln and Guba (1985) view case study research as a form of writing or presentation of reporting results for naturalistic inquiry, and not as a method of inquiry. Agostinho (2005) also notes that if a researcher was to follow a particular qualitative research method such as case study, which can deviate from the purest form of the paradigm, the researcher is in fact following an entire philosophy of inquiry. Agostinho (2005) mentions the naturalistic inquiry paradigm (Lincoln and Guba, 1985) has more recently (Lincoln and Guba, 2000) been renamed as the constructivist inquiry. This research has a constructivist research worldview and case study research approach in order to explore and study the phenomenon of ICT infrastructure funding and factors which foster innovation in education in a context which otherwise could not be examined.

3.6.5 Quality of qualitative research

Leitz and Zayas (2010) state the criteria derived by Lincoln and Guba (1985) for evaluating the quality of qualitative research is the most cited standards for evaluating qualitative work and provides direction for researchers. Whittemore, Chase and Mandle (2001) class these criteria as "gold standard". Lincoln and Guba (1985) define credibility as the degree to which a study's findings represents the meanings of the research participants. This research included member checking to provide the research participants an opportunity to review their responses and fine tune the results of the 20
questions asked of them during the research interviews. Drisko (1997) believes the interpretations must be authentic and accurate accounts of the descriptions given by the research participants. Every attempt has been made to increase the rigour of this research in terms of the logic behind the methodological procedures followed, accuracy of results obtained and data analytics employed. In addition, Padgett (2008) sees credibility in qualitative research as managing the risk of research reactivity and bias. This research reactivity is the potential for researchers to impose pressure on the participants to change the findings of the research. A reflexivity journal has been maintained throughout the research to record feelings and experiences the researcher encountered during the research interviews and observations undertaken.

3.6.6 Confirmability

Confirmability is the ability of others external to the study, to corroborate findings as mentioned by Drisko (1997) and Lincoln and Guba (1985). Shenton (2004) explains the work must be the result of the experiences and ideas from the participants, and not the preferences of the researcher. It is important this concept is understood by the researcher and every attempt is made not to influence the findings.

3.6.7 Transferability

Transferability is described by Sandelowski (1986) as "fittingness" or the degree to which research findings will fit situations outside the study and found meaningful. Leitz and Zayas (2010) explain transferability improves when the researcher finds other contexts in which the findings can apply. In fact, Devers (1999) suggests for findings to be claimed as transferable the contexts must be similar and the study's context should be described in detail and should relate to the context of other settings. Thick descriptions have been produced to help with the explanations of the settings and context in which the research has been undertaken to help with transferability of
research findings. Leitz and Zayas (2010) also remind us the importance of credibility such that transferable findings that are not credible do not contribute to the knowledgebase.

3.6.8 Interviews

Interviews were conducted in the IT Managers’ office. This is a quiet air-conditioned space with comfortable seating for the interviewees away from distractions. Any information was viewed on a large white board with information projected from an interactive data projector. This process included a feature which allowed a template to be shown, questions asked, results recorded and saved or emailed to the researcher upon finishing the interview.

3.6.8.1 Tools used for conducting interviews

The tools used for conducting interviews included the use of a Microsoft surface pro 3 tablet computer held in a dock on the desk. This device was used to record the audio of the interviews. The device can be seen in Figure 3.6.8.1A.

Figure 3.6.8.1A Microsoft Surface Pro tablet device used for interviews
The list of questions were also maintained in a Microsoft word document on the tablet device and was used to ask the questions of the participants. Notes were also taken on the tablet device using Microsoft Excel and the comment field feature.

The final question 20 required the use of an interactive data projector to display 5 sub questions relating to how the participants would rate several innovative tools. The data projector is shown in Figure 3.6.8.1B. Questions were asked and the results would be written directly on to the whiteboard. At the end of the data collection this screen was emailed to the researcher from the data projector.

Figure 3.6.8.1B Interactive data projector used for question 20.

3.6.8.2 Environment for interviews

The interviews were conducted inside the office of the researcher, who works as the IT Manager for the School. The environment was clean, quiet and air-conditioned, providing a great atmosphere for the interviews. The environment is shown in Figure 3.6.8.2.
3.6.8.3 Example transcription

Once the interview was audio recorded, each interview needed transcribing into text. All 25 interviews required each of the 19 questions asked of the interviewees to be transcribed. This required careful listening and often replaying of more than 11 hours of audio recordings for accurate transcription. An example of a couple of the research questions is shown in Figure 3.6.8.3.

<table>
<thead>
<tr>
<th>Question #</th>
<th>Question Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What do you believe innovation in education entails?</td>
</tr>
<tr>
<td></td>
<td>I think innovation in education is where you look at the needs of the students and they are not being meet. So you actually have a problem to solve and you have to solve that problem by finding new ways and better ways of doing things.</td>
</tr>
<tr>
<td>Keywords:</td>
<td>Innovation is problem solving in order to better meet the needs of students.</td>
</tr>
<tr>
<td>2</td>
<td>How important is innovation to your teaching practice in the classroom?</td>
</tr>
<tr>
<td></td>
<td>For me I am a very reflective teacher in the classroom and I like to cater for all of the individual needs of the students in my class. So I use innovation a lot in terms of seeing that a need is not being meet. So I try to be creative and find other ways and new ways of teaching of assessment tasks and to accommodate for all needs of the students. So I would like to feel that I am fairly innovative.</td>
</tr>
<tr>
<td>Keywords:</td>
<td>Important. Teacher reflection allows me to accommodate individual needs of students in my classroom.</td>
</tr>
</tbody>
</table>

Figure 3.6.8.3. Example audio transcription from interview of participant.
3.6.9 Thematic analysis

Assigning an attribute to specific data helps to identify patterns which can be analysed later as mentioned by Richards (1999). In this study, thematic analysis was used to identify dominant themes such as money, time and training that may be used to foster innovation in education. This process of data analysis was used during and after the data collection process to facilitate the reduction of themes and creation of categories (Merriam, 1988). Further content analysis enabled a focus on the 3 main themes and calculations for how important each theme was for each of the \( n=25 \) participants in fostering innovation.

3.6.9.1 Example coding

Interview audio transcriptions were coded to identify the themes encountered in the responses from participants. As well as hand-written notes, themes related to money was highlighted blue, those themes related to requiring more time was highlighted light green and those requiring more training was highlighted dark green. Additional themes and other important concepts were highlighted purple. Any comments which may provide quotes were highlighted pink. These can be seen in the example of the thematic analysis as shown in Figure 3.6.9.1.
3.7 Mixed methods research

A convergent parallel mixed methods approach is a form of mixed methods design in which the researcher converges quantitative and qualitative data at approximately the same time. Both the quantitative and qualitative data is integrated and interpreted as the overall results of the research (Creswell, 2013). In this research, the descriptive quantitative data for ICT infrastructure between 2012 and 2016 is used for examining the efficient operation of a School organisation, which leads to saving money. These additional funds support the needs of teaching and learning for fostering innovation in education. The key areas for placement of funding in order to foster innovation in education is determined by the case study qualitative research conducted with 25 research participants.

As Yin(2014) states, mixed methods research involves collecting complementary data, allowing the researcher to examine more complicated, richer, research evidence.
3.8 Research sample size

While it is important for researchers to adhere to study procedures for qualitative research, some researchers say flexibility is the key to demonstrating the iterative process which changes as the study develops such as Davies and Dodd (2002), Drisko (1997), Frankel (1999) and Morrow (2007). As Leitz and Zayas (2010) mention, the data sample size may change depending on whether data saturation has been reached. In this research, a sample size of 25 was seen as suitable. This number was seen to cover Junior, Middle and Senior School teachers with 12 different teaching departments across the Middle and Senior Schools and several layers of teaching management. Several non-teaching staff members were also part of the purposive sampling selection in order to examine perspectives from support staff. More than 25 data samples were seen as not providing any more useful information or reaching a more significant data saturation level. Furthermore, additional data samples were not possible due to time and resource constraints.

3.9 Data collection

As identified by Yin (2011), good case study data collection benefits from multiple sources of evidence. Yin (2011) states case study research can include both quantitative and qualitative data and in an effort to increase the rigour of the research, triangulation of information was sought. The aim is to achieve convergence of information when three or more sources of data point to the same facts or interpretations (Yin, 2011).

This research study included archival records and physical artifacts in the form of quantitative capital ICT infrastructure components and costs. These were extracted from Tax Invoices and budgeting tables used for purchasing technology items over a 5 year period from 2012 to 2016.
The qualitative data included interviews with 25 staff from the teaching and learning and non-teaching and learning areas, covering 12 separate teaching and learning departments and teachers as well as management staff from Junior School through to Senior School. Participant observations were conducted from the perspective of the IT Manager for the School and direct observations were recorded in the form of more than 130 photos taken of the teaching and support areas throughout the School. These direct observations included field notes and deliberate interpretations of what has been observed. In some cases, information was presented from more than one point of view.

The number of questions for interview participants was aimed at collecting sufficient data from research participants while not exhausting the interviewees which may lead to a clutter of information and a confusion of responses as mentioned by Babbie (1990), Wadsworth (1997) and Leung, Cooper and Robertson (2004).

3.10 Data analysis

3.10.1 Descriptive quantitative results of ICT infrastructure expenditure from 2012 to 2016.

This data analysis examines the numerical data which represents ICT capital and ICT recurrent budget components and identifies trends in expenditure. Well performing educational facilities strives to operate ICT infrastructure as efficiently as possible, while aiming to accommodate the requirements for innovative practices in teaching and learning.

3.10.2 Thematic analysis of innovation in education interviews with staff (n=25).

This data analysis searches for factors which staff believe will help to foster innovation in education. Other data collected through alternative methods will be examined for rival explanations in order to show the highest level of rigour throughout the research.
3.11 Validity and reliability

As there is no statistical significance for the quantitative data examined in this research, there was no focus placed upon the validity or reliability of means, standard deviations or significance values in reporting of the numerical data. However, the data extracted should be transferable to another educational facility wishing to perform the same research and therefore the steps required should be clearly defined.

3.12 Trustworthiness of data (rigour)

From a qualitative research perspective, the trustworthiness of the data involves several strategies such as triangulation of data sources, the use of direct observations, member checking, peer debriefing, audit trails, thick descriptions, negative case analysis for reviewing rival explanations, researcher bias identification, reflexivity journal and prolonged engagement.

3.12.1 Triangulation of data

Triangulation of data is seen as obtaining a more complete understanding of the phenomenon under study (Breitmayer, Ayres and Knafl, 1993) and a method of increasing the credibility and validity of research results owing to convergence and corroboration of data (Duffy, 1987; Rossman and Wilson, 1985). Several authors including Duffy (1987) and Morse (1991) highlight triangulation as a strategy for enriching the data collected in ways that reveal new dimensions and details about the phenomenon under study. Mathison (1988) adds that triangulation can make sense of social phenomena which can indicate further areas of research.
3.12.1.1 Interview data

The interview data was recorded via a tablet device, transcribed and thematic analysis was used to code the results and provide a summary of the main themes fostering innovation in education for this case study. In addition, in order to show rigour in the case study research, member checking, debriefing, triangulation of data, audit trails, thick descriptions, negative case analysis leading to examination of rival explanations and maintenance of a reflexivity journal was undertaken.

3.12.1.2 Direct observations

Direct observations involved taking photos of the work areas for non-teaching staff and photos of classroom and staff areas for staff involved in the interviews. These direct observation images also included some photos of the buildings the staff worked in. Not only was the photos used to corroborate data, it was also used to provide rival explanations for funding issues to increase the rigour and thoroughness of the research. An example of direct observation photos is shown in Figure 3.12.1.2.
3.12.1.3 **Within method and across method triangulation**

Across-method triangulation combines two or more research traditions in the same study. Faithful (1991), Mashaba (1994) and Hanson (1994) have all successfully made use of this technique.

Across-method triangulation was used in this study by making use of qualitative interview data, direct observations and quantitative methods relating to hypothesis
questions using ratings for technology innovation and teaching method innovation to achieve convergent validity.

Within-method triangulation combines two or more similar data collection approaches for measuring the same variable. In this research, within-method triangulation was used as interview data was used in addition to direct observations to explore the need for funding of classroom technology and teaching environments in order to foster innovation in education.

3.12.1.4 Methodological triangulation

In terms of methodological triangulation, simultaneous triangulation occurred due to the use of quantitative analysis for question 20, used to rate the new and old forms of innovative technology and qualitative thematic analysis occurring at the same time with the open-ended research questions (questions 1 to 19). Sequential triangulation also was conducted as the descriptive quantitative analysis for ICT infrastructure components lead to the exploration for what teaching and non-teaching staff believed may foster innovation in the work.

3.12.2 Member checking

Member checking involves seeking feedback from the research participants in order to corroborate the findings (Creswell and Miller, 2000; Padgett, 2008). Member checking can be used to strengthen credibility in qualitative studies, however, as Barush, Gringeri and George (2011) state, the process has been criticized. When the participants have varying perspectives on the same data, whose view prevails. Throughout this research, the member checking process has reduced the reliance on researcher bias and interpretation and has increased the reliability and validity of the results. By listening deeply and raising questions with participants, as mentioned by
Barush, Gringeri and George (2011), the researcher has been given an opportunity to clarify or develop their thoughts which again strengthen their findings.

Shenton (2004) explains member checking could include selecting research participants in the data analysis or returning to a sample of participants with a draft of the findings to gauge the degree of agreement with the findings. This research included checking results with all of the \( n=25 \) research participants to ensure accuracy of the research findings. It must also be noted, although each of the 19 research questions were shown to the participants during the member checking process, only those questions relating to money, time and training were tested for accuracy. Padgett (2008) identifies member checking as raising practical concerns such as not having access to research participants during the member checking stage or assuming a sample of participants will provide the same results as all of the research participants.

The member checking process took place after the initial research interviews, though importantly before the data analysis took place. As mentioned by Sandelowski (1993) and Morse et al 2002, once the results have been synthesised, decontextualized and abstracted from individual participants, the individual participants may not recognise themselves or the data that encapsulated their experiences. However, Glaser & Strauss (1967) and Melia (1982) suggest research participants should review the verbatim transcripts and that they will be able to respond to their own words. In addition, Koch (1994) further suggests that participants should read the constructions derived from the analysis process. The member checking undertaken in this research was processed before the data analysis and gave the participants a detailed overview of their responses to all 19 questions in a very clear manner. This provided a very clear understanding of how their responses would affect the overall summation of results,
indicating the importance of the 3 main factors thought to foster innovation in education, these being money, time and training.

3.12.3 Peer debriefing

3.12.3.1 Definition of peer debriefing

Denzin (1994) states that debriefing is one technique which increases "the credibility of a project". Green (1994) defines peer debriefing as one of the "new procedures" to authenticate researcher interpretation. Learning and knowledge develop as peer debriefers and researchers extract the meaning from various data, ideas and methods (Schon, 1987).

Lincoln and Guba (1985) identify four purposes for peer debriefing. Firstly, debriefers encourage the researcher to probe for bias and deeper understanding. Support was given in terms of additional readings and studying the human side of the findings collected. Secondly, debriefing supports the researcher testing emerging hypotheses in a risk-free environment. Support was provided for gathering research data such as interview responses and direct observation photos within the guidelines of the ethics approval obtained. Thirdly, peer debriefing offers researchers the opportunity to develop and test upcoming steps in the research design. Research questions where fine-tuned and additional research data analysed to increase the rigour of the research. Lastly, researchers are able to express frustration and gain support and encouragement from a peer. Both research supervisors were available for personal support during the research process.

3.12.3.2 Knowledgeable other is a peer debriefer

A peer debriefer is known as a 'knowledgeable other' who is used as part of a strategy associated with qualitative research to ensure credibility and trustworthiness during the
research process (Figg and Jaipal, 2009; Erlandson, Harris, Skipper and Allen 1993; Lincoln and Guba 1985). The use of the 'knowledgeable other' can be used to challenge and critique interpretations which help 'to reduce or even remove blind spots' associated with qualitative data analysis as stated by Gordon (2006). This 'knowledgeable other' has been referred to as a critical friend (Gordon, 2006; Wennergren and Ronnerman, 2006). Costa and Kallick (1993) also state that critical friends act as peer debriefers in order to provide an external perspective in order to ensure rigor in the trustworthiness and credibility of the research. The researcher was fortunate to find two 'knowledgeable others'. This included a primary supervisor with experience in research techniques and an industry supervisor with experience in the field in which the study was performed.

3.12.3.3 Personal details shared during peer debriefing

Peer debriefing can involve some time divulging details about personal lives in order to understand factors that influence or impede the work of researchers (Figg, Wenrick, Youker, Heilman and Schneider, 2009). The peer debriefing atmosphere for some researchers can feel like a safe place, both professionally and personally, where they may just need people willing to listen (Figg, Wenrick, Youker, Heilman and Schneider, 2009). Cassell (1980) mentions that researchers who have completed a research project are recommended to use peer debriefing to facilitate examination of their relationship with participants, especially when dealing with complex ethical and interpersonal issues. The industry supervisor was very supportive during the research phase due to personal research issues and organisational political behaviour. For example, both supervisors knew of and were supportive during the loss of a family member during the research process. Barber and Walczak (2009) indicate that the primary responsibility of the peer debriefer is to critique the researcher's work in order to improve credibility. This working relationship should be based on honesty, trust and
communication as stated by Spall (1998). Fanning and Gaba (2007) mention the success to debriefing results from the debriefer providing a supportive climate where the researcher can share their experiences in a frank, open and honest manner. It is also important for the debriefer to acknowledge the vulnerability of the researcher, which must be respected always. Researchers are encouraged to use peer debriefing as a way of consulting with colleagues experienced in qualitative methodology as suggested by Padgett (2008). This discussion of research processes and the feedback provided to researchers can greatly enhance the quality of the study as stated by Shenton (2004).

3.12.3.4 The process of peer debriefing

The process of peer debriefing allows the researcher to examine stages of research design, data collection practices and data analysis while specifically chosen colleagues provide constructive feedback and encourage the researcher to explore the research process from multiple perspectives (Figg et al., 2009). Peer debriefing is a process to enhance the credibility of qualitative research (Spillett, 2003). Spillett (2003) mentions that the role of the peer debriefer is to encourage the researcher to consider the different methodological activities available and to provide feedback in respect to the accuracy and completeness of the data collection and data analysis practices. Lincoln and Guba (1985) state the ultimate purpose of peer debriefing is to provide an external check on the inquiry process. Peer debriefing discussions between the researcher and an impartial peer exam the progress of an investigation covering aspects such as preliminary data collection and initial data analysis and track through the methodological steps towards the concluding analysis (McMillan and Schumacher, 1997). Barush, Gringeri and George (2011) suggest that peer debriefing is a process of discussing and questioning of their work with a peer in a consistent and systematic fashion and to document the process in notes that can be later found useful throughout
the analytic process. A database of research information collected was provided to both supervisors to highlight progress of the research and for feedback of research processes and data collected and analysed.

3.12.3.5 Successful peer debriefing

Successful peer debriefing include commitment, continuity and knowing individual expectations are meet for the researchers, in addition to academic and emotional support (Figg, Wenrick, Youker, Heilman and Schneider, 2009). It must be noted that commitment can involve active participation with the researcher, sharing expertise, reviewing work or simply listening. Closely linked to commitment is continuity and prolonged engagement, in addition to providing moral support and encouragement to persevere. This was provided by both supervisors when the need arose. Peer debriefing can help researchers explore various research paradigms and strategies (Figg, Wenrick, Youker, Heilman and Schneider, 2009). Maxwell (1996) recommends seeking feedback from a variety of people, those who are familiar with the phenomena under study and those that are not. The result will be different sorts of comments and data in which both are considered valuable. Research ideas and concepts were discussed with other work colleagues external to the core data collection participants, providing additional feedback for the researcher. Lincoln and Guba (1985) state that debriefing is unquestionably a useful utility when properly engaged and the peer debriefer should probe for meaning, bias and understanding.

3.12.3.6 Other research strategies

Research methods texts encourage the use of peer debriefing in order to enhance the credibility or validity of qualitative research (Creswell, 1998; Ely, Anzul, Friedman, Garner and Steinmetz, 1991; Lincoln and Guba 1985; Maxwell, 1996; Merriam 1998). Spall (1998) suggest that peer debriefing is complementary to other qualitative research
strategies such as prolonged engagement in the research context, member checks, negative case review, referential adequacy and triangulation. This research undertakes these additional complementary qualitative research strategies to increase the credibility and rigour of the research undertaken. Areas in which debriefing take place are known to debriefers and researchers as a 'place' which offers rich resources for collaborative learning (Baskett and Marsick, 1992).

3.12.3.7 Disadvantage of peer debriefing

While it seems common sense to apply peer debriefing and auditing to research processes, some suggest these steps interfere with the search for "deeper structure of meaning" as described by Padgett (2008). As Leitz and Zayas (2010) mention, this may lead the researcher away from their intimate interaction with data. Keeping this in mind, this research utilised a constant process of feedback and examining data and processes with supervisors to explore rival explanations of exposed ideas and data.

3.12.3.8 Debriefer traits

The best qualities to look for in choosing a peer debriefer include experience in methodological training and qualitative research methods. Debriefers also need to understand the epistemology of qualitative research and what constitutes quality for this paradigm (Spillet, 2003). Spall (1998) mentions that the debriefer should be a peer whose input challenges and stimulates exploration of alternatives related to the project. In addition, the debriefer should also aim to make the researcher aware of personal values and perspectives that may taint or bias the data interpretation process. Spall (1998) suggests the researcher identifies the peer debriefer for their research at the proposal writing stage. Dissertation students chose debriefers with knowledge of the current phenomena being studied and who also had similar backgrounds in qualitative methodology. In addition, peer debriefers act as objective observers of the research
process, serve in the capacity of consultants in making research decisions, bring fresh perspectives to data interpretation and provide moral support during research (Figg and Jaipal, 2009). Researchers can prefer to seek out peer debriefers who are skilled in thematic analysis coding and category processing if that suits their research. In the case of this research, the peer debriefer may also offer ideas and suggestions for literature reviews, books to read, advice on data collection, data analysis and reviewing drafts. They will also benefit from advice in identifying sources of bias (Figg, Wenrick, Youker, Heilman and Schneider, 2009). Spillett (2003) also provides suggestions for finding debriefers, the frequency and duration of the meetings, activities to undertake, the type of dialogue that should occur and how to address the peer debriefing in the research report.

Spall (1998) indicates the trust involved in choosing the correct debriefer and the importance of that trust developing effective peer debriefing relationships. This includes the ability of researchers feeling comfortable with discussions and disagreements resulting in researchers feeling respected and valued for their contributions. Spall (1998) mentions the importance of the relationships between debriefers and researchers where there was an assurance of nondisclosure of sensitive matters, protection for the anonymity of respondents and support for the integrity of the researchers. Spillett (2003) provides guidance about the activities of a peer debriefer, however this focuses on the debriefer's role in developing the research methodology. Spillet (2003) also states that researchers should report on how the debriefer is chosen, the nature of the debriefing relationship and the effect of the relationship on the research, the frequency, duration and content of the meetings and the effect of debriefing on research and outcomes. It must be noted for this research, the primary supervisor was chosen by the university, while the industry supervisor was chosen by the researcher for the reasons explained above.
Additional strengths and skills for peer debriefers can be drawn from organisational politics and gender dynamics in organisational settings as described by Kanter (1977) and Morgan (1986). O'Neill (1995) states that organisational power imbalances do not disappear despite the best efforts of organisational members. Therefore, (Cooper, Brandon and Lindberg, 1998) recommend the selection of a peer debriefer with expertise in organisational theory. The industry supervisor chosen for this research has a recent background in this field of work and understands the organisational settings better than most. Cooper, Brandon and Lindberg (1998) suggest that we all learn through the process of questioning and clarification. In addition, they go on to suggest that when dealing with psychosocial aspects of organisational life, it is best to tackle issues when they are fresh. When dealing with the process of change it has been stated by Fullan and Miles (1992) that conflict is inevitable. Issues dealing with communication and source of influence where examples include expertise, opportunity and personal attributes have been mentioned by Bacharach and Lawler (1980).

3.12.3.9 Choosing a debriefer

Barber and Walczak (2009) state the researcher must take into consideration the characteristics and qualifications of the potential peer debriefer in order to enhance the credibility of the research. As previously explained, the primary supervisor for this research was chosen by the university and not by the researcher. However, the industry supervisor was chosen by the researcher based on confidence the researcher had in terms of knowing and working with the industry supervisor for the last 10 years. The background of the industry supervisor included business and teaching experience in addition to a professional doctorate in education. This also included experience mentoring Masters level students.
Barber and Walczak (2009) suggest the desired characteristics of a peer debriefer may not exist and therefore the best alternative is to use a diverse group of peer debriefers to provide different perspectives and expertise. In this research study the primary supervisor works in a university as senior lecturer in computer science with a current knowledge of qualitative methodological practices which helped with the research design. The industry supervisor has a background in teaching and learning in schools, business and budget experience which helped with coding and analysis.

3.12.3.10 Debriefer benefits

Spall (1998) suggest that a benefit from the peer debriefing process is that it establishes credibility for the research with both the researcher and debriefer exploring possible areas of bias which could be missed by the researcher if they are consumed by the details of the research project. Lincoln and Guba (1985) state the peer debriefing process helps to "keep the research honest". It helps to keep researchers on course as mentioned by Cooper, Brandon and Lindberg (1998). Spall (1998) states that feedback from some research students indicated the debriefing sessions urged them to become organised and meet deadlines. This was certainly the case for this research. Additionally, methodological steps helped in the overall planning or organization of their projects. Spall (1998) also describes how students found encouragement from debriefers when results were shared and milestones were obtained. This professional doctorate study has found the same sorts of encouragement and excitement from both supervisors when completing research steps and milestones. Peer debriefing may also provide the researcher with a coping mechanism for the stress that accompanies fieldwork (Zigarmi and Zigarmi, 1980).

Cooper, Brandon and Lindberg (1998) mention that few researchers deploy the peer debriefing process at the end of their research study, despite the final phase of the
research involving just as many interpersonal, theoretical and ethical considerations. This research has involved peer debriefing on a constant basis and the benefits gained from peer debriefing has only magnified during the final stages. Lincoln and Guba (1985) offer a cautious approach to thoughtful, empathic and flexible advice for researchers who may feel discouraged if they feel their insights and judgements are not what they should be. Debriefers should be aware of becoming too influential and not demanding adherence to any particular methodological process Lincoln and Guba (1985).

Spall (1998) suggests peer debriefing provided continuous professional development. In addition, debriefers with experience in qualitative research and in particular managing field notes helped researchers manage the large accumulation of data over a long period of time, Spall (1998). The result was the construction of graphic presentations and management plans for the data collected. Spall (1998) writes that peer debriefing was a development process. Wasser and Bresler (1996) refers to this as 'joint striving' and Schratz (1993) refers to this as 'collective reflection'. Therefore, the skills required for debriefing were learned, expanded upon and applied and practiced. In addition, these skills were transferable to other peer debriefing situations. Spall (1998) indicates that readers of research reports judge the credibility of the findings from procedures and processes such as peer debriefing. Therefore, an in-depth account should describe the debriefing experience. This should include information such as how often the sessions were held, who the debriefer was and any outstanding contribution the debriefer made to the sessions. The entire research peer debriefing process for this study has been a fluid and flexible arrangement in which meetings were mixed between weekly, fortnightly and sometimes monthly sessions, depending on the needs of the researcher. Spall (1998) indicates peer debriefing is necessary for producing high quality dissertations. However, Spall (1998) and Cooper, Brandon and
Lindberg (1998) focus on the roles and relationships between researcher and debriefer, without the details associated with the debriefing sessions.

3.12.3.11 Debriefer process

Peer Debriefing is seen by some advocates as seeking an external colleague who can support the credibility of the findings (Appleton 1995, Burnard 2002 and Cassell 1980). Lincoln and Guba (1985) requires researchers to interpret data in the same way if overall credibility is to be increased. Spall (1998) indicates that debriefers have used research methodology literature to test the types of interview questions or to expand on interpretative skills used for data analysis. These include activates suggested by Strauss and Corbin (1990) to develop analytical sensitivity to emerging data. Several peer debriefing sessions have included laterally thinking of alternative meanings for data, rival explanations and often negative case analysis, leading to improved interpretation of research data, increased credibility and rigour throughout the research process.

Schutz (1994) and Cutcliffe and McKenna (2004) suggest that analysis of data in qualitative research is an individual and unique process between the researcher and the data gathered. It is stated by Andrews, Lyne and Riley (1996), Cutcliffe and McKenna (1999) and McBrien (2008) that no two researchers will interpret the data the same way. It is recommended by Ryan-Nicholls and Will (2009) that researchers make use of peer debriefing in qualitative research with caution. The answer is not to have multiple researchers reach the same thematic coding, but instead see them agree upon data labels and the same logical paths taken to arrive at those labels (Graneheim and Lundman 2004). There is little information regarding strategies and practices associated with peer debriefing (Barber and Walczak, 2009) Several researchers (Creswell, 1994; Creswell and Miller, 2000; Lincoln and Guba, 1985; Merriam, 1998; Weiss, 1994) recommend using peer debriefing to improve the credibility of qualitative
research. Spall (1998) mentions that each peer debriefing session will vary just as each research design varies. Barber and Walczak (2009) indicate the peer debriefer role includes acting as the conscience and critic for the researcher's work, providing a "second opinion" on the meaning of data and emerging theory. This research has greatly benefited from the use of peer debriefing.

Barber and Walczak (2009) provide the following best practices for peer debriefing: Orient the peer debriefer to the research and data. Mutual preparation in advance of each meeting. Meet regularly and in person to debrief. This was only possible for the industry supervisor due to geographic distance between primary supervisor and researcher. Review and debrief 20-25% of data.

3.12.3.12 Debriefer typical questions

Spall (1998) mentions several questions debriefers can ask of researchers to check for bias. These include "What are possible alternative steps?", "What are other ways to state the question?", "Who else might have similar or different information?", "What brought you to this conclusion?", "How do you think the respondent gained this knowledge?", "Did you ever think of ...?", "Have you considered ...?" and "Could you explain ...?" Several of these questions were asked by the researcher and some by the supervisors throughout the many debriefer sessions.

3.12.4 Audit trails

Audit trail rigour requires the researcher to clearly indicate the decisions undertaken throughout the research and to explain the methodology followed and interpretation of data processes. It was noted by Koch (1994) that readers may not share the same interpretation of the research data as the researcher, however, they should at least follow the logic followed by the researcher in deriving the interpreted results. The audit
trail is constructed from a comprehensive notes relating to the contextual background of the data and the rational followed for all methodological decisions (Glaser and Strauss 1967, Rodgers and Cowles 1993, Ryan-Nicholls and Will 2009). Decisions made during the data collection and analysis processes, if documented, can enhance rigour of the research by presenting a comprehensive 'trail' (Richards 1999, Bringer, Johnston and Brackenridge 2004, Silverman 2010). Audit trails can be used to increase confirmability in qualitative research Barush, Gringeri and George (2011). Good record keeping throughout the research process is part of the accountability or transparency for audit trail criterion (Anfara, Brown and Mangione 2002). Auditability is the degree to which research procedures are documented and can be followed by someone outside the project and critique the research process (Padgett, 2008). Leitz and Zayas (2010) explain strategies for increasing auditability include maintaining an audit trail, engaging in peer debriefing and including a report of what research processes and occurrences took place throughout the project with an inclusion of reflexivity. This research includes an audit trail in order to demonstrate accountability of the processes followed, to increase confirmability and allow readers the chance to follow the logic used throughout the research and the methods engaged to interpret the findings.

This research allowed the interpretation of data by the researcher to become examined by each research participant, at the member checking stage, in order to confirm the findings were not just the perception of one person. Furthermore, the results across multiple interviews (n=25) provided additional credibility to the research. Thematic Analysis used coding queries to find text that stated 'money', 'funds', 'time' 'training' as examples of important themes mentioned by research participants.
Bryar (1999) and Ryan-Nicholls and Will (2009) mention the discernment of the means used to achieve data interpretation and the methodology followed can be achieved by an audit trail. Ultimately, the end product will be judged on the process undertaken and the trusting in the descriptions recognisable to readers as suggested by Rubin and Rubin (1995), and Horsburgh (2003).

It has been noted by Bassett 2009, Silverman 2010 and Bergin 2011, researchers need to guard against excessive emphasis on rare findings that help the preferred argument of the researcher. In addition, a reflexivity journal has been maintained to help with protecting against researcher preferences or bias.

3.12.5 Thick descriptions

Thick descriptions include accounts of the context, research methods followed and examples of raw data with the intention of allowing readers to consider their interpretations as stated by Stake (1995), Popay, Rogers and Williams (1998) and Dawson (2009). The reader can then decide for themselves if the findings are transferable to another context as stated by Graneheim and Lundman (2004). Thick descriptions have been included of the context and settings of the research interviews and also through direct observation photos of the classroom technology and general building design. The result is a rich and vigorous presentation of the findings with appropriate quotations which is suggested by Graneheim and Lundman (2004) as enhancing transferability. Leitz and Zayas (2010) highlight thick description as particularly significant in constructivist research and in ethnographic studies, although thorough description of the context and research procedures is relevant for any form of qualitative research irrespective of the paradigmatic position chosen. Leitz and Zayas (2010) describe thick descriptions as including prolonged engagement such as multiple interviews, the frequency, duration and intensity of data collection, probing techniques,
whether interviews were audio-recorded, note taking and whether saturation was achieved. Creswell and Miller (2000) explain the concept of thick description as providing the reader with a credible account of the event to the point where the reader feels transported into a setting or situation and feel as though they have experienced or could experience the events as described throughout the study. This is the intention of the thorough research process, in order for the reader to feel as though they have been transported into the settings in which the research was undertaken.

Lincoln and Guba (1985) make use of the term transferability or parallel term for generalisability which is strengthened with the use of thick description. Readers can make a more informed decision regarding the potential for application into other contexts with a more detailed account of the research context. Koch (1994) mentions the degree of transferability is greatly increased when the original context of the research is adequately described so that judgements can be made. In order for the reader to make an informed decision about the transferability of the findings, detailed descriptions are needed as suggested by Lincoln and Guba (2000), Firestone (1993), Stake (1995), Bogdan and Biklen (2003) and McKee (2004). This will also include responses from research participants in relation to key factors fostering innovation in education which can be found in Table 5.2.12.

Additional thick descriptions in terms of quotes from participants can be seen in Table 5.2.3. These quotes give an insight into how staff identify with innovation for example and was indicated by Houghton, Casey and Shaw (2012) as providing the readers of this research with the ability to make informed decisions about the findings when applied to their own contexts. “Innovation is using new and emerging technologies in classroom learning environments” is recognition that innovation is linked with technology. However two examples of linking innovation with something
other than the technology are “Innovation doesn't have to be a product, it can be a process” or “Innovative teaching practices involve providing a task, unpacking the student thinking and using this as a teachable moment in the classroom”. Then there is recognition of both technology and teaching practices with the quote, "Innovation in education is both styles, technology and way of teaching”.

Further thick descriptions can be found in the form of direct observation photos found in Appendix E. These help the reader interpret their own opinions on whether innovation for example is linked to lack of funding by displaying building age, provision of facilities and services for work areas, classroom teaching and staff areas.

3.12.6 Negative case analysis

Negative case analysis is a strategy used when a researcher deliberately seeks contrasting evidence as described by Padgett (2008). The negative case analysis strategy should also apply to the data analysis stage of the research process as suggested by Leitz and Zayas (2010). This strategy has been noted as especially useful for constructivist research as indicated by Creswell and Miller (2000). In addition, Drisko (1997) states seeking contradictory evidence is essential to achieving a complete and exhaustive exploration of a phenomenon. Barush, Gringeri and George (2011) suggest that negative case analysis can be used to challenge the emerging patterns in a study. This could then aid in the exploration of rival explanations to further increase the rigour of the research. In this case study, rival explanations have been used to explain why some participants believed no money, time or training were needed in their departments for fostering innovation. These can be seen in particular in Appendix R.
3.12.7 Researcher bias

To minimise research reactivity and bias, Junker (1960) suggests a range of engagement from complete participant to complete observer and various degrees of each in between. In this research, the researcher acknowledges the management of technology requires constant funding and resource allocation. However, while the research benefits from the partial participant and partial observer engagement over a period of 5 years as the researcher is employed in a position of IT management at the School, the researcher has been constantly aware of any affect this may have on the interpretation of the findings.

Leitz and Zayas (2010) remind us researchers must be mindful regarding the potential impacts research procedures can have on findings. Drisko (1997) alert researchers to becoming self-aware of their own influences on research projects. Researcher bias can come from preconceived ideas of the researcher which may unintentionally shape the design of the study and therefore lead to a misrepresentation of the data as described by (Leitz, Langer and Furman, 2006). Horsburgh (2003) states that research questions, research procedures and the processes followed for data analysis will have the potential to become influenced to some degree by the experience and knowledge base of the researcher.

In addition, Leitz and Zayas (2010) state some authors may include a statement of self-disclosure in which the researchers acknowledge their own bias and potential for influencing the research findings. The researcher has been as open as possible in acknowledging any influence placed on the findings and has increasingly sought rigorous research approaches in an attempt to demonstrate a high level of research credibility and thoroughness.
3.12.8 Reflexivity journal

Barber and Walczak (2009) state that reflexivity requires researchers to be aware of their own thought process, epistemology and subjectivities during the analytical process. Guillemin and Gillam (2004) mention that reflexivity involves critical reflection of how the researcher constructs knowledge from the research process. This can include those factors which influence the construction of the knowledge throughout the research and how these influence the planning, conduct and writing up of the research. Johnson and Waterfield (2004) define reflexivity as a thoughtful consideration of a researcher's standpoint through reflection which may occur through keeping a written journal and engaging in dialog with peers. In fact, Barber and Walczak (2009) regard reflexivity as an important component of the evolving peer debriefing process which can lead to resolving discrepancies between the individual interpretations of the researcher and debriefer.

Guillemin and Gillam (2004) point out that reflexivity is not an activity that happens at one point in time, but instead during the entire research process.

It has been suggested by Jasper (2005) it is important for researchers not to remove personal responses or contributions to research and Rodgers and Cowles (1993) remind us that throughout qualitative research the researcher is considered part of the research instrument. Therefore the research process and credibility of the research rests upon procedures and the self-awareness of the researcher as stated by Stoecker (1991), Rodgers and Cowles (1993) and Mantzoukas (2005).

A reflective diary is considered an important part of reflexivity (Rodgers and Cowles 1993, Koch 1994, Koch and Harrington 1998, Johnson 1999 and Jootun, McGhee and Marland, 2009). A well maintained reflective diary should show the history of the researcher and their personal interests and involvement in the research.
It should also demonstrate how the theoretical perspective has affected data collection
and analysis as indicated by Van Maanen (1991), Toffoli and Rudge (2006). The
reflective diary should also show any personal challenges and instincts the researcher
experienced during the research as mentioned by Primeau (2003) and Rolfe (2006).

The reflexivity journal for this research can be found in Appendix F.

3.12.9 Prolonged engagement

Prolonged engagement requires a researcher to spend a sufficient amount of time in the
field of study in order to develop trust and relationships which allow the researcher to
see and understand the settings from an insider’s point of view. The result will be a
rich description of the settings of the research, understanding a variety of perspectives
and constructing meanings from members in that setting. It also must be noted that the
length of time for prolonged engagement or persistent observation is dependent on the
author's accountability with regard to methods used in the research process.

Prolonged engagement & persistent observation requires spending sufficient
time in the field to gain full understanding of phenomena and show sign of lack of new
information concluding that information saturation has been achieved (Altheide and
Johnson, 1994).

This research was conducted over a 12 month period for the qualitative research
component. However, the quantitative research data was extracted over a period of 5
years. In fact, the researcher who is the IT Manager at the School, formed a good
understanding from an insider’s point of view and managed a persistent observation
due to having been employed in the current IT Manager position for this longer period
of time.
3.13 Ethical considerations

This research followed the guidelines of the Faculty of Business Human Research Ethics Committee from CSU. Ethics approval is shown in Appendix G. All participants were required to read participation information sheets and sign consent forms as shown in Appendix H and Appendix I respectively. A certificate of appreciation was awarded to each participant in recognition of their contribution to this research project as shown in Appendix J. Every effort was made to provide a high level of anonymity and confidentiality. Gregory (2003) claims participants are not likely to reveal their real feelings or opinions, if they do not believe their confidentiality is confirmed. In addition, due to some participants linking some questions to management decisions and the thoughts of possible future negative impacts to themselves, confidentiality, not anonymity, is the key issue to address (Gorman and Clayton, 2005). Bryman (2004) explains ethical issues are not only limited to physical harm, but potential psychological issues as well. All participants took part in the project voluntarily and participants were told they could leave the study at any time. Information given by participants was disguised to protect their identity (Newman and Brown, 1996). As explained by Liebermann (2013), it is important to acknowledge each participant was informed there was no pressure to take place in the study and the participants were free to leave the study at any time.

Researchers need to be aware of the level of voluntary acknowledgement by the participants. During this research a few of the participants were working under the IT Manager and therefore despite the IT Manager assuring them of complete anonymity and confidentiality, this voluntary agreement could be questionable (Pritchard, 2002). As stated by Johnson (2002), despite following the ethical guidelines, it is important to tell the truth. This is easier when using a reflexivity journal to keep track of your
thoughts and ideas as a researcher, especially during a longitudinal research project. Some responses to research questions, including appointments for interviews, may require emails from participants in view of other office staff, which may impact their willingness to respond (Murray and Sixsmith, 1998). All interview dates and times are recorded in Table 5.2.1 and Table 5.2.2.1.

Direct observation photos were reviewed for any written text that may indicate the location of the School used in the study and these were removed or smudged to avoid recognition. In addition to ensuring there was no harm to the participants, the quality of the information gathered was important to the researcher (Miles and Huberman, 1994).

Ethical considerations include having a good understanding of ethical conduct in conducting respectful research (Tilley, 1998). As Tilley and Powick (2002) explain, if participants reviewed their own interview transcripts, they would see the poor grammar as a reflection of themselves. For this reason, all transcripts from original audio tapes were not shown to interviewees during the member checking process. Only the coding from thematic analysis was shown to interviewees for confirmation of their responses to questions relating to more funding, more time and more training as these were considered the main themes derived from the research.

Information for this study will be kept for no more than a period of 5 years. Data, considered confidential is stored on a device with password protection and is safely stored away from public viewing.

3.14 Conclusion

This chapter describes the research design and why a mixed methods approach was chosen. A quantitative method for the ICT infrastructure components was conducted
and the use of qualitative method was used for the exploring how best to foster innovation in education. The use of a constructivist paradigm was explained and why that was best suited to this study. Explanations were given for the use of a hypothesis for comparing old and new technology and teaching methods. Descriptions were given for the use of thematic analysis in determining important themes from the research.

Research sample size and data collection methods were explained. Data Analysis for the quantitative and qualitative methods was explained.

The importance of showing rigour in the research was thoroughly examined covering many topics including triangulation, member checking, peer debriefing, audit trails, thick descriptions, negative case analysis, researcher bias, reflexivity journals and prolonged engagement.

Finally, ethical considerations including procedures and conduct for respectful research was explained.

The next two chapters describe the data analysis for this research. The first chapter describes the quantitative data analysis component.
Chapter 4. Data Analysis – Quantitative

4.1 Background and demand for ICT Infrastructure

One of the key justifications for expenditure on ICT Infrastructure is data that shows the need for increases in demand for IT services. IT Services notice demand increasing in the areas of internet usage, print and copier services, wireless services for client devices, storage, backup and DR services and virtual machines used for different administration functions throughout the School. Large numbers of helpdesk tickets each year can indicate training required for staff using various information technology systems and the proactive need to replace aging equipment, which if not replaced can require a lot of troubleshooting. These services are discussed in the following sections.

4.1.1 Demand for internet services

Internet usage has increased from an average of 40GB of data per week during the early months of 2012 through to an average of more than 260GB per week during the peak months in late 2016. Many learning based activities rely on internet usage. With the increased use of Youtube and video-based training for students, sufficient bandwidth is required to service these activities. Therefore, efficient and adequate ICT
infrastructure is required. The data shown below outlines the expensive capital expenditure items required to support the above activities.

Appendix K.1 shows the demand for internet usage from 2012 to 2016, which is the period in which data was collected for this case study. Additional yearly charts are shown in Appendix K.2 (2012), Appendix K.3 (2013), Appendix K.4 (2014), Appendix K.5 (2015) and Appendix K.6 (2016).

4.1.2 Demand for printer and copier services

Demand for printing and photocopyer services is high. The School has almost 2000 users, more than 110 printers and photocopiers and processes on average, 1.75 million pages per year with daily totals peaking around 17000 pages in a day and most term time daily averages exceeding 7000 pages per day as shown in Appendix L.

4.1.3 Demand for wireless services

The demand for wireless services has been increasing at the School as more devices make use of the mobility of devices with wireless capability. More than 900 wireless devices and more than 600 wired devices can attach to the network each day as shown in Appendix Q.

4.1.4 Demand for storage, backup and DR services

The demand for storage services grew from the need to store staff and student information on the School campus. New technology in the form of hyper-convergence technologies has taken advantage of high de-duplication and compression techniques to store more data than was ever possible in less storage space. This was evident when the server and SAN replacement involved sizing a new system for storage, retrieval and disaster recovery mechanisms was sized smaller than previous systems and still
allowing for predicted future growth. An example is shown in Appendix N, where more than 167TB of data including backups is stored in just 15TB of space. De-duplication results in a ratio of 8.1 to 1 in terms of space savings and compression results in a 3 to 1 saving. Local and remote DR services also result in file and folder restoration processes taking only a matter of minutes for data saved historically over a previous 6 month period. The new hyper-convergence system also resulted in improvements in reduced need for tape backup media and off-site backup services, VMWare licensing, power usage and rack capacity.

4.1.5 Demand for virtual machines

Many internal and external systems make use of virtual machine (VM) technologies inside the School ICT infrastructure. These are required due to the need for internal file storage space, exchange mail services, security services, print services, School information and administration services and other external business related requirements. A total of more than 40 virtual machines are managed by the IT Services team and the ICT infrastructure required to support School functions. IT Services are constantly reviewing the need for VMs and how to operate them more efficiently.

Some virtual machine usage includes ad-hoc creation and maintenance of VMs to support additional print services such as the Fuji Xerox ustore feature for custom print anywhere, anytime printing abilities. Flexischools require a VM for allowing the use of integration of payment systems with student and staff ID cards within the School. An ADFS server is used to allow SSO integration with an external program for managing leave requests for staff. These are additional to VMs used for domain controllers, file servers, web servers, exchange servers, SQL database servers and other required VMs for infrastructure services.
4.1.6 Demand for helpdesk support

The quantity of helpdesk tickets indicate the demand for IT Services. Appendix O displays more than 2000 tickets on average are generated and documented from 2012-2016 (total of 10827 recorded). Many helpdesk tickets are not recorded due to staff and students requiring quick, on the spot, help and support at the technical support services counter. Phone calls can also often result in fast and instant support without the need for generation and documentation of a helpdesk ticket. However, despite this, there is an ongoing demand for troubleshooting support from the IT Services team, with an average of more than 215 helpdesk ticket recorded per week (IT Services are available for 50 weeks per year).

4.2 Quantitative Data Collection and Analysis

4.2.1 ICT Infrastructure capital budget items

Table 4.2.1.1 lists the costs recorded for the major components of capital infrastructure required to maintain the School ICT infrastructure over a 5 year period from 2012 to 2016.
Table 4.2.1.1 Components for Capital budget 2012-2016 (template for data).

<table>
<thead>
<tr>
<th>Purchase Description</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Individual ADP 3 YRS NBD</td>
<td>$110</td>
<td>$110</td>
<td>$100</td>
<td>$90</td>
<td>$92</td>
</tr>
<tr>
<td>- Individual Deployment</td>
<td>$55</td>
<td>$55</td>
<td>$35</td>
<td>$22</td>
<td>$25</td>
</tr>
<tr>
<td>- Individual Bag</td>
<td>$40</td>
<td>$30</td>
<td>$37</td>
<td>$34.55</td>
<td>$35</td>
</tr>
<tr>
<td>- Individual Tekskin</td>
<td>$11</td>
<td>$11</td>
<td>$11</td>
<td>$11</td>
<td></td>
</tr>
<tr>
<td>- Total Individual Laptop Cost</td>
<td>$216</td>
<td>$206</td>
<td>$183</td>
<td>$158</td>
<td>$163</td>
</tr>
<tr>
<td>1:1 Laptops</td>
<td>368221</td>
<td>332468</td>
<td>334150</td>
<td>301167</td>
<td>267050</td>
</tr>
<tr>
<td>Laptop Deployment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8200</td>
<td>0</td>
</tr>
<tr>
<td>Data Projectors</td>
<td>28660</td>
<td>66083</td>
<td>11189</td>
<td>85000</td>
<td>77000</td>
</tr>
<tr>
<td>SAN</td>
<td>90000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SAN Switches</td>
<td>25400</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SAN Implementation</td>
<td>15000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Servers</td>
<td>28000</td>
<td>26616</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Backup Servers/Tape Drives</td>
<td>0</td>
<td>24811</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Simplivity Solution</td>
<td>0</td>
<td>0</td>
<td>229000</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>UPS (Major)</td>
<td>17500</td>
<td>6406</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Server Room Electrical</td>
<td>18500</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cisco Switches</td>
<td>0</td>
<td>0</td>
<td>235019</td>
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<td>0</td>
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<tr>
<td>Fibre Cables</td>
<td>0</td>
<td>0</td>
<td>4258</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cisco WAPs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>69300</td>
</tr>
<tr>
<td>WAP Implementation</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17500</td>
</tr>
<tr>
<td>Cisco SFPs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>44000</td>
</tr>
<tr>
<td>Software (Major)</td>
<td>34400</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Apple iPads</td>
<td>0</td>
<td>2174</td>
<td>18000</td>
<td>0</td>
<td>81000</td>
</tr>
<tr>
<td>Admin Desktops</td>
<td>0</td>
<td>71875</td>
<td>0</td>
<td>0</td>
<td>60600</td>
</tr>
<tr>
<td>Staff Devices</td>
<td>0</td>
<td>0</td>
<td>144100</td>
<td>49000</td>
<td>0</td>
</tr>
<tr>
<td>PrintRoom Printers</td>
<td>0</td>
<td>9980</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Printer - ID Cards</td>
<td>0</td>
<td>8971</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>625681</td>
<td>549384</td>
<td>746716</td>
<td>672367</td>
<td>616450</td>
</tr>
</tbody>
</table>

The individual table items are explained below.

The total capital expenditure is hovering around the $700K amount and all depends on when key infrastructure components are due for replacement. This is shown in Figure 4.2.1.1.
The total laptop fleet costs have dropped by more than one third (37.9%) or from $368221 in 2013 to $267050 in 2017. The specification of the device has almost remained unchanged during the last 5 years, with more pressure placed on vendors to provide the device at lower costs. This has been the result of more competition between suppliers. This drop in total laptop fleet costs are shown in Figure 4.2.1.2 below.

Individual laptop pricing has dropped dramatically with more pressure placed on suppliers. Initially, vendor incumbency was replaced with more competition between suppliers and has reduced the price of the same or similar specification-based machine
by more than half (51.3%) or from $905 in 2013 to $598 in 2017 per laptop. This trend is shown in Figure 4.2.1.3.

![Figure 4.2.1.3. Individual laptop cost.](image)

Total pricing for laptop accessories includes NBD (Next Business Day) warranty for 3 years, ADP (Accidental Damage Protection) for 3 years with $0 excess, a laptop bag, a tekskin for students to customise the look of their laptop and protect the surface of the laptop from damage and the cost of imaging and deploying the laptop. These prices have also reduced through negotiating harder with suppliers on price. The total for accessory pricing for laptops has dropped by almost one third (32.5%), from $216 in 2013 to $163 in 2017. These trends in laptop accessories is shown in Figure 4.2.1.4.

![Figure 4.2.1.4. Cost of laptop accessories.](image)
Laptop deployment costs normally come from recurrent budgets unless there is a change in device requiring different infrastructure to support the new type of device. These prices have been negotiated with suppliers by offering suggestions on how to run the imaging process more efficiently with greater interaction and collaboration between IT Services staff in the School and staff working for external vendors. This price has dropped significantly by 220%, from $55 per device in 2013 to $25 per device in 2017. When $30 is saved for each laptop deployment and there is 350 laptops in the yearly laptop deployment process, savings of more than $10000 each year are possible.

Data projectors are best purchased for all classrooms at one time. This results in the same type of projector in terms of training for staff, software to utilise all of the features of the projector, mounting and support structures in terms of costs for installation and ease of troubleshooting for technical service staff. However, the initial request for $250K in one capital budget year was not possible due to the limited budget for IT Services. This has meant a gradual process of deployment across the 110 classrooms and the unfortunate deployment of several different data projector models.

The traditional servers and storage mechanisms included 6 servers and 1 SAN. The SAN purchased in 2009 was 40TB in capacity. In 2013, this SAN capacity increased to 60TB of raw storage space. Servers were replaced each year as pairs having been used for the 3 year warranty period. SAN Switches were used to connect different interface formats and were part of the older, more traditional server/storage process. Part of the implementation process for installing and configuring the new SAN required external contractors to ensure the School made the most of the new technology purchased and all equipment was installed and operated efficiently.
High end, though far less expensive, desktop server were installed as backup servers running DPM or Data Protection Management server software which was free and part of the School's MVLA (Microsoft Volume Licensing agreement). Storage was provided for restoration of data for several months on site. This made data restoration by IT support staff easy. Data was then archived off to tape using LTO4 and LTO5 tapes on LTO5 tape drives. These tapes were moved off-site on a rotational basis using an external data protection company in which the cost is part of the recurrent budget.

In 2015, the introduction of hyper-convergence solutions to the School was announced. Initial conversations around scoping the size of the backup solution required a smaller 25TB solution. This was only possible once the technology was fully understood. In the Simplivity solution, a specifically designed PCI card called an Omnistack accelerator card was used to manage data with high compression and deduplication algorithms before the data was written to disk storage. In addition to this, due to the large storage savings offered, local DR was established and the ability to store a week of VM backups was implemented. A simple wizard can be used to restore file and folders data within seconds to a mounted CD-rom drive for restoration to any target. This solution not only made good business sense in terms of the overall pricing compared to the traditional server and storage solutions, it offered several "soft" cost savings. The reduction in overall CPU usage produced a reduction of $3000 per year in VMWare costs. Not needing the VEEAM licensing for backup to a DR site reduced the licensing a further $7000 a year. Not as many tapes were needed and the number of tapes rotated off-site also reduced costs by a further $3000 a year. Additional savings were possible due to reduced power requirements when the previous 20RU of rack space was reduced to 6RU.
The main server room is protected by a 16KVa UPS with a run time of over 30 minutes under full load. This would give the IT Services team time to safely shutdown virtual machines and other equipment before power was fully disconnected. However, the UPS only needs to keep the rack of equipment running for less than one minute as the external diesel generator is started. The generator can maintain full load for more than 3 days without requiring refilling.

When the older 10KVA UPS was moved to the DR site, the new 16KVA UPS required 3 phase power upgrades and the installation of new power surge protection devices.

As part of the upgrade of the network from 1GB to 10GB, new network switches were purchased. These new Cisco 4500 series core switches and 2960X edge switches provided the capacity of 10GB network capability to the edge of the network. The network switch upgrade also provided the opportunity to implement a smart port solution, where the CDP or Cisco Discovery Protocol was used to identify the manufacturer of the device plugged into the switch, via part of the MAC address of the device, and associated the device with a specific VLAN for network segregation and security reasons. Phones, WAPs, printers, computers and other devices were all identified by colour coded thin Ethernet cabling which made identification and troubleshooting of end devices easier, but also provided better ventilation for the more than 50 racks of equipment around the school.

As part of the network upgrade from 1GB to 10GB, one redundant link was upgraded from OM1 to OM3 to enable 10GB bandwidth for data.

In preparation for the upgrade to 10GB and the knowledge more devices were becoming 'ac' enabled for faster wi-fi speeds, the WAPs (Wireless Access Points) were upgraded from the previous 'n' grade speed of 300Mbps to the new 'ac' grade 1300Mbps
speed. The network was still limited by 1GB copper Ethernet patch leads running from
the network switches to the RG45 network wall ports connecting the WAPs. However,
this still represented a more than three-fold increase in speed for end users using 'ac'
enabled wireless devices.

The WAP installation required a firmware upgrade of the Cisco 5508 wireless
controller so the controller could recognise and communicate with the 2800 series 'ac'
WAPs. In addition, once the new WAPs were installed, a site survey was performed to
see if the network coverage required any further modification.

To complete the upgrade to the 10GB network, the SFP (Small form-factor
pluggable transceivers) were also upgraded to 10Gb capable.

To help with automating the creation of user accounts from the School truth
database, an external company was contracted to install and configure software. This
reduced the amount of time required by IT Services, on new user creation and general
user maintenance.

In 2014, a couple of Apple iPads were purchased for research purposes and to
see how best to cater for larger numbers of the devices in the School environment. In
2015, 24 Apple iPads were purchased for each of the Junior School classroom teachers,
providing them with a year of trailing apps on the device to see how best they could
use the device. In 2017, 100 Apple iPads were purchased for Junior School. Since the
upper Junior School, years 3 to 6 were part of the 1:1 laptop program at the School,
those year levels received a storage cube for charging and syncing apps top the devices
and 6 iPads per year level. However, for the lower Junior School, years pre-prep to
year 2, each classroom received the storage box and 6 iPads.
All administration staff receive a new desktop computer every 3 years. The specification of each desktop is the same in an attempt to maintain a SOE (Standard Operating Environment) so technical management is as easy as possible for the small number of IT Services staff.

All staff receive a new staff laptop every 3 years. In 2015, a decision was made to choose two separate devices, one a windows device and one an Apple device. The School infrastructure was not prepared for the introduction of Apple devices, and therefore the introduction of Apple devices was postponed until sufficient infrastructure such as an MDM for management of Apple iPads and other iOS devices could be implemented. This also included managing bonjour traffic from Apple devices and providing the ability of air-print services to Apple devices. Devices usually required funding of $1300 per device and an additional $350 was required for docks, adaptors and cables for connecting devices to data projectors and other audio visual equipment.

In 2014, a specific wide format colour inkjet printer was purchased from the IT capital budget. Future purchases come from another budget directly related to print room activities.

Each year more than 1300 student ID cards are printed. Some staff cards are also printed due to change of titles or the requirement for new photos. The costs of cards and colour cartridges, plus cleaning strips come from the recurrent budget. However, in 2014, two new Magicard ID card printers were purchased for redundancy purposes.

4.2.2 ICT Infrastructure recurrent budget items

The majority of maintenance costs come from replacing or repairing UPS units, printers, data projector associated cabling and equipment, speakers and other electrical
repairs. With smarter purchasing options and increased pressure on suppliers to provide more competitive pricing, overall maintenance costs have reduced by more than 250%, from $53500 in 2013 to $21000 in 2017. One example is the original idea of paying an outside vendor more than $400 to come and clean and fix an older laser printer. The better solution was to simply replace the entire laser printer with a new printer purchased in slightly larger quantities of 6 with high yield toner cartridges for less than $400 for each printer. The School manages more than 60 of these devices around the School and would on average replace at least 12 each year. These maintenance costs over a 6 year period from 2012 to 2017 are shown in Figure 4.2.2.1.

![Maintenance Subtotals](image)

**Figure 4.2.2.1. Recurrent budget maintenance costs.**

Software licensing is one area where costs have increased significantly by more than 152.5%, from $125900 in 2012 to $192050 in 2017. Although the School is paying correctly for services used in terms of number of licenses, larger vendors such as the School information system, TASS and the Microsoft Volume Licensing are a huge drain on funding and need to be questioned as to what the School receives for their high costs. TASS unfortunately is key to maintaining the School "truth" database where all staff, student and School administration records are kept. The Microsoft Volume Licensing pays for all operating system and office suite software used throughout the
School which is installed on more than 2000 devices and the server operating system software including specialised server programs are installed on more than 60 virtual machines servers used to run the backend infrastructure at the School. Much negotiation between suppliers has taken place to reduce pricing, however, these licensing costs still remain high. Recurrent budget software licensing costs are shown in Figure 4.2.2.2.

![Software Licensing Costs](image)

**Figure 4.2.2.2. Recurrent budget software licensing costs.**

Software and programming covers some ad-hoc customisation to the School TASS software and smaller websites used for adding value to various subject areas. Costs for this area are usually around the $5000 amount, however, during 2013, a mobile phone app was purchased for $10000 and in 2014 and 2016 more than $30000 was spent on Moodle, the School LMS. The recurrent budget software programming costs are shown in Figure 4.2.2.3.
The section covering miscellaneous or other components of the ICT recurrent budget include topics which do not change very much each year. However, it is this history of costs which each year encourage the IT Manager and budget holder to look for ways of reducing costs and finding ways to run the ICT operations of a School more efficiently. Items which appear out of place include the extra $10000 cost in 2015 for purchasing more monitors. In addition are once-off items including bus service activities, lecture theatre upgrades and repairs, print room equipment and firewall configuration expenses. These additional expenses explain the added expense found during 2013 to 2016 and in particular 2014 and 2015, where costs were almost 25% higher than usual ($87100 compared with $70000). The recurrent budget miscellaneous or other costs are shown in Figure 4.2.2.4.
In general, not a lot of money is associated with training. On average, only $7000 a year is spent on training for 5 IT Service staff members and needs to pay for training materials, exam vouchers and equipment. Due to the lack of time for undertaking IT Service work, the School cannot have staff away from the School for days or weeks during the year on external training courses. Therefore, the School has managed to certify itself as a Certiport, Prometric and Pearson VUE testing centre. This way, staff can attend to online courses and participate in exams all without leaving the School campus. Money is then saved in expensive inner city parking and travel expenses. The recurrent budget training costs are shown in Figure 4.2.2.5.
Research and Design expenses of around $5000 often becomes contingency funds as these funds are lost to cover other items requiring replacing or repairing. The recurrent budget R&D costs are shown in Figure 4.2.2.6.

![Figure 4.2.2.6. Recurrent budget R&D costs.](image)

Laptop Deployment costs of $5000 a year on average include additional cables and adaptors, bags and accessories not included in the initial purchase of laptops. These costs can be associated with staff and student devices. Most items are predicted for purchase during the main laptop or device rollout in order to buy them at the best price in terms of discount for quantity. However, sometimes unexpected increases in cohort enrolments require additional devices and associated equipment. Recurrent budget laptop deployment costs are shown in Figure 4.2.2.7.
Figure 4.2.2.7. Recurrent budget Laptop deployment costs.

Apple Deployment include cables and adaptors for use in connecting Apple devices with equipment. These cables and adaptors can be quite different to the equipment used by Windows devices and means lots of different cables and adaptors are needed to support the differing equipment. Currently, $2000 a year is spent on Apple deployment activities. Recurrent budget deployment costs are shown in Figure 4.2.2.8.

Figure 4.2.2.8. Recurrent budget Apple deployment costs.

In summary, the first step in optimising expenditure is to audit the equipment and to be aware of the costs and warranty periods. Table 4.2.1.1 shows the components for
the Capital budget from 2012 to 2016. Knowing when IT equipment is in need of replacement due to warranty expiration, means you can plan for discounts and specials offered by vendors. You can also plan to purchase some items in bulk and negotiate discounts with vendors such as data projectors. Knowing the individual components of the laptop program and what they have cost over previous years encourages ways to negotiate better pricing each year. This can sometimes derive from more accurate numbers of items purchased and therefore less wastage. In addition, internal IT staff may deploy images to laptops for less costs than an outside contractor. Purchasing a new type of technology such as the hyperconvergence equipment compared to the traditional servers and SAN resulted in optimising the initial purchase price and ongoing "soft costs" such as virtual machine licensing and power savings in the server room. New technology in terms of smarter network switches provided less troubleshooting time for network system administrators by making use of smart port technology, no longer requiring programming or "taging" each port for a specific purpose such as VLAN traffic for WANs or VLAN traffic for phones and printers. Apple devices such as iPads were only purchased once a MDM was in place, making the process of device and application deployment almost zero touch for IT staff.

4.2.3 Innovation in Education Q20 – Hypothesis testing

Question 20 for the innovation in education aspect of the research involved 5 sub questions asking for a rating out of 10 for old and new forms of technology and innovation. The questions were displayed in Microsoft Word as a table and displayed on a 2.4m x 1.2m interactive whiteboard allowing the researcher to record interviewee responses by hand in full view of the participant. An example is shown below in Figure 4.2.3.1.
<table>
<thead>
<tr>
<th>20</th>
<th>How would you rate the following innovative tools?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Non Touch-enabled laptops (A1/10) 3/10</td>
</tr>
<tr>
<td></td>
<td>... Touch-enabled laptops (B1/10) 7/10</td>
</tr>
<tr>
<td></td>
<td>Data Projectors (A2/10) 5/10</td>
</tr>
<tr>
<td></td>
<td>... Wireless Data Projectors (B2/10) 7/10</td>
</tr>
<tr>
<td></td>
<td>Desks with Displays/Books/3D models (A3/10) 7/10</td>
</tr>
<tr>
<td></td>
<td>... ZSpace Augmented Reality Device (B3/10) 9/10</td>
</tr>
<tr>
<td></td>
<td>Explicit Teaching (A4/10) 8/10</td>
</tr>
<tr>
<td></td>
<td>... Heutagogy Self-directed learning (B4/10) 6/10</td>
</tr>
<tr>
<td></td>
<td>... LMS Individual Learning Styles accommodated (C4/10) 4/10</td>
</tr>
<tr>
<td></td>
<td>Standard data for students via TASS (A5/10) 3/10</td>
</tr>
<tr>
<td></td>
<td>... Big Data Analytics (B5/10) 9/10</td>
</tr>
</tbody>
</table>

**Figure 4.2.3.1. Interactive whiteboard used to record ratings.**

The results for all 5 questions are shown in Table 4.2.3.1.
### Table 4.2.3.1 Question 20 – Hypothesis (Old innovation versus new innovation)

<table>
<thead>
<tr>
<th>#</th>
<th>Non-Touch</th>
<th>Touch</th>
<th>DPs</th>
<th>W. DPs</th>
<th>Models</th>
<th>Aug. Reality</th>
<th>Exp. Teach.</th>
<th>Huet Data</th>
<th>ILS Data</th>
<th>Std Data</th>
<th>Big Data</th>
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</table>

| Avg | 5.64 | 7.8 | 5.9 | 8.44 | 5.12 | 7.44 | 6.68 | 7.9 | 7.3 | 5.32 | 8.24 |

Old: 5.74
New: 7.85

The average rating given by 25 participants for how innovative the perception was for older technology was 5.74. This rating for newer, proposed technology was given an average value of 7.85.

Details of each of the 5 sub questions for question 20 are shown below. These results were used by “R for Windows” software program to test if the means of the two sets of data were different to a significance value of 0.05.
4.2.3.1 Question 20 – Sub question 1 (Non-touch Versus Touch screen laptops)

The aim is to prove that the means of both old and new innovative technology ratings are different.

For this to happen, the null hypothesis needs to be proven invalid and the alternative hypothesis needs to be proven true. That is, there is a difference in the means of the ratings, showing that staff consider the new innovative technology as more innovative than the older technology. This requires a p-value less than the significance value of 0.05. (Below two sample t-test : p-value = 1.632 e-06)

ie. The averages of the two groups are not similar to each other. R(non-touch)-R(touch) <> 0.

\[
\begin{align*}
> & \text{nontouch <- c}(6,8,6,5,8,7,3,4,7,8,3,6,6,6,6,5,6,6,4,5,2,8,5,5,6,6) \\
> & \text{touch <- c}(8,9,9,7,9,7,7,6,7,10,9,7,7,6,8,7,8,10,8,9,7,6,8,8) \\
> & \text{t.test(nontouch,touch, var.equal=TRUE)} \\
> & \text{Two Sample t-test} \\
> & \text{data: nontouch and touch} \\
> & \text{t = } -5.4641, \text{ df = 48, p-value = 1.632e-06} \\
> & \text{alternative hypothesis: true difference in means is not equal to 0.} \\
> & \text{95 percent confidence interval:} \\
> & \text{-2.954816 -1.365184} \\
> & \text{sample estimates:} \\
> & \text{mean of x mean of y} \\
> & \text{5.64 7.80} \\
\end{align*}
\]

To check that one mean is greater or less than the other mean, we use a one sided t-test. Again the test shows the p-value is far less than the significance value of 0.05. It is therefore concluded that the means are different to each other for the two data sets used.

(Below one-sided t-test : p-value = 8.162e-07)

\[
\begin{align*}
> & \text{t.test(nontouch,touch, alt="less", var.equal=TRUE)} \\
> & \text{Two Sample t-test} \\
> & \text{data: nontouch and touch} \\
> & \text{t = } -5.4641, \text{ df = 48, p-value = 8.162e-07} \\
> & \text{alternative hypothesis: true difference in means is less than 0.} \\
\end{align*}
\]
95 percent confidence interval:
-Inf -1.496984
sample estimates:
mean of x mean of y
5.64  7.80

4.2.3.2 Question 20 – Sub question 2 (Data Projectors Versus Wireless Data Projectors)

The aim is to prove that the means of both innovative technology ratings are different.

For this to happen, the null hypothesis needs to be proven invalid and the alternative hypothesis needs to be proven true. That is, there is a difference in the means of the ratings, showing that staff consider the new innovative technology as more innovative than the older technology. This requires a p-value less than the significance value of 0.05. (Below two sample t-test : p-value = 1.944e-06)

ie. The averages of the two groups are not similar to each other.
R(Data Projectors)-R(Wireless Data Projectors) <> 0.
> datap <- c(5,4,7,7,8,7,5,2,9,7,7,9,3,4,7,5,8,5,4,6,8,4,5,8,4)
> wdatap <- c(6,6,8,8,9,9,7,8,10,10,9,9,7,8,9,9,8,8,10,10,10,10,6,9,8)
> t.test(datap,wdatap, var.equal=TRUE)

Two Sample t-test
data:  datap and wdatap
t = -5.4138, df = 48, p-value = 1.944e-06
alternative hypothesis: true difference in means is not equal to 0.
95 percent confidence interval:
-3.4559 -1.5841
sample estimates:
mean of x mean of y
5.92  8.44

To check that one mean is greater or less than the other mean, we use a one sided t-test. Again the test shows the p-value is far less than the significance value of 0.05. It is therefore concluded that the means are different to each other for the two data sets used.
(Below one-sided t-test : p-value = 9.718e-07)
> t.test(datap,wdatap, alt="less", var.equal=TRUE)
  Two Sample t-test
data:  datap and wdatap
t = -5.4138, df = 48, p-value = 9.718e-07
alternative hypothesis: true difference in means is less than 0.
95 percent confidence interval:
  -Inf -1.739295
sample estimates:
  mean of x mean of y
  5.92      8.44

4.2.3.3 Question 20 – Sub question 3 (3D Models Versus Augmented Reality)

The aim is to prove that the means of both old and new innovative technology ratings
are different. For this to happen, the null hypothesis needs to be proven invalid and the
alternative hypothesis needs to be proven true. That is, there is a difference in the means
of the ratings, showing that staff consider the new innovative technology as more
innovative than the older technology. This requires a p-value less than the significance
value of 0.05. (Below two sample t-test : p-value = 0.003437)

ie. The averages of the two groups are not similar to each other. 
R(models)-R(augr) <> 0.
> models <- c(5,3,6,5,8,6,7,8,8,0,4,5,3,6,6,2,5,5,10,5,3,3,2,6,7)
> augr <- c(0,9,9,5,10,10,9,10,8,0,9,8,9,10,3,8,3,6,10,7,10,9,8,9,7)
> t.test(models,augr, var.equal=TRUE)
  Two Sample t-test
data:  models and augr
t = -3.0783, df = 48, p-value = 0.003437
alternative hypothesis: true difference in means is not equal to 0.
95 percent confidence interval:
  -3.8353305 -0.8046695
sample estimates:
  mean of x mean of y
  5.12      7.44

To check that one mean is greater or less than the other mean, we use a one sided
t-test. Again the test shows the p-value is far less than the significance value of 0.05. It
is therefore concluded that the means are different to each other for the two data sets used.

(Below one-sided t-test : p-value = 0.001718)

\[
\text{t.test(models,augr, alt="less", var.equal=TRUE)}
\]

Two Sample t-test
data:  models and augr
t = -3.0783, df = 48, p-value = 0.001718
alternative hypothesis: true difference in means is less than 0.
95 percent confidence interval:
-Inf -1.055947
sample estimates:
mean of x mean of y
5.12      7.44

4.2.3.4 Question 20 – Sub question 4a (Explicit Teaching Versus Heutagogy)

The aim is to prove that the means of both old and new innovative technology ratings are different. For this to happen, the null hypothesis needs to be proven invalid and the alternative hypothesis needs to be proven true. That is, there is a difference in the means of the ratings, showing that staff consider the new innovative technology as more innovative than the older technology. This requires a p-value less than the significance value of 0.05. (Below two sample t-test : p-value = 0.04711)

ie. The averages of the two groups are not similar to each other.
R(expt)-R(Heut) <> 0.
\[
> \text{expt} <- \text{c}(6,10,7,6,8,3,8,8,10,4,3,5,6,7,9,10,5,2,10,4,5,5,7,9,10)
> \text{Heut} <- \text{c}(8,10,9,7,8,8,6,8,10,10,8,7,8,7,10,10,8,8,7,6,9,8,7,3,10)
> \text{t.test(expt,Heut, var.equal=TRUE)}
\]

Two Sample t-test
data:  expt and Heut
t = -2.0377, df = 48, p-value = 0.04711
alternative hypothesis: true difference in means is not equal to 0.
95 percent confidence interval:
-2.38405733 -0.01594267
sample estimates:
mean of x mean of y
6.68      7.88
To check that one mean is greater or less than the other mean, we use a one sided
t-test. Again the test shows the p-value is far less than the significance value of 0.05. It
is therefore concluded that the means are different to each other for the two data sets
used.

(Below one-sided t-test : p-value = 0.02356)
> t.test(expt,Heut, alt="less", var.equal=TRUE)
  Two Sample t-test
data:  expt and Heut
t = -2.0377, df = 48, p-value = 0.02356
alternative hypothesis: true difference in means is less than 0.
95 percent confidence interval:
  -Inf -0.2122872
sample estimates:
  mean of x mean of y
  6.68      7.88

4.2.3.5 Question 20 – Sub question 4b (Explicit Teaching Versus Individual Learning
Styles)

The aim is to prove that the means of both old and new innovative technology ratings
are different. For this to happen, the null hypothesis needs to be proven invalid and the
alternative hypothesis needs to be proven true. That is, there is a difference in the means
of the ratings, showing that staff consider the new innovative technology as more
innovative than the older technology. This requires a p-value less than the significance
value of 0.05. (Below two sample t-test : p-value = 0.3539)

> expt <- c(6,10,7,6,8,3,8,8,10,4,3,5,6,7,9,10,5,2,10,4,5,5,7,9,10)
> ils <- c(7,10,8,7,8,7,4,8,10,10,8,6,8,7,9,10,5,5,5,6,2,7,6,6,8,10)
> t.test(expt,ils, var.equal=TRUE)
  Two Sample t-test
data:  expt and ils
t = -0.93613, df = 48, p-value = 0.3539
alternative hypothesis: true difference in means is not equal to 0.
95 percent confidence interval:
  -1.8886898  0.6886898
sample estimates:
mean of x mean of y
6.68    7.28

t.test(expt,ils, alt="less", var.equal=True)
  Two Sample t-test
data:  expt and ils
t = -0.93613, df = 48, p-value = 0.1769
alternative hypothesis: true difference in means is less than 0
95 percent confidence interval:
  -Inf 0.4749947
sample estimates:
mean of x mean of y
  6.68    7.28

4.2.3.6 Question 20 – Sub question 4c (Explicit Teaching Versus Heutagogy and Individual Learning Styles - Average)

The aim is to prove that the means of both old and new innovative technology ratings are different. For this to happen, the null hypothesis needs to be proven invalid and the alternative hypothesis needs to be proven true. That is, there is a difference in the means of the ratings, showing that staff consider the new innovative technology as more innovative than the older technology. This requires a p-value less than the significance value of 0.05. (Below two sample t-test : p-value = 0.1341)

> expt <- c(6,10,7,6,8,3,8,8,10,4,3,5,6,7,9,10,5,2,10,4,5,5,7,9,10)
> both <- c(7.5,10,8.5,7,8,7.5,5,8,10,10,8,6.5,8,7,8,10,6.5,6.5,6.5,4,8,7,6.5,5.5,10)
> t.test(expt,both, var.equal=TRUE)
  Two Sample t-test
data:  expt and both
t = -1.5239, df = 48, p-value = 0.1341
alternative hypothesis: true difference in means is not equal to 0.
95 percent confidence interval:
  -2.0874667  0.2874667
sample estimates:
mean of x mean of y
  6.68    7.58
t.test(expt,both, alt="less", var.equal=TRUE)
Two Sample t-test
data:  expt and both
t = -1.5239, df = 48, p-value = 0.06705
alternative hypothesis: true difference in means is less than 0.
95 percent confidence interval:
 -Inf 0.09055674
sample estimates:
mean of x mean of y
 6.68 7.58

4.2.3.7 Question 20 – Sub question 5 (Standard Data Versus Big Data)

The aim is to prove that the means of both old and new innovative technology ratings are different. For this to happen, the null hypothesis needs to be proven invalid and the alternative hypothesis needs to be proven true. That is, there is a difference in the means of the ratings, showing that staff consider the new innovative technology as more innovative than the older technology. This requires a p-value less than the significance value of 0.05.

(Below two sample t-test : p-value = 9.579e-08)
> stdd <- c(6,2,7,7,8,5,3,4,5,5,3,6,5,8,5,2,7,4,8,9,3,5,5,6,5)
> bigd <- c(9,9,9,10,8,9,7,8,10,8,8,8,7,8,9,7,10,4,6,9,9,8,9)
> t.test(stdd,bigd, var.equal=TRUE)
Two Sample t-test
data:  stdd and bigd
t = -6.2732, df = 48, p-value = 9.579e-08
alternative hypothesis: true difference in means is not equal to 0.
95 percent confidence interval:
-3.8559 -1.9841
sample estimates:
mean of x mean of y
 5.32  8.24

To check that one mean is greater or less than the other mean, we use a one sided t-test. Again the test shows the p-value is far less than the significance value of 0.05. It
is therefore concluded that the means are different to each other for the two data sets used.

(Below one-sided t-test : p-value = 4.79e-08)

> t.test(stdd,bigd, alt="less", var.equal=TRUE)

Two Sample t-test
data:  stdd and bigd
t = -6.2732, df = 48, p-value = 4.79e-08
alternative hypothesis: true difference in means is less than 0.
95 percent confidence interval:
  -Inf -2.139295
sample estimates:
  mean of x mean of y
  5.32      8.24

4.2.3.8 Question 20 – Summary of results

The alternative hypothesis tested true for all questions rating old innovation and new innovation, except when comparing explicit teaching and heutagogy and individual learning styles. It would appear that staff, teaching and non-teaching, perceive the new technology to be an improvement on the old technology. However, explicit teaching is still important as the data shows that self-directed learning is not always preferred and if anything a combination of explicit teaching and heutagogy is implemented without any relevance to teacher age, year level of teaching or teacher qualification. Seems dependent on teacher personal preference. The average rating given by the research participants was 6.7 for explicit teaching and 7.9 for heutagogy. Therefore explicit teaching was still regarded as a likely teaching method for staff.

4.2 Quantitative Data Analysis Summary

ICT infrastructure capital budget data shows trends of data expenditure over a 5 year period from 2012 to 2016. One of the major annual expenses is the cost of the 1:1 laptop program and hard work has yielded a reduction of the costs of the devices by
37.9%. This includes a reduction in individual device costs by 51.3% and a reduction in device accessories by 32.5%. The introduction of hyper-convergence technology has provided a cost effective server and storage solution complete with disaster recovery and date restore capability within seconds. Many other capital budget items have been discussed, highlighting the sorts of capital items required to maintain an enterprise school environment.

The ICT infrastructure recurrent item budget has covered areas such as maintenance, software licensing, programming, miscellaneous, training or R&D costs and device deployment costs. Of main concern is the software licensing costs which have increased significantly over the last few years.

Of particular significance is the hypothesis which states that all new technology is seen as more innovative than the preceding technology in use. This was the case across all research participants for technological equipment. However, new methods of teaching practice such as self-directed learning or heutagogy was not believed as replacing the traditional explicit teaching methods. In fact, results showed there was a combination of both of these styles of teaching practice in use across the K-12 cohorts.

Demand for various ICT infrastructure services maintains basics of innovation only be adhering to warranty periods and keeping existing equipment working. Demands for innovation however, needs an extension of ICT infrastructure to make the most of the end user experience. This means ICT infrastructure needs to exceed the expectations of end users by delivering more than adequate wireless performance and bandwidth for delivery of cloud based learning experiences. In addition to this are the teaching and learning requests for time and training. With the correct ICT infrastructure in place, additional innovative practices can take place through more efficient use of time for equipment training and awareness. (Old and inadequate equipment can result
in the end user experience including waiting for devices to boot or connect to the servers and waiting or postponing training on equipment until repairs can be made.)

Note that these demands come from the DigiTal committee requests for new innovative technology and from what is seen as the obstructive behaviour of IT management when insufficient infrastructure is in place due to insufficient funding.

Note that it always will be difficult to know when staff are sincere with their intentions to utilize technology with the aim of enhancing learning outcomes as opposed to wanting new shiny devices based on personal bias only.

The next chapter describes the qualitative data analysis component.
Chapter 5. Data Analysis – Qualitative

5.1 Background for Innovation in Education

The literature review lists three main factors for fostering innovation in education. These three factors are the focus of interview questions aimed at exploring whether staff in this case study, consider these factors as important and whether they play a part in fostering innovation in the context of this case study.

Questions asked of research participants came from the literature review and some of the pressing issues the researcher encountered during the management process of IT at the School. Some innovation in education questions probed the participants for a deeper understanding of the issues encountered. The thematic analysis of the transcribed interviews looked for unusual themes. However, the most important areas were the key findings in terms of money, time and training.

Additional analysis was undertaken on several other factors thought to be important for supporting innovation in an educational context. These include personal entrepreneurship, action researchers, life-long learning, ability-driven education and individual learning styles.
Finally, a School innovation rating was investigated as a way for School leadership to gauge how well the culture for staff and the ICT infrastructure and proposed future technology will help foster innovation.

Rigour is shown in terms of demonstrating thick descriptions and details for interviews and in addition, data triangulation using interviews and direct observation photos.

5.2 Qualitative Data Collection and Analysis

5.2.1 Interview details

Table 5.2.1 lists the interview information for the 25 research participants. Interviewee initials have been removed so as not to identify the research participants. The interview order was recorded to ensure there was fairness in how much time was given to each participant. As the data shows, each participant was given the time they needed to fully answer each of the 19 questions and the length of the interviews varied from 808 seconds (13+ minutes) to 2695 seconds (44+ minutes).

The total time for all 25 interviews was 11.375 hours. The total word count for all transcriptions was 87634 words and amounted to 160 pages of interview transcription data.
Table 5.2.1 Research interview details.

<table>
<thead>
<tr>
<th>Interview Order</th>
<th>Length[Sec]</th>
<th>Completed</th>
<th>Word Count</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>1136</td>
<td>Yes</td>
<td>2477</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
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<td>Yes</td>
<td>3981</td>
<td>7</td>
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<td>16</td>
<td>2641</td>
<td>Yes</td>
<td>5119</td>
<td>8</td>
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<tr>
<td>11</td>
<td>1482</td>
<td>Yes</td>
<td>2836</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
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<td>Yes</td>
<td>4161</td>
<td>7</td>
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<tr>
<td>13</td>
<td>904</td>
<td>Yes</td>
<td>2031</td>
<td>5</td>
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<td>2</td>
<td>1389</td>
<td>Yes</td>
<td>2675</td>
<td>6</td>
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<td>12</td>
<td>1858</td>
<td>Yes</td>
<td>5046</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>1921</td>
<td>Yes</td>
<td>5051</td>
<td>8</td>
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<tr>
<td>14</td>
<td>1169</td>
<td>Yes</td>
<td>1895</td>
<td>5</td>
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<tr>
<td>19</td>
<td>1201</td>
<td>Yes</td>
<td>2377</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>1901</td>
<td>Yes</td>
<td>4938</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>1706</td>
<td>Yes</td>
<td>2922</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>808</td>
<td>Yes</td>
<td>1586</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>2695</td>
<td>Yes</td>
<td>5650</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>1696</td>
<td>Yes</td>
<td>3269</td>
<td>6</td>
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<tr>
<td>10</td>
<td>2219</td>
<td>Yes</td>
<td>5739</td>
<td>9</td>
</tr>
<tr>
<td>25</td>
<td>1098</td>
<td>Yes</td>
<td>2309</td>
<td>5</td>
</tr>
<tr>
<td>24</td>
<td>1520</td>
<td>Yes</td>
<td>3399</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>1836</td>
<td>Yes</td>
<td>4704</td>
<td>8</td>
</tr>
<tr>
<td>21</td>
<td>1435</td>
<td>Yes</td>
<td>3015</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>1514</td>
<td>Yes</td>
<td>2634</td>
<td>5</td>
</tr>
<tr>
<td>23</td>
<td>1318</td>
<td>Yes</td>
<td>2502</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>1766</td>
<td>Yes</td>
<td>3483</td>
<td>6</td>
</tr>
<tr>
<td>22</td>
<td>1991</td>
<td>Yes</td>
<td>3835</td>
<td>7</td>
</tr>
</tbody>
</table>

40952 Seconds  87634 160
682.53 Minutes
11.375 Hours

5.2.2 Interview schedule details

Initial Interview schedule details are shown in Table 5.2.2.1. Interviews were conducted within the ethical approval period of 4.12.2015 to 4.12.2016. On average, each interview audio transcription took 3.2 hours to transcribe, ready for thematic analysis. The full details of the initial interview responses are shown in Appendix P.
Table 5.2.2.1 Initial research interview schedule details.

<table>
<thead>
<tr>
<th>Date</th>
<th>Progress</th>
<th>Total(Min)</th>
<th>Transcription (Approx. Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.05.2016</td>
<td>7</td>
<td>99.27</td>
<td>16.54</td>
</tr>
<tr>
<td>23.05.2016</td>
<td>10</td>
<td>70.73</td>
<td>11.79</td>
</tr>
<tr>
<td>30.05.2016</td>
<td>13</td>
<td>92.93</td>
<td>15.49</td>
</tr>
<tr>
<td>06.06.2016</td>
<td>16</td>
<td>68.78</td>
<td>11.46</td>
</tr>
<tr>
<td>13.06.2016</td>
<td>19</td>
<td>82.33</td>
<td>13.72</td>
</tr>
<tr>
<td>20.06.2016</td>
<td>22</td>
<td>65.60</td>
<td>10.93</td>
</tr>
<tr>
<td>27.06.2016</td>
<td>25</td>
<td>479.64min</td>
<td>79.94</td>
</tr>
</tbody>
</table>

Average interview time : 19.18min
Average interview transcription time : 79.94/25 = 3.1976 Hours

Note: Finished Wednesday 22.06.2016

Member checking interviews were planned for 3 to 4 months later than the initial information gathering interviews. These interviews were conducted within the ethics approval period and were slightly shorter than the initial interviews, with initial interviews averaging 19.18 minutes in length and the member checking interviews averaging 12.88 minutes in length as shown in Table 5.2.2.2.

Table 5.2.2.2 Member checking interview schedule details.

<table>
<thead>
<tr>
<th>Date</th>
<th>Progress</th>
<th>Total(Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>05.09.2016</td>
<td>14</td>
<td>173</td>
</tr>
<tr>
<td>12.09.2016</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>03.10.2016</td>
<td>22</td>
<td>29</td>
</tr>
<tr>
<td>10.10.2016</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>17.10.2016</td>
<td>25</td>
<td>14</td>
</tr>
</tbody>
</table>

Average member checking interview time : 12.88min

Note: Finished Thursday 20.10.2016

Note that member checking interviews were meant to cover a two week period, however, due to the busy teaching and learning exam and marking period the member checking process took more than 5 weeks to complete, with the final participant sick
for a couple of weeks. The full details of the member interview responses are shown in Appendix Q.

5.2.3 Quotes from staff on “Innovation is?”

Table 5.2.3 contains quotes from staff on what they believe “Innovation is”. Both teaching and non-teaching administration staff acknowledges innovation can be both technology and pedagogy. It must also be noted that staff mention various reasons for innovation such as benefits aimed at students, unstructured time tables for classes, technology usage and improvements in the way content is delivered.
Table 5.2.3 Quotes from staff in response to question “Innovation is?”.

<table>
<thead>
<tr>
<th>Question 1 - Innovation is?</th>
<th>Staff Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finding new ways and better ways of doing things.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Innovation isn't just hardware, it is also pedagogy in itself.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Look at more efficient and effective ways to transfer skills.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Children learn what they want to learn at any time.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Changing the way you would normally approach something.</td>
<td>Teacher</td>
</tr>
<tr>
<td>You learn from the past and educate for the future.</td>
<td>Non-teaching</td>
</tr>
<tr>
<td>Forward thinkers. Not being a follower of technology.</td>
<td>Non-teaching</td>
</tr>
<tr>
<td>Coming up with new ideas for the benefit of teaching and learning.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Not about all the bells and whistles.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Trying new things and different things.</td>
<td>Teacher</td>
</tr>
<tr>
<td>How you think more than anything else.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Implement future technology now.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Using new and emerging technologies.</td>
<td>Non-teaching</td>
</tr>
<tr>
<td>Creative in reaching all students.</td>
<td>Non-teaching</td>
</tr>
<tr>
<td>First new ideas, second how to implement in classroom.</td>
<td>Teacher</td>
</tr>
<tr>
<td>The latest of technologies.</td>
<td>Non-teaching</td>
</tr>
<tr>
<td>Making sure we are on top of what is happening in the profession.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Finding new ways to get better outcomes for our children.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Helping students to access and participate in the world of the future.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Looking to the future, mirroring the world we are heading into.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Innovation in education is both styles, technology and way of teaching.</td>
<td>Non-teaching</td>
</tr>
<tr>
<td>Restructuring timetable for classes and the way we have always taught.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Thinking outside the box. Different methods of content delivery.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Is constantly changing and adapting to the needs of the students.</td>
<td>Teacher</td>
</tr>
<tr>
<td>Thinking differently, pushing boundaries and getting kids to think differently.</td>
<td>Teacher</td>
</tr>
</tbody>
</table>

5.2.4 Number of issues raised through thematic analysis of interview transcriptions

The majority of staff raised issues of money (100%), time (100%) and training (92%) as requirements for helping foster innovation in this case study.

The highest number of coded references was the question of "money" which had a total of 195 mentions in the interview transcriptions as shown in Table 5.2.4. The
next was "time" with 161 mentions, followed by "117 mentions of "training". Clearly, money is the key factor for helping to drive innovation in education in this case study.

It must also be noted that money was requested mostly by teaching staff, whether they were in classroom teaching roles or in management roles (total mentions was 60+94=154). Requests for more time was more evident with management staff (94) and training was most likely requested by classroom teaching staff and management staff (40+57=97). An additional note is required to indicate how teaching and non-teaching staff were expected to work. All non-teaching staff were asked to work 48 weeks a year with a 38-hour work week guided by an EBA (Enterprise Bargaining Agreement). However, teaching staff are under contracts in which they are expected to work 1230 hours which includes around 38-40 weeks a year of campus teaching workloads and 12 weeks of annual leave. This often meant teaching staff work well above the indicated hours of work each day and could explain why staff feel as though more time as well as money would help them manage a professional development workload in addition to teaching plus extra-curricular activities.
Table 5.2.4 Number of issues raised.

<table>
<thead>
<tr>
<th>Coding query for &quot;Money&quot;</th>
<th>Number of participants</th>
<th>Number of coded who raised the issue.</th>
<th>Number of coded references to the issue.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching staff - Classroom only (n=7)</td>
<td>7</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Teaching staff - Classroom &amp; Management (n=12)</td>
<td>12</td>
<td></td>
<td>94</td>
</tr>
<tr>
<td>Non-Teaching staff (n=6)</td>
<td>6</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>195</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coding query for &quot;Time&quot;</th>
<th>Number of participants</th>
<th>Number of coded who raised the issue.</th>
<th>Number of coded references to the issue.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching staff - Classroom only (n=7)</td>
<td>7</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>Teaching staff - Classroom &amp; Management (n=12)</td>
<td>12</td>
<td></td>
<td>94</td>
</tr>
<tr>
<td>Non-Teaching staff (n=6)</td>
<td>6</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>161</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coding query for &quot;Training&quot;</th>
<th>Number of participants</th>
<th>Number of coded who raised the issue.</th>
<th>Number of coded references to the issue.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching staff - Classroom only (n=7)</td>
<td>7</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Teaching staff - Classroom &amp; Management (n=12)</td>
<td>10</td>
<td></td>
<td>57</td>
</tr>
<tr>
<td>Non-Teaching staff (n=6)</td>
<td>6</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>117</td>
</tr>
</tbody>
</table>

7 teaching staff recorded 60 issues relating to money or 8.57 issues each. 12 teaching staff who are also management recorded 94 issues relating to money or 7.83 issues each. 6 non-teaching staff members recorded 41 issues relating to money or 6.83 issues each. This means that teaching staff were more than 25% more likely to request additional funding than non-teaching staff. (8.57/6.83)

In terms of time, 7 teaching staff recorded 39 issues with time or 5.57 issues each. 12 teaching staff who are also management, recorded 94 issues relating to time or 7.83
issues each. 6 non-teaching staff members recorded 28 issues relating to money or 4 issues each. Teaching staff who are also management staff were more than 95% more likely to request more time for their role. (7.83/4)

7 teaching staff recorded 40 issues relating to training or 5.71 issues each. A total of 12 teaching staff who are also management recorded 57 issues relating to training or 4.75 issues each. 6 non-teaching staff members recorded 20 issues relating to money or 3.33 issues each. Teaching staff were more than 71% more likely to request more training than non-teaching staff.

5.2.5 New technology requested by staff

Staff were asked for what types of new technology they would like to make use of if there was no budget limitations for their departments. As can be seen from the 25 responses below in Table 5.2.5, the comments vary from modern, futuristic use of augmented reality, and green room concepts to simple requests of more funding for software and more powerful devices.
Table 5.2.5 New technology requested by staff.

<table>
<thead>
<tr>
<th>Technology requested by staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented reality, Minecraft, Blogs.</td>
</tr>
<tr>
<td>Video conferencing technology.</td>
</tr>
<tr>
<td>IWB, Time for research &amp; training.</td>
</tr>
<tr>
<td>Latest laptops, iPads &amp; cameras.</td>
</tr>
<tr>
<td>Science Software - genetics?</td>
</tr>
<tr>
<td>Robotics for cleaning/monitoring.</td>
</tr>
<tr>
<td>Automated Job System</td>
</tr>
<tr>
<td>e-Portfolios, Virtual Learning.</td>
</tr>
<tr>
<td>Pen technology, touch screens.</td>
</tr>
<tr>
<td>IWB, Better overhead cameras.</td>
</tr>
<tr>
<td>Social Media usage in real-time.</td>
</tr>
<tr>
<td>Ipads / Laptops, Digital Portfolio.</td>
</tr>
<tr>
<td>Student data in cloud</td>
</tr>
<tr>
<td>Poster or Banner maker</td>
</tr>
<tr>
<td>Audio Visual - Creative</td>
</tr>
<tr>
<td>Cisco VOIP phones and WAPs.</td>
</tr>
<tr>
<td>Recording software, Macs/iPads.</td>
</tr>
<tr>
<td>More iPads.</td>
</tr>
<tr>
<td>Device enabling group work.</td>
</tr>
<tr>
<td>More powerful laptops</td>
</tr>
<tr>
<td>SSO - All database systems connected.</td>
</tr>
<tr>
<td>Augmented reality, Green Room.</td>
</tr>
<tr>
<td>Tablets or iPads</td>
</tr>
<tr>
<td>Data and video analysis, Feedback.</td>
</tr>
<tr>
<td>CNC Mills, Laser cutters, software.</td>
</tr>
<tr>
<td>CNC Mills, Laser cutters, software.</td>
</tr>
</tbody>
</table>

5.2.6 Importance of innovation

The same question was posed to 25 staff, approximately 4 to 5 months apart. This question was “How important is innovation to your teaching practice or in the classroom or work area?”. The second time the question was asked, previous responses were not disclosed to see if their results were similar and in which way they would differ. Overall, the results showed a 6% increase in innovation importance as shown in Table 5.2.6. However, with such a small 6% change in the overall rating staff would give to the importance of innovation, it seems safe to say most staff would rate innovation as moderately important.
Table 5.2.6 Innovation importance as seen by staff.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Important.</td>
<td>Very Important</td>
<td>6</td>
<td>8</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Important.</td>
<td>Very Important</td>
<td>6</td>
<td>8</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Essential.</td>
<td>Essential</td>
<td>10</td>
<td>10</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Very Important.</td>
<td>Quite Important</td>
<td>8</td>
<td>7</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Moderately Important.</td>
<td>Moderately Important</td>
<td>5</td>
<td>5</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Very Important.</td>
<td>Moderately Important</td>
<td>8</td>
<td>5</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Very important.</td>
<td>Very Important</td>
<td>8</td>
<td>8</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Very important.</td>
<td>Extremely</td>
<td>8</td>
<td>9</td>
<td>1.13</td>
<td></td>
</tr>
<tr>
<td>Important.</td>
<td>Very Important</td>
<td>6</td>
<td>8</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Moderately.</td>
<td>Moderately Important</td>
<td>5</td>
<td>5</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Very Important.</td>
<td>Extremely Important</td>
<td>8</td>
<td>9</td>
<td>1.13</td>
<td></td>
</tr>
<tr>
<td>Important.</td>
<td>Crucial</td>
<td>6</td>
<td>10</td>
<td>1.67</td>
<td></td>
</tr>
<tr>
<td>Pretty important.</td>
<td>Moderately Important</td>
<td>7</td>
<td>5</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Important.</td>
<td>Very Important</td>
<td>6</td>
<td>8</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Really Important.</td>
<td>Very Important</td>
<td>8</td>
<td>8</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Pretty important.</td>
<td>Quite Important</td>
<td>7</td>
<td>7</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Crucial.</td>
<td>Very Important</td>
<td>10</td>
<td>8</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Very Important.</td>
<td>Moderately Important</td>
<td>8</td>
<td>5</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Most important.</td>
<td>Very Important</td>
<td>5</td>
<td>8</td>
<td>1.60</td>
<td></td>
</tr>
<tr>
<td>Really Important.</td>
<td>Very Important</td>
<td>8</td>
<td>8</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Important.</td>
<td>Critical</td>
<td>6</td>
<td>10</td>
<td>1.67</td>
<td></td>
</tr>
<tr>
<td>Very Important.</td>
<td>Very Important</td>
<td>8</td>
<td>8</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Very important.</td>
<td>Moderately Important</td>
<td>8</td>
<td>5</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Vitally important.</td>
<td>Highly Important</td>
<td>9</td>
<td>8</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>Absolutely Important.</td>
<td>Very Important</td>
<td>9</td>
<td>8</td>
<td>0.89</td>
<td></td>
</tr>
</tbody>
</table>

Average Average Increase
7.32 7.52 1.06

Likert Scale: (Highest)
Critical/Crucial/Essential 10
5.2.7 Personal Entrepreneurship

Staff were asked if they make use of personal entrepreneurship in the classroom. This included experimenting with ICT applications, researching how to use ICT applications and reflecting on the achievements and shared experiences with other colleagues. The data, as shown in Table 5.2.7, indicate 84% of staff believe they make use of personal entrepreneurship in the classroom. The results are shown graphically in Figure 5.2.7.
Table 5.2.7 Staff making use of personal entrepreneurship in the classroom.

<table>
<thead>
<tr>
<th>Q11 - Personal Entrepreneurship?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes. Encourage risk taking.</td>
</tr>
<tr>
<td>Yes. Keep up with new apps.</td>
</tr>
<tr>
<td>No.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes. Investigate software.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes. PD Courses and software.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>No. Confidence may change that.</td>
</tr>
<tr>
<td>Yes. Arduino &amp; Podcasts.</td>
</tr>
<tr>
<td>Maybe.</td>
</tr>
<tr>
<td>Yes. Often more for others.</td>
</tr>
<tr>
<td>Yes. Video formats.</td>
</tr>
<tr>
<td>Yes. Curriculum research.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes. Shared learning experiences.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Maybe/(Yes)</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
</tbody>
</table>

**Results:** Yes (84%) Maybe (8%) No (8%)
5.2.8 Action Researcher

Staff were asked if they had become an action researcher in the classroom. This was explained as a way to identify problems encountered in education and finding the best technological solution. The data is shown in Table 5.2.8. The results are shown graphically in Figure 5.2.8.
Table 5.2.8 Staff becoming action researchers in the classroom.

<table>
<thead>
<tr>
<th>Q12 - Action Researcher?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>No.</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes. Identify Technology.</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes. Digital Portfolios.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
<tr>
<td>Maybe. Investigate issues.</td>
</tr>
<tr>
<td>Yes. More time for feedback.</td>
</tr>
<tr>
<td>Yes. Time to research.</td>
</tr>
<tr>
<td>Yes. Constant research.</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes. InDesign example.</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Maybe. Need time and training.</td>
</tr>
<tr>
<td>Maybe/(Yes)</td>
</tr>
<tr>
<td>Yes. Find a way around challenges.</td>
</tr>
<tr>
<td>Yes.</td>
</tr>
</tbody>
</table>

**Results:** Yes (84%) Maybe (12%) No (4%)

Figure 5.2.8 Staff becoming action researchers in the classroom (Results).
5.2.9 Life-long learning

Staff were asked if they encourage life-long learning in the classroom. For students to achieve life-long learning, they need to acquire the skills to seek new information, to think critically, show initiative to meet the challenges of our modern, fast-changing world, use higher-order thinking and think laterally. The data, as shown in Table 5.2.9, show 100% of staff encourage life-long learning. The results are shown graphically in Figure 5.2.9.

Table 5.2.9 Staff encouraging life-long learning in the classroom.

<table>
<thead>
<tr>
<th>Q13 - Life-long learning?</th>
<th>Yes, Thinking and enquiry skills.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolutely. Part of school philosophy.</td>
</tr>
<tr>
<td></td>
<td>Yes. Encourage risk taking.</td>
</tr>
<tr>
<td></td>
<td>Yes. Develop Independent learners.</td>
</tr>
<tr>
<td></td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Yes. Life skills &amp; Mini business prep’.</td>
</tr>
<tr>
<td></td>
<td>Yes. Think critically and investigate.</td>
</tr>
<tr>
<td></td>
<td>Yes. We are all learners.</td>
</tr>
<tr>
<td></td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Yes. Curing cancer... think outside box.</td>
</tr>
<tr>
<td></td>
<td>Definitely. Process not the product.</td>
</tr>
<tr>
<td></td>
<td>Yes. Flipped-classroom Recordings.</td>
</tr>
<tr>
<td></td>
<td>Absolutely.</td>
</tr>
<tr>
<td></td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Yes. Life learning journey.</td>
</tr>
<tr>
<td></td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Yes. Have the skills to find information.</td>
</tr>
<tr>
<td></td>
<td>Yes. Preparing students for life beyond.</td>
</tr>
<tr>
<td></td>
<td>Yes. Open-ended outcomes.</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes. That is what drama does.</td>
</tr>
<tr>
<td></td>
<td>Definitely</td>
</tr>
<tr>
<td></td>
<td>Absolutely.</td>
</tr>
<tr>
<td></td>
<td>Absolutely. Giving the kids the skills to think.</td>
</tr>
</tbody>
</table>

Results: Yes (100%) Maybe (0%) No (0%)
5.2.10 Ability-driven education

Staff were asked if they have ever been a part of ability-driven education. This type of education requires a reduction in the workload, a reduction in the reliance on high-stakes assessment systems, the integration of multidisciplinary ICT programs and the inclusion of alternative pathways. The data, as shown in Table 5.2.10, shows only 32% of staff believe they have been a part of ability driven education and 52% saying no involvement at all. The results are shown graphically in Figure 5.2.10.
Table 5.2.10 Staff who believe they have been a part of ability-driven education in the classroom.

<table>
<thead>
<tr>
<th>Q14 - Ability-driven education?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe. School trying but still traditional.</td>
<td></td>
</tr>
<tr>
<td>Yes. Competency-based business programs.</td>
<td>No.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>No. Exams don't show true character.</td>
<td>Yes. Data collection to help teaching.</td>
</tr>
<tr>
<td>Maybe. Not so much now.</td>
<td>Yes. Differentiated unit plans.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>Yes. Every day in Junior School.</td>
<td>No.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>Yes. Negotiate reduced curriculum.</td>
<td>Maybe. No real focus on outcomes.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>Only in the past, not now!</td>
<td>Yes. Cater for ability levels - differentiation.</td>
</tr>
<tr>
<td>No.</td>
<td>No.</td>
</tr>
</tbody>
</table>

**Results:** Yes (32%) Maybe (16%) No (52%)
5.2.11 Individual learning styles

Staff were asked if they cater for individual learning styles in the classroom. If teachers and students are aware of individual learning styles, the chance to enhance teaching and learning outcomes for students is increased, through better support of the identified individual learning styles. This can be made more difficult through the use of an LMS where it can become very difficult to assess how students behave and learn in a course compared with the traditional face-to-face classroom activities. The data, as shown in Table 5.2.11, shows 92% of staff believe they cater for individual learning styles in the classroom. The results are shown graphically in Figure 5.2.11.
Table 5.2.11 Staff who believe they cater for individual learning styles in the classroom.

<table>
<thead>
<tr>
<th>Q15 -Individual Learning Styles?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes. Constant process of support.</td>
</tr>
<tr>
<td>Yes. Design process-&gt; Differentiation.</td>
</tr>
<tr>
<td>Yes. HOH-&gt;teacher-&gt;Diff Support.</td>
</tr>
<tr>
<td>Yes. Teaching different ways.</td>
</tr>
<tr>
<td>Yes. Play to your strengths.</td>
</tr>
<tr>
<td>Yes. Cater for handicaps.</td>
</tr>
<tr>
<td>Maybe. Teacher age dependent.</td>
</tr>
<tr>
<td>Yes. Visual &amp; Kinaesthetic.</td>
</tr>
<tr>
<td>Yes. Teaching different ways.</td>
</tr>
<tr>
<td>Yes. Part of appraisal process.</td>
</tr>
<tr>
<td>Yes. Innovation is talking face to face.</td>
</tr>
<tr>
<td>Yes. To our best ability.</td>
</tr>
<tr>
<td>Yes. More in Junior School.</td>
</tr>
<tr>
<td>Yes. But could do more.</td>
</tr>
<tr>
<td>Yes. Differentiation Support.</td>
</tr>
<tr>
<td>Yes. Do our best to cater.</td>
</tr>
<tr>
<td>Yes. Student individual needs.</td>
</tr>
<tr>
<td>Yes. Own visual language.</td>
</tr>
<tr>
<td>Maybe.</td>
</tr>
<tr>
<td>Yes. Differentiated planning &amp; support.</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

**Results:** Yes (92%) Maybe (8%) No (0%)

Figure 5.2.11 Staff catering for individual learning styles in the classroom (Results).
5.2.12 Key factors for fostering innovation in education.

Data analysis was performed on the responses for questions relating to the key factors fostering innovation in education, these being money, time and training. Results for money are shown graphically in Figure 5.2.12.1 and were 64.80% (Yes more money is needed, 22.4% maybe (or could be interpreted as sometimes) more money is needed and 12.0% no more money is not needed.

![Money required for Innovation?](image)

**Figure 5.2.12.1 Money required for Innovation (Results).**

Results for time were 60.8% (Yes more time is needed), 25.6% maybe more time is needed and 13.6% no more time is not needed as shown graphically in Figure 5.2.12.2.
Figure 5.2.12.2 Time required for Innovation (Results).

Results for training were 60.0% (Yes more training is needed), 14.7% maybe more training is needed and 25.3% no more training is not needed as shown graphically in Figure 5.2.12.3.

Figure 5.2.12.3 Training required for Innovation (Results).

As a result, those staff members indicating yes or maybe (sometimes) money, time and training were needed are concluded as 88.0% (money), 86.4% (time) and 73.7% (training). These results were averaged and displayed in the following graph.
shown in Figure 5.2.12.4. This was an average of 82.8% (61.9% yes plus 20.9% maybe).

![Money, Time & Training required for Innovation?](image)

**Figure 5.2.12.4 Money, time and training required for Innovation (Results).**

### 5.2.13 Innovation Culture Rating (ICR).

The total satisfaction with the level of money, time and training is indicated by a no response to these 3 questions. This comes to 17.3% ICR (Innovation Culture Rating) as shown in Table 5.2.13. The data can be represented in a graph of percentage of satisfaction of key factors fostering innovation as shown graphically in Figure 5.2.13. This value can also be interpreted as only when staff specifically state "no" and not "yes" or "maybe" to there being a need for money, time and training to support innovation. This would still only deliver an ICR of 38.1% if only “yes” responses were used in concluding innovation is supported. It must be noted this value can be harsh. It would only require staff to indicate a 'maybe' to sufficient money, time and training provided to foster innovation over a period of years, and the result is signifying a 'no'. In the context of this study, a value for ICR of 38.1% is a reasonable value, especially
given the amount of funding directed towards improving ICT infrastructure over the last few years.

However, this rating can easily improve if greater emphasis is placed upon funding for technology, release time for staff to work with the technology and proposed teaching methods and the appropriate professional development required for staff to fully utilise the new technology in the classroom and work areas of the School.

Table 5.2.13 Innovation Culture Rating (ICR) values.

<table>
<thead>
<tr>
<th>BIIR :</th>
<th>&quot;Yes&quot;</th>
<th>&quot;Yes&quot; + &quot;Maybe&quot;</th>
<th>&quot;No&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money</td>
<td>64.8%</td>
<td>88.0%</td>
<td>12%</td>
</tr>
<tr>
<td>Time</td>
<td>60.8%</td>
<td>86.4%</td>
<td>13.6%</td>
</tr>
<tr>
<td>Training</td>
<td>60.0%</td>
<td>73.7%</td>
<td>26.3%</td>
</tr>
<tr>
<td>Average</td>
<td>61.9%</td>
<td>82.7%</td>
<td>17.3%</td>
</tr>
<tr>
<td>ICR = (1 - Average)</td>
<td>38.1%</td>
<td>17.3%</td>
<td>ICR</td>
</tr>
</tbody>
</table>

Figure 5.2.13 Satisfaction of key factors fostering innovation.

5.2.14 Innovation Rating Potential for Technology (IRPT).

Question 20 of the quantitative research component investigated the rating potential for various new types of technology and teaching methods. These were scored out of
10 and was used to prove the hypothesis in which there was no difference between the ratings given by staff for using new and old versions of technology and teaching methods, or support the alternative hypothesis in which there was found to be a difference in the ratings given by staff for using the new and old versions of technology and teaching methods.

In addition, these values for ratings of old and new technology and teaching methods were used as a rating for potential technology and teaching methods for the School, and used in the generation of an overall Balance of Infrastructure and Innovation Rating (BIIR). These values for old and new technologies are shown in Table 4.2.3.1. The average of old ratings was 5.74/10 and the average of new ratings was 7.86/10.

5.2.15 Balance of Infrastructure and Innovation Rating (BIIR).

The BIIR or Balance of Infrastructure and Innovation Rating (BIIR) is \( \text{ICR} \times \text{IRPT} = 17.3\% \times 5.74 = 0.99 \) (old technology).

The BIIR or Balance of Infrastructure and Innovation Rating (BIIR) is \( \text{ICR} \times \text{IRPT} = 17.3\% \times 7.86 = 1.36 \) (new technology).

The rating for BIIR in this case study was unfortunately low. However, the rating for IRPT was reasonable, indicating staff considers the proposed new technology as an improvement over the older current technology and teaching methods. The BIIR can improve with more funding directed towards innovative technology and teaching methods. This will happen once the ICT infrastructure is in place, ready to support the needs of the innovation sought by teaching and learning, which in turn, will result in more funding available for fostering innovation.
5.2.16 Direct observation photos.

Part of the rigour in research and use of data triangulation, more than 130 photos were taken of classroom and buildings in an attempt to try and understand and justify why staff may think additional funding is needed in their area of teaching or work practice. The location and quantity of direct observation photos are shown in Table 5.2.16. In addition, investigations were undertaken with staff who believed funding was not required for fostering innovation in their work area.

**Table 5.2.16 Direct observation photos locations and quantity.**

<table>
<thead>
<tr>
<th>Field Note Descriptions</th>
<th>Building Photos</th>
<th>Total Photos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room1</td>
<td>Room2</td>
<td>Room3</td>
</tr>
<tr>
<td>(1 Photo)</td>
<td>(1 Photo)</td>
<td>(2 Photos)</td>
</tr>
<tr>
<td>DS1</td>
<td>DS2</td>
<td>DS3</td>
</tr>
<tr>
<td>(2 Photos)</td>
<td>(2 Photos)</td>
<td>(2 Photos)</td>
</tr>
<tr>
<td>F3</td>
<td>F8</td>
<td>F11</td>
</tr>
<tr>
<td>(2 Photos)</td>
<td>(2 Photos)</td>
<td>(2 Photos)</td>
</tr>
<tr>
<td>K2</td>
<td></td>
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The staff member most likely to not request additional funding, has a designated work area in a modern building, with air-conditioning and modern technological equipment. This is the print room containing a lot of modern copiers and large format printers with a reasonable amount of space, cupboards and table area. A detailed description with photos can be seen in Appendix R.

The two staff members, who specifically mentioned the need for additional funding, have older rooms, one with and one without air-conditioning, however, both require updated work-spaces and more funding for ease of integration of technology into the classroom. A detailed description with photos are displayed in Appendix S and T.

Perhaps any lack of funding for technology was offset by the comfortable work environment for staff.
5.3 Qualitative Data Analysis Summary

Interviews were conducted within the ethics approval duration and included member checking to increase the rigour of the research. These member checking interviews were completed 4 to 5 months later than the initial interviews, covering all 25 research participants. Initial interviews were on average 19.18min in length and the member checking interviews were on average 12.88min in length. A total of almost 80 hours was spent transcribing the audio transcriptions.

Quotes from teaching and non-teaching staff concluded innovation can be technology and pedagogy. The importance of innovation as seen by teaching and non-teaching staff is considered moderately important and was confirmed by asking staff the same question 4 to 5 months apart.

The majority of staff believe in the use of personal entrepreneurship (84%), action research (84%), life-long learning (100%) and individual learning styles (92%). However, only 32% of staff believe they have been involved with any sort of ability-driven education.

Teaching and learning management staff were the most likely to request more time and money for fostering innovation in education. The key factors for fostering innovation in education include a satisfaction level of 12% for money, 13.6% for time and 25.3% for training. These factors contribute to an ICR or Innovation Culture Rating of 17.3%. In addition, the Innovation Rating Potential for Technology using the older technology was 57.4% and the new proposed technology was 78.6%. The overall Balance of Infrastructure and Innovation Rating (BIIR) was 0.99 for the old technology and 1.36 for new technology.
Direct observation photos were used to understand why one staff member in particular did not request more funding for their work area. In this case, funding had already been spent on modernising the equipment in use and the work location was in a newer building with more modern facilities. This was thought to explain why no additional funding was required by the staff member.

The following chapter discusses the results of the research.
Chapter 6. Results and Discussion

6.1 Introduction

In this chapter the findings from the quantitative analysis and qualitative analysis are presented. The primary research aim was to examine how to improve educational innovation through better budget awareness and planning? Research questions were constructed to examine how to efficiently implement an ICT infrastructure and what typical components made up a typical yearly budget. Additional research questions were constructed in order to examine the key factors for fostering innovation in education. This was important as the ICT infrastructure funding needs to align with the aim of supporting the innovative requests from teaching and learning while also maintaining the day-to-day technical operations of the School.

A Balance of Infrastructure and Innovation Rating (BIIR) was devised to provide educational leadership with a way to gauge whether innovation practices are supported by the current educational environment. All findings were achieved while aiming to perform research with the highest level of rigour. Rival explanations for results are mentioned to provide the reader with every opportunity to interpret their own findings.
This chapter commences with a summary of the quantitative research results, followed by a summary of the qualitative research results and finally answers to the initial research questions.

6.2 Quantitative Research

6.2.1 Demands for services

To justify money spent on both capital and recurrent ICT infrastructure items, there needs to be clear signs of demand for IT Services. The quantitative research clearly demonstrates the increased demand for internet usage throughout the School. Internet usage increased consistently from 50GB per week during 2012 through to 700GB per week during 2016. This pattern of demand for internet services justified the outlay of capital in particular to upgrade the network bandwidth from 1GB to 10GB. In addition, WAPs were upgraded to allow for the latest wireless technology to accommodate client devices connecting and transmitting data at the fastest speed possible with current technology. Furthermore, constant high demand for printer and copier services sees the School printing more than 1.7 million sheets per year, again justifying the need for stable and efficient ICT infrastructure operating at the highest speed possible.

IT Services also need to maintain more than 40 VMs catering for the various needs of services throughout the School. More than 2000 helpdesk tickets per year are recorded acknowledging the need for troubleshooting and support from staff and students.

Funding spent on storage and server technology has provided an opportunity to incorporate hyper-convergence technology which has provided a more efficient and cost effective means for storing data, retrieving data and enabling a disaster recovery platform. Additional soft costs including reduced VMware licensing, less rack space for server equipment and reduced power costs have been achieved.
6.2.2 ICT infrastructure capital budget items

Capital budget items included storage and server technology which included the implementation of the Simplivity hyper-convergence technology costing around $230,000.00. Each year the cost of deploying and maintaining a 1:1 laptop program for around 1000 students costs the School around $300,000.00. Constant competition has forced pricing down for these products. The upgrade of the network infrastructure has included costs of more than $235,000.00 for the network switches, a further cost of $44,000.00 for network SFPs, some additional fibre cable work costing $4258 and the cost of new WAP implementation costing $69,300.00. Each year data projectors are reviewed and renewed if required with annual costs varying from more than $11,000.00 to more than $85,000.00. Non-teaching staff admin desktops are replaced every 3 years, with costs of more than $60,000.00 every 3 years. Other smaller capital budget costs add to produce yearly capital budget costs of between $549,000.00 and more than $746,000.00.

6.2.3 ICT infrastructure recurrent budget items

Each year maintenance costs are required to maintain School ICT infrastructure. Understanding where these costs are associated and purchasing in bulk, while increasing and maintaining vendor competition has helped to reduce these totals. Software licensing is the largest contributor to recurrent budget item costs. It is important to ensure the School is paying correctly for software licensing in case an audit occurs, however, reviewing this each year will ensure the School also does not pay for items which it may not require. Other items including misc/other vary greatly each year. Training and R&D allow some on-site training and use of technology, however, IT Services staff find it hard to allocate time for this due to their high
workload. Device deployment incurs costs no matter what the brand of the device is and this is always part of the recurrent item budget list.

In addition to this, school leadership and decision makers need to understand that the same amount of funding each year does not accurately take into account the uneven, yearly cost of equipment replacement due to warranty expirations. Some equipment include 3 year warranties, some 4, some 5 and some EOL or End of Life which is quite unpredictable. The school can benefit from saving power by monitoring ICT usage patterns by making sure automatic sensors are in place for turning off data projectors after 6pm and ensuring power saving settings exist for computing devices where possible. Additionally, if ICT management are involved in air-conditioning of classrooms, temperatures should be set to no less than 24 degrees during summer and turned off when not in use. Furthermore, by recycling paper and printer cartridges and UPS batteries where possible will also promote sustainability.

6.2.4 Innovation in Education Q20 – Hypothesis testing

A null hypothesis was formulated stating there was no difference in ratings given for old and new technology in use in the School. 25 research participants were asked about 5 types of old and new forms of technology with one of these included as old and new forms of teaching practices. All of these involving technology proved the alternative hypothesis correct. In other words, all staff believe the use of the new technology would improve innovation if used in their classrooms and work area. However, the null hypothesis held true for the question based on teaching practices. Staff did not see the use of new forms of teaching practice, such as self-direct learning or heutagogy as innovative. Or at least they did not see the older form of teaching (explicit teaching) as being replaced by heutagogy. In fact, some staff claim using both types of teaching methods and this was irrespective of age of teacher or age of classroom students. Initial
assumptions were Junior School teaching staff may see younger aged students requiring more explicit teaching and not as much use of self-directed learning opportunities. However, senior School staff and students still combined and made use of both types of teaching methods and regarded them both as innovative depending on how the teacher chose to use them.

6.3 Qualitative Research

6.3.1 Rigour in interview process

It was important to show rigour throughout the research process. Information is presented in Tables 5.2.1 and 5.2.2.1, detailing interview dates, duration, word count, page count and time taken to perform interview transcriptions. A second round of member checking interviews was conducted 3 to 4 months later than the original interviews with details presented in Table 5.2.2.2. This gave research participants a chance to review their responses and modify the results.

Triangulation of data was used where possible to increase the rigour of the research. Interviews and member checking interviews were combined with direct observation photos to compile a more complete understanding of how money, time and training for fostering innovation was established.

The results from thematic analysis was used to confirm the number of times issues were raised throughout the interviews of staff. The importance of innovation was asked twice with a period of 4 to 5 months between interviews. Again, this process helped in strengthening the rigour of the research.

Topics mentioned throughout the literature, such as personal entrepreneurship, action researcher, life-long learning, ability-driven education and individual learning styles were asked of interviewees. The majority of responses, greater than 80% agreed
with the literature on these teaching approaches except for ability-driven education. Some staff were not sure if this was used at all, some stated without hesitation either yes or no. There was quite a noticeable contrast between different teaching staff when asked this question.

All interviews were conducted within the ethics approval period. Any variations in timing for interviews or the duration over which the interviews were conducted have been documented.

6.3.2 What is innovation

All staff were asked about what innovation was for them. Some stated it was clearly not just technology but the pedagogy as well. This was important from a research perspective as it highlights innovation as being teaching methods and other factors other than the traditional physical information technology. Some responses included not following others and being forward thinkers. A non-teaching staff member stated that this was being creative in reaching all students. This was also important as it was firstly a non-teaching staff member that mentioned it and secondly, the link with individual learning styles and catering for the needs of each student. Another non-teaching staff member stated innovation was both technology and the way of teaching. Other teaching staff did claim that innovation was implementing future technology now and trying new and different things.

6.3.3 Number of issues raised

The transcribing process and the use of thematic analysis found the highest number of issues were around insufficient funding of innovation. The word “Money” was identified 195 times throughout the transcribing of the 25 interviews. Another interesting fact was teaching staff were 25% more likely to request additional funding
than non-teaching staff. This is not a large difference, however, it more likely acknowledged by staff working in non-air-conditioned classrooms. In addition, teaching staff who are also management staff are 95% more likely to request additional time for their role. Teaching staff with both teaching workloads and management tasks have the need for better time management. Teaching staff were also 71% more likely to request training than non-teaching staff. More requests from teaching staff for training on new technology introduced into the classroom is not surprising.

6.3.4 Types of technology requested

Types of technology requested by staff is very important as it sets the agenda for both capital and recurrent budget items. IT Management need to know the types of technology teaching and learning desire through the creation of the ICT strategic plan in order to purchase, implement and maintain the correct ICT infrastructure. If the SIR is to be of use to School Management and the IRPT is relevant in terms of finding out the enthusiasm for proposed future innovative products, then the requested list of technology by staff is essential. Some items such as augmented reality, green rooms and robotics are available today, but affordability is the key. Other items such as an increased number of devices, more powerful devices and more equipment in general such as laser cutters and CNC mills also require additional funding. However, some technology items require time and training for staff to fully utilize the advantages of the new technology. These can include modern video conferencing tools for language subjects, better use of interactive data projectors, integration of social media in real-time, the creation and use of e-portfolios for students and parent feedback, the knowledge of how to make the most of the latest data and video analysis tools and better administration software for non-teaching staff such as SSO.
6.3.5 Importance of Innovation

It must also be stated here that all 25 research participants were asked how important they saw innovation to their teaching in the classroom or work area. Most staff saw innovation as important. Again to demonstrate rigour in the research, the same question was asked twice, 3 to 4 months apart, with only a 6% increase in results.

6.3.6 Personal Entrepreneurship

84% of staff believe they make use of personal entrepreneurship in the classroom. Despite not having sufficient funding for higher levels of technological equipment to help with classroom teaching, staff continue to experiment and research with ICT applications in various ways. If more funding, more time and more training was allocated, personal entrepreneurship would flourish even more by granting staff the chance to ‘tinker’ with technology and integrate different methods of content delivery into the curriculum. Staff indicated they should encourage risk taking, keep up with new applications by investigating software through training courses and having time to ‘tinker’ with technology. This also included sharing the learning experience with other staff.

6.3.7 Action Researcher

84% of staff agreed they made use of action researching in their role. If IT support is missing or late in providing solutions to problems encountered by staff, individuals are left to look into the solutions themselves. This unexpected advantage of limited IT support encourages action researching within the teaching and non-teaching roles. However, sustainable and strategic support would see staff provided with sufficient funding for equipment, time for ‘tinkering’ and regular and appropriate training. Staff
commented on needing time for research and feedback, identifying the technology and finding ways around challenges.

6.3.8 Life-long learning

100% of staff stated they supported life-long learning in the classroom. All students should be given the appropriate skills to gather information, think critically upon this information and develop initiatives for higher-order thinking and lateral thinking strategies. Staff added comments such as encouraging risk taking, developing independent learners, thinking outside the box and thinking about the process, not just the product.

6.3.9 Ability-driven education

32% of staff believe they have been involved with ability-driven education at the School. Staff indicated they have made use of alternative pathways for student learning, however, a reduction in the workload and reliance on high-stakes assessment systems has not been encountered. Comments from staff included the use of differentiation support for mixed abilities, differentiated unit plans and in some cases exams not showing the true character of student abilities.

6.3.10 Individual Learning Styles

92% of staff believe they cater for individual learning styles and 8% stated maybe or from time to time they make use of individual learning styles. All staff agree supporting student learning through individual learning styles produces increased learning outcomes for students. It was noted that this is difficult through standardised learning methods such as using an LMS. The best approach is through one-on-one, face-to-face classroom activities; however, time and low support staff numbers can limit this approach.
6.3.11 Key factors for fostering innovation in education

Three important factors were identified for fostering innovation in education. 88% of staff stated that money was a key factor for fostering innovation in education either all of the time or most of the time. A second key factor was sufficient time allocated to ‘tinkering’ with technology, release time for developing learning plans which involved ICT and time provided for training. A total of 86.4% of staff believe time was needed all or most of the time in order to foster innovation in education. The third factor for fostering innovation in education was training or professional development in which staff agreed 74.7% of the time this would help foster innovation in education. If these values are quite high as in this case study, then more attention should be given to providing money, time and training in order to foster innovation in education.

6.3.12 Balance of Infrastructure and Innovation Rating

The Balance of Infrastructure and Innovation Rating (BIIR) is created from the Innovation Culture Rating (ICR) and the Innovation Rating Potential for Technology (IRPT). The ICR is a percentage based on the users (teaching and non-teaching staff) for what they perceive is sufficient for fostering innovation in terms of the above 3 key factors for fostering innovation. The three key factors, money, time and training combine to create the culture in the educational facility for innovation as seen by the staff who will implement innovation. The IRPT, which is a value out of 10, is a way of determining if staff are encouraged by the prospective new technology and teaching methods proposed for the next few years. The IRPT also indicates to ICT management the sorts of technology, driven by the ICT strategic plan, which would need to be supported and implemented by the IT Services team. This helps with future decisions for capital and recurrent budget expenditure. If staff indicated a 100% agreement with the culture for fostering innovation in terms of money, time and training and in
addition, rated the proposed new technology and learning methods as 10 out of 10, the BIIR would have a maximum value of 10. A value under 5 is not considered great for fostering innovation in education. A value between 5 and 10 is considered a great platform for encouraging moral of staff. This includes sufficient support in terms of money, time, training and the new technology and teaching methods.

The rating for BIIR in this case study was low with a value of 0.99 for old technology and 1.36 for the new proposed technology. However, the rating for IRPT of 5.74/10 for old technology and 7.86/10 for new proposed technology was reasonable, indicating staff considers the proposed new technology as an improvement over the older current technology and teaching methods. A value of 17.3% for ICR is low for this case study. The BIIR can improve with more funding directed towards innovative technology and teaching methods.

6.3.13 Direct Observation Photos

Direct observation photos were taken in order to provide increased rigour in the research through data triangulation. One of the key factors for the ICR was money. By looking at staff working conditions, it was hoped to explain why some staff indicated there was a need for more funding while other staff stated there was no need for additional funding. More than 130 photos were taken of various classrooms and staff rooms in order to understand more about how staff would rate funding.

Of particular concern, was a staff member who indicated no money was needed in their work area. After examining the building and work area (see Appendix R), it was noted the building was relatively new, had air-conditioning and the technological equipment was modern and well supported.
In contrast, other staff members showed older classrooms, no air-conditioning and some older and outdated technology (see Appendix S).

6.4 Research Questions

6.4.1 Main Research Question

*How can we improve educational innovation through better budget awareness and planning?*

Most of the innovative practices whether they make use of technology or not, require the sufficient implementation of ICT infrastructure. Many of the innovative practices that make use of technology would not work without sufficient and efficiently implemented ICT infrastructure. In addition, since the ICT infrastructure needs to be in place before many technologies can work, funding can easily be exhausted on the ICT infrastructure, leaving no funding for the important, innovative classroom products to be integrated into the curriculum. There needs to be an awareness of both the ICT infrastructure required to service the needs for the technology chosen by teaching and learning and the purpose and intended learning outcomes for students.

Similar to the ICT maturity model devised by Nolan (1973 and 1979), there is a form of equilibrium obtained between how much money should be spent on ICT infrastructure and how much money is available for the innovative practices and technology proposed for integration into classroom teaching. This will vary each year due to a complex array of technological and budgetary variables and will differ according to each educational facility.

6.4.2 Main Sub Research Question

*Can a rating be developed which can help educational leadership with fostering innovation?*
Balance of Infrastructure and Innovation Rating (BIIR) = Innovation Culture Rating (ICR) x Innovation Rating Potential for Technology (IRPT).

Where:

Innovation Culture Rating includes a rating (No=1 or Yes=0) for the following 3 factors:

- Money required for Innovation (Questions 6, 10, 16, 18 and 19) [Value range 0.0 to 1.0]
- Time required for Innovation (Questions 6, 9, 16 and 19).
- Professional Development needed for Innovation (Questions 8, 17 and 19).

Innovation Rating for Innovation is Q20 from the qualitative research with a rating for old versus new technology [Value range 0 to 10].

If staff determine that sufficient money, time and training has been provided to foster innovation in education, the ICR will equal 1. This means that staff believe sufficient support has been provided in terms of money, time and training to adequately foster innovation.

If staff rate the new, proposed technology as 10 out of 10, the maximum value for innovation, then the staff believe the implementation of the new technology is worthwhile and will support fostering of innovation in the educational faculty.

Both of the maximum values (1 for ICR) and (10 for IRPT) will create a maximum value of 10. This caters for the key factors effecting innovation in education and the proposed technology supported by an efficient and sustainable ICT infrastructure. If values are low (say less than 5 out of 10) the key factors fostering innovation need to be reviewed. In addition, the proposed technology supported by sufficient ICT infrastructure may also need reviewing.

Therefore, this rating for balancing infrastructure and innovation can help educational leadership with fostering innovation as it takes into account the key factors found in literature which foster innovation in education and allows staff to rate the proposed incoming technology. In addition, the approval of the proposed technology should only occur when IT Management
can confirm the efficient and sustainable ICT infrastructure is in place to support the innovative technology.

6.4.3 ICT Infrastructure sub research question 1

*How can ICT infrastructure expenditure become further optimized?*

Understanding the components that make up the ICT infrastructure and looking at ways to purchase equipment at lower costs is a good start. However, keeping abreast of new technology, can result in short-term and longer-term savings. These can be obvious and other times they can include 'soft costs' where advantages can be gained in terms of lower power costs, licensing costs and improved productivity for staff.

These processes help address the initial question posed by Berghout, Nijland and Powell (2011) whether costs and benefits of IT management can be organised more efficiently.

6.4.4 ICT Infrastructure sub research question 2

*Is there a justification for ICT infrastructure expenditure?*

Early indications for the need for expenditure were obtained. These were mainly targeting higher internet usage and therefore guided the expenditure aimed at providing an ICT infrastructure that would cope with increased traffic across the School campus. The School upgraded the internet connection speed from 100MB to 1GB a few years ago in anticipation of increased demand on internet usage. ICT infrastructure components such as network switches were upgraded from 1GB to 10GB and were due for upgrading as they were out of warranty. Some fibre was replaced to allow for 10GB bandwidth across the entire campus. SFP modules were upgraded to allow for switches and fibre to communicate at the 10GB speed. Finally wireless access points were upgraded to allow edge devices to make use of the new 'ac' wireless speeds increasing
from 300MB to 1GB. An ISP traffic report clearly demonstrates the dramatic increase in internet usage over the period from 2012 to 2016. With the addition of using clickview, youtube, other internet surfing and cloud based products for learning, the School is now in a far better position to take advantage of these changes in technology.

It was mentioned by Muhoza et al., (2014) in section 2.4.2.5 where infrastructure expenditure needs to be strategically planned where ICT staff and end users can make successful use of the new equipment. There also needs to be a definite demand for services by end users and this has been outlined as demands for internet bandwidth and therefore, fiber backbone infrastructure supplying sufficient capacity to adequately service the needs of teaching and learning. In addition, network switches and switching technology such as SFPs were upgraded to provide a bottleneck free solution.

6.4.5 ICT Infrastructure sub research question 3

What ICT infrastructure components are considered important for the efficient running of an education environment?

These have been listed in this case study in Table 2.3.1. Data storage, processing power, security, backup and restoration technologies, computing devices and access to the internet are fundamental components of infrastructure required in an educational environment. For teaching and learning to make the most of innovative practices and increase learning outcomes for students, these infrastructure components are required. These components also need to be reviewed on a regular basis to cater for possible integration of new advancing technologies and to constantly align the need for ICT infrastructure with the needs of teaching and learning by adhering to ICT strategic plans.
6.4.6 Innovation in education sub research question 1

*What factors provide a positive school culture for innovation?*

Money, time and training were all proven as key factors for fostering innovation in a School during this case study. More than 82% of responses indicated these 3 factors were required to improve innovation.

Money was not only required to purchase physical technology and software. It is also required to support more time and training for staff and was mentioned in section 2.4.2.3 Budgets This case study asked staff if time was needed to help support and foster innovation in their classrooms. More than 74% of staff indicated that more time was needed which was first mentioned in section 2.4.2.4 IT Support. Research has shown that time can be thought of as either time in general (Becta, 2004; Schoepp, 2005; Jacobsen, 1998; Sicilia, 2006, Pajo and Wallace, 2001) or time in terms of developing instructional guidelines (Hirschbuhl and Faseyitan, 1994; Nantz and Lundgren, 1998; Sammons, 1994; Beaudin, 2002; Byrom, 1998; Anderson, Varnhagen and Campbell, 1998) or release time (Brace and Roberts, 1996; Redmann and Kotrlik, 2004; Rogers, 2000) which allows staff to 'tinker' with the technology. The idea of providing sufficient professional development to staff was mentioned in section 2.4.2.2 Training.

6.4.7 Innovation in education sub research question 2

*Do staff rate the potential for new technology and teaching practices higher than older technology and teaching practices in terms of fostering innovation?*

Yes, this was true for 4 of the 5 questions relating to technology in terms of hardware such as modern laptops, advances in data projector technology, the introduction of
augmented reality products and the introduction and use of big data analysis in education.

The null hypothesis to be tested is that the average of the two groups of data (old technology innovation rating and the new technology innovation rating) are not different to each other.

Only one of these research questions were proven true. This was the comparison of old and new methods of teaching practice. All other forms of technology upgrade or improvement resulted in staff acknowledging an improvement in innovation by using the new technology.

The final chapter of this thesis describes the conclusion for the research.
Chapter 7. Conclusion

7.1 Summary and Critique

7.1.1 Summary of the contributions of this work

This research contributes to the research by introducing a new Balance of Infrastructure and Innovation Rating (BIIR), which can be used by decision makers in senior School leadership to understand if large investments made in ICT infrastructure and innovative technology will be utilised efficiently by staff.

In addition, decision makers in senior School leadership can utilise the Innovation Culture Rating (ICR) to gauge how well money, time and training are viewed by staff for fostering innovation in their School. Proposed new technology can be reviewed using the Innovation Rating Potential for Technology (IRPT) in the School by reviewing how staff anticipates the improvements in delivering innovation, using technology and teaching practice before there is a commitment to funding for this implementation.

This research is based on a mixed-methods approach, combining a descriptive quantitative research component for ICT infrastructure budget items and a qualitative research component. Both of these were based on a constructivist ontological stance.
aiming to build knowledge about the phenomenon under study and contribute to a
better understanding of the case study participants. Furthermore, this research also
made use of rigorous research techniques to explore and confirm the key factors which
foster innovation in education as described in section 2.6. Overwhelmingly, the results
for this case study conclude and confirm the key factors for fostering innovation in
education, where more than 82% of the results stating the importance of these factors
in the acceptance and implementation of technology by staff.

In addition, this research has added a new rating for gauging the likelihood of
implementation of technology and teaching practices before senior management
commit to funding large amounts of money into purchasing equipment. This rating for
School Innovation and the potential for innovation, is based on the culture of the
educational environment, which the literature and this research confirms is drawn from
sufficient funding, time and training. It is also based on direct feedback from the staff
entrusted with using this potential future technology.

Technology implementation and purchasing decisions in relation to what
technology to implement are often left to IT management and financial decision
makers. If the enablers and chief stakeholders in the chosen technology, which are the
staff, are included in the purchasing decisions, this will produce more efficient use of
the technology. In turn, this enables more effective implementation and integration of
the technology into delivering the curriculum and greater learning outcomes for
students.

7.1.2 Critique of the research approach

In conducting this research, a constructivist research approach was used to explore the
life settings of participants as teaching and non-teaching staff in a K-12 private School.
The social constructivist approach allowed for open-ended questions of participants in
order to derive a deeper meaning and understanding of the phenomenon under study in the context in which it occurs. This particular approach proved suitable and the merging of knowledge gained from the literature and this case study research has confirmed several key factors likely to foster innovation in education, as stated in section 2.6, as well as the importance of ICT infrastructure and the role it plays in supporting teaching and learning.

The quantitative research component of the mixed-methods approach was used in a descriptive form only with no statistical significance. In terms of generalisability and transferability of the findings, readers of this research need to understand the context in which the research was undertaken, examine and explore the components of the ICT infrastructure which may differ between educational environments and the budgets provided due to School size and other factors. However, the concept of balancing funding between the innovative technology and the ICT infrastructure required to support the proposed innovation can be drawn. The types of ICT infrastructure mentioned in this research may enable readers who are associated with IT purchasing decisions, an opportunity to include components they may not usually include.

In addition, the quantitative research component was initially believed to follow a positivist ontological world view as there is only one reality and certainly no subjectivity in the results obtained from data over the period of time from 2012 to 2016. However, some capital budget decisions could be the result of subjective reasoning on behalf of IT management which could differ between educational facilities due to factors not present in every situation. Therefore, in order to show rigour in the approach to finding the truth in this case study, some subjectivity and therefore an approach
based on social constructivism was undertaken, also acknowledging the affect researcher bias may play in the generalisability of results.

The qualitative research component of this mixed-methods approach followed a rigorous path including triangulation of data from interviews, direct observations, thick descriptions and a reflexivity journal to ensure accuracy of the results. The information gathered during the research is offered to the reader to make up their own mind as to the interpretation of the results. Initial participant interviews were accurately recorded, audio transcribed and thematically analysed, followed several months later with member checking interviews to ensure the accuracy of responses.

This research case study was conducted in Australia, from one private co-educational K-12 School. Responses were purposively sampled from 25 research participants working in several teaching departments and several non-teaching administration positions. The teaching positions covered as many different departments, student ages and staff ages as possible to provide a broad range of results. If time permitted, more participants would have been included in the research and a multi-case study would have been possible.

This research was conducted with a high level of rigour to ensure the credibility of the findings. ICT infrastructure data was captured over a long period of time, 5 years, from 2012 to 2016 using a purely descriptive quantitative process. Key factors which foster innovation in education as identified through the literature were confirmed through the rigorous qualitative research process undertaken. The use of the social constructivist ontological stance was used to ensure the phenomenon under study was examined in depth using open-ended questions of research participants in the context in which it occurs. The credibility of the study was reinforced by additional member checking of interview data to ensure the accuracy of the findings. Peer debriefing with
both supervisors was used on a regular basis to ensure the research was following correct guidelines for both rigorous and ethical processes.

The next section describes the implications for the research. These implications are for educational leadership, staff and IT management.

7.2 Implications

This research makes a significant contribution to understanding how efficient use of funds for ICT infrastructure and the proposed innovation, which the infrastructure is intended to support, should be efficiently identified and implemented. This state of equilibrium between funding spent on the ICT infrastructure and the innovation sought by educational institutions is best understood when all factors are known by the decision makers involved. These findings have theoretical implications for proposing a new Balance of Infrastructure and Innovation Rating (BIIR) for gauging how the current School culture and staff are prepared for the implementation of innovative technology.

7.2.1 Implications for educational leadership

The implications for educational leadership, if the use of the Balance of Infrastructure and Innovation Rating (BIIR) is implemented as a test for support within the teaching and learning body, could lead to great savings in terms of effective use of the innovative technology purchased. There could also be savings for directing time and training resources by identifying with staff their needs as stakeholders in the process of implementing innovative technology driven by pedagogy.

As technology becomes more complex and more integrated into so many aspects of our lives, there will become an increasing need for IT professionals and consultants advising senior educational management and school boards. A thorough knowledge of
IT infrastructure and how it drives and supports innovation in education should be highly regarded by educational leadership in order to efficiently run an educational facility.

The shortage of funding for Schools in general and for technology will add pressure to increasing efficient practices across all areas of IT management. The impact of these technologies effect more general areas of School management than ever before. One such example includes student ID cards and adding funds efficiently through online portals for ease of access by parents. In addition to ID card security and purchasing products such as tuckshop meals and clothing items, the ID cards can be used for printing purposes allowing students and parents to manage their own cashless solution for multiple services. However, this adds more complex layers of management for IT in terms of ensuring student record data is securely synchronised between multiple systems. These systems include school identity software such as Microsoft active directory, printer management software and ID card printing solutions.

7.2.2 Implications for staff

The implications for staff is a greater awareness of their own technological abilities in using the technology proposed by educational leadership. If this information helps to highlight the needs for release time, planning time and tinkering time for the technology, then staff should not feel overwhelmed with the time pressures associated with the introduction of new technology. Staff also need to know ahead of time, their own need for professional development in using the proposed new technology, in order to plan sufficiently for training before the expected implementation of technology in the classroom or workplace. It is therefore, the staff involvement in the development of the Balance of Infrastructure and Innovation Rating (BIIR) which should provide adequate notice for staff of the proposed future technology.
7.2.3 Implications for Information Technology Management

The implications for IT Management is a better understanding and process of identifying the needs of delivering pedagogy. The pedagogy drives the technology. This is the first conversation required between stakeholders. Research is then undertaken on the innovative technology sought by teaching and learning. Following this is the ICT infrastructure required to support the proposed innovative technology. However, the ICT infrastructure is implemented first in order to support the innovations implemented at the edge of the physical network. IT management staff need to be aware of the support required by staff in using the technology and this includes appropriate ICT infrastructure, services and equipment which aim to reduce time consuming tasks and training offered to increase the efficient use of the expensive technology purchased.

Furthermore, if ICT budgets include both ICT infrastructure and innovative technology, then a balance is required between the two to ensure sufficient ICT infrastructure is in place to support the innovative technology introduced in the classrooms and work places. It follows, that purchasing ICT infrastructure with all of the available funds will leave no funding for the devices and products required at the edge of the physical network requested by staff.

A description of the limitations of the research follow.

7.3 Limitations

Due to time and resource constraints, this doctoral dissertation has its limitations with respect to what can be included in the research. This includes the limitation of a single case study, number of interviews, the list of research topics associated with the main research concept and aim. As an exploratory study, open-ended questions in the qualitative portion of the research allowed for the inclusion of additional ideas and
concepts identified through the thematic analysis of data collected. The key factors thought to foster innovation for example where the main focus of the research, however, other factors could be studied and perhaps would be through future research directions, however, due to a purpose to keep on track, were limited. The quantitative research component was also limited to a 5 year period for purposes of capturing budgetary data from 2012 to 2016.

A single case study was conducted in this research. Additional studies could broaden the research to include multiple case studies. It was thought not possible due to time and resource limitations to conduct a multiple case study approach during this research. Every attempt was made to conduct rigorous research to ensure confirmability and transferability of these research findings to other educational environments. Furthermore, the purposive sample aimed to cover as many departments as possible and cover all year levels in the K-12 School. Obviously, some year levels and subjects were not included due to the research constraints and this has been acknowledged. Triangulation of data was used to process several sources of information with the aim of improving the reliability of the findings. Though case study research design lacks the validity, reliability and ability for generalisability compared with other research designs, all attempts were made during the research design, data collection and data analysis of both the quantitative and qualitative components of this mixed-methods approach, in combination with a constructivist ontological stance to ensure accuracy, rigour and a richer analysis.

Researcher bias and a personal lens used by the researcher should also be acknowledged. It is hoped this insight brought more in-depth results to the research and in no way has led to a prejudice of the results. Of course, it still needs to be acknowledged that the researcher knew and worked with the interviewees and this
could have affected the results. However, all interviewees were asked the same questions in the same order and consistency hoping to offer no chance for bias. In fact, the open-ended questions offered an opportunity for participants to openly and freely explain their involvement in the case study research. The methodology used and the rigour shown throughout the research aims to accurately describe the phenomenon under study and offer the reader a chance to conclude their own findings from the research.

The next section describes the significance of this research.

7.4 Significance of the research

It is common these days to see every educational institution announcing their use of innovation and technology and the large sums of money spent on teaching methods and in particularly the technology. If only a few percent of the overall budgets can be saved by guiding the purchasing decisions this could save educational institutions thousands, if not, millions of dollars each year.

Understanding the components which make up the ICT infrastructure provides a full picture of the budget items and therefore helps decision makers with the ability to fine tune these components in terms of new technology discoveries and negotiating better pricing with vendors.

Expensive capital investments were justified to improve the capacity of the School to engage in innovative practices with new technology. 10GB networking technologies, faster 'ac' wireless speeds, improved printing and internet services will result in better cloud based learning practices for staff and students.

A rating was created to help educational leadership obtain feedback from staff who could potentially use the new technology before the purchasing decisions were
made. This could potentially save millions of dollars by ensuring the new technology is purchased, not for the sake of new technology, but for utilising the technology to its fullest potential.

Three factors found in the literature for fostering a positive culture of innovation were investigated. These were money, time and training. All were sought more by staff, however, not exclusively as some staff indicated. If these factors were taken seriously in an attempt by Schools to increase the innovative culture, increased innovation should occur. Funding should be wisely allocated to new technology once it has been approved by the staff who will be using the technology. Sufficient time should be given to staff to tinker with the technology and integrate it into the classroom lessons and work practices. Sufficient, regular and appropriate training should be given to staff on how to use all aspects of the new technology.

A relationship was found between the funding spent on ICT infrastructure and the resulting innovation used by teaching and learning. One side of the funding pendulum could result in too much funding spent on ICT infrastructure and not enough left in annual budgets for the innovative technology. The other side of the funding pendulum could also result in not enough funding spent on the correct ICT infrastructure, resulting in the purchase of innovative technology unable to function due to missing or inadequate ICT infrastructure. In addition, staff indicated funding was important for purchasing new technology, for allocation of spare time for learning and integrating technology into the classroom and for obtaining professional development on the proposed new technology.

It is the hope of this research into technology budgets, the ICT infrastructure components and the innovative technology implemented, which may result in a better way to inform strategic decision makers of the efficiency in which funding is spent. In
turn, this should lead to more funding for the technology used by end users and more effective usage of the technology by staff in the classroom. If staff believe they are supported by educational management through sufficient funding, sufficient time for the implementation, planning and testing of technology and the appropriate professional development in using the technology, there will be far greater usage of the technology to help deliver higher learning outcomes for students.

Given the significance of the research explained above, the following section provides recommendations for future research.

7.5 Recommendations for future research

This research could be used to further explore the concepts of what technology is thought to increase innovation in education, which hopefully leads to greater learning outcomes for students. What technology constitutes budget requests each year would be useful between Schools as a way of helping to identify what each School finds among its staff and students as relevant in the aim of fostering innovation.

The Balance of Infrastructure and Innovation Rating (BIIR) could be further researched by testing this approach with several case studies conducted from both public and private schools. This could help to identify if funding assigned to technology thought to foster innovation, will be well accepted and adapted by the staff which implement the technology, well before the final funding decision has been completed.

Despite the recommendations from senior educators, staff making the purchasing decisions and the IT steering committees, if these recommendations are not based on feedback from the staff intended to use the technology, the risk will be the purchase of technology which is not used to its fullest potential. This feedback, according to the findings of this research, will take the form of requests for additional money for funding
technology, more release and tinker time and the allocation of appropriate professional
development. However, more research needs to be undertaken to gauge the usefulness
of the Balance of Infrastructure and Innovation Rating (BIIR) as a way of listening to
what staff believe will foster innovation in the classroom and knowing the funding is
directed in areas where it will be most efficiently used. The Balance of Infrastructure
and Innovation Rating (BIIR) is a combination of the culture of the School derived
from the funding, time and training offered to staff as part of the funding exercise and
the Innovation Rating Potential for the technology proposed in the next budget.
Additional research into how different Schools compare with these ratings using the
multiple case study research could indicate the effectiveness of the rating in different
educational environments.

It should also be noted that each school will be different and levels of technology
thought to foster innovation in one School could be quite different in another School.

Perhaps with more time or future research directions, more research could gauge
relative advantage or the degree to which the innovation is better than the former
process. Observability is the degree to which innovation results can be seen by others.
Both of these are summed up in the Innovation Rating Potential for Technology by
allowing staff to decide on both relative advantage and observability to a degree, with
observability more prophetic than reality until the chance is provided to use the
technology. More detailed research could be undertaken to examine these 5
characteristics as mentioned by Rogers (1995) to provide a more robust and rigorous
approach to the intended innovation before the commitment to purchasing.
Compatibility, Complexity and trial ability may be considered with demonstrations of
the intended technology.
Another future research direction could be testing Rogers (2003) theory of diffusion of innovations. This could be used to see how a proposed innovative technology passes through early stages of adoption through to wide spread use as truly innovative. In addition, Rogers (1995) explains the innovation-decision process in section 2.1.2 and highlights the rate of awareness-knowledge for an innovation is faster than the rate of adoption. Future research could also take into account the rate of adoption of various intended technologies with the promise of increases in innovation.

Future research directions could also utilise the maturity model developed by Nolan (1979) to examine the advantages of implementing innovation once the correct infrastructure is in place. This could include researching examples of innovation implemented before the correct infrastructure was developed and to outline the issues experienced as a result.

Future research should include investigating why staff say no to additional funding. What are the moderating variables at play here in a School environment? Are some staff saying no to additional funding due to their work conditions including modern air-conditioning, comfortable furniture and sufficient work resources? Should consider social action rising from the new knowledge gained from the research and more critical reflection on current IT management practices. More should be undertaken to drive efficiencies. Efficiencies gained in deployment of laptop fleets are due to the control provided to the IT manager by senior leadership. However, the control of paper usage in photocopying is not under the direct control of IT management due to the structure of human resources in the School. This needs to be given more attention in terms of driving whole School efficiencies and not just those areas under the direct control of the IT manager. It would be expected these matters are brought to the attention of senior leadership through emails, committee meetings and
conversations around ICT and whole School strategic directions. These often occur during budgeting times of the year. Schools could benefit from a direct involvement from IT management in senior School leadership strategic decision making as many efficiencies are gained through the awareness and implementation of ICT strategies and data detection.

Finally, a point needs to be addressed with reference to the high photocopier usage costs. Senior School leadership need to address the high costs of photocopier usage. However, IT Management are not included in School leadership strategic direction. This needs to be noted as an item Senior School leadership ignores or does not consider important as it may mean staff will be upset with having to be accountable for their actions which costs the School money. In addition, IT management needs to be proactive in seeking to ensure educational leadership are aware of inefficient practices and highlighting easily generated reports indicating this information.

The final section of this dissertation provides a conclusion and final reflection of the research.

7.6 Conclusion and final reflection

I set out on this research journey aiming to find how best to balance funding spent on the ICT infrastructure which I have managed in my various roles for more than two decades, with the funding of innovative technology requested by teaching and learning and support staff in an educational institution. Through the increased knowledge gained from studying different research methods and epistemological processes, including rigorous processes, a proposed new Balance of Infrastructure and Innovation Rating (BIIR) has been created.
I have found inspiration and motivation throughout this research in particular from Yin (2014).

If the Balance of Infrastructure and Innovation Rating (BIIR) is used in an educational environment, it is hoped the outcome will be efficiently implemented ICT infrastructure which aims to offer the highest level of support to efficiently implemented innovation in terms of the technology used. If this aids the funding for the implementation of innovative technology and helps identify the time and training needed for staff to effectively use technology, which in turn, increases innovation, then greater learning outcomes should follow for students.
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Appendix A. Components for Capital budget 2012-2016 (template for data).

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## Appendix B. Components for Recurrent budget 2012-2016 (template for data).

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<td>USB Keys/Memory Sticks</td>
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<td>Internet Connection</td>
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<td>Telephones</td>
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<td>SMS Credits</td>
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<td>Total ICT recurrent item requirement</td>
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</table>
Appendix C. Research questions for fostering innovation in education (Teaching staff).

<table>
<thead>
<tr>
<th>Question #</th>
<th>Question description for interviewee</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What do you believe innovation in education entails?</td>
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<tr>
<td>2</td>
<td>How important is innovation to your teaching practice in the classroom?</td>
</tr>
<tr>
<td>3</td>
<td>Do you believe you currently use innovative teaching practices in the classroom?</td>
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<tr>
<td>4</td>
<td>What technology do you make use of in the classroom?</td>
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<tr>
<td>5</td>
<td>Do you consider your current technology as innovative?</td>
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<tr>
<td>6</td>
<td>What prevents your current technology from being innovative?</td>
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<tr>
<td>7</td>
<td>What new technology would you like to use in the classroom?</td>
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<tr>
<td>8</td>
<td>Do you need more professional development in using technology effectively?</td>
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<tr>
<td>9</td>
<td>Do you need more time in learning to use new technologies?</td>
</tr>
<tr>
<td>10</td>
<td>What obstructive ICT behaviour prevents innovation in the classroom?</td>
</tr>
<tr>
<td>11</td>
<td>Do you use personal entrepreneurship in the classroom?</td>
</tr>
<tr>
<td>12</td>
<td>Have you become an action researcher?</td>
</tr>
<tr>
<td>13</td>
<td>Do you encourage life-long learning?</td>
</tr>
<tr>
<td>14</td>
<td>Have you ever been a part of ability-driven education?</td>
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<tr>
<td>15</td>
<td>Do you cater for individual learning styles?</td>
</tr>
<tr>
<td>16</td>
<td>Do you believe we have a financial commitment towards ICT for education?</td>
</tr>
<tr>
<td>17</td>
<td>Are you receiving an acceptable level of ICT training for your teaching position?</td>
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<tr>
<td>18</td>
<td>Is there a supportive school leadership towards the beneficial use of technology?</td>
</tr>
<tr>
<td>19</td>
<td>Do you successfully integrate ICT in the classroom?</td>
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</tbody>
</table>
### Appendix D. Research questions for fostering innovation in education (Non-Teaching staff).

<table>
<thead>
<tr>
<th>Question #</th>
<th>Question description for interviewee</th>
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<tbody>
<tr>
<td>1</td>
<td>What do you believe innovation in education entails?</td>
</tr>
<tr>
<td>2</td>
<td>How important is innovation to your non-teaching area which you support?</td>
</tr>
<tr>
<td>3</td>
<td>Do you believe you currently use innovative work practices?</td>
</tr>
<tr>
<td>4</td>
<td>What technology do you make use of in your area?</td>
</tr>
<tr>
<td>5</td>
<td>Do you consider your current technology as innovative?</td>
</tr>
<tr>
<td>6</td>
<td>What prevents your current technology from being innovative?</td>
</tr>
<tr>
<td>7</td>
<td>What new technology would you like to use in your work areas?</td>
</tr>
<tr>
<td>8</td>
<td>Do you need more professional development in using technology effectively?</td>
</tr>
<tr>
<td>9</td>
<td>Do you need more time in learning to use new technologies?</td>
</tr>
<tr>
<td>10</td>
<td>What obstructive ICT behaviour prevents innovation in your work area?</td>
</tr>
<tr>
<td>11</td>
<td>Do you use personal entrepreneurship in your work area?</td>
</tr>
<tr>
<td>12</td>
<td>Have you become an action researcher?</td>
</tr>
<tr>
<td>13</td>
<td>Do you encourage life-long learning?</td>
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<tr>
<td>14</td>
<td>Have you ever been a part of ability-driven education?</td>
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<tr>
<td>15</td>
<td>Do you cater for individual learning styles?</td>
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<tr>
<td>16</td>
<td>Do you believe we have a financial commitment towards ICT for education?</td>
</tr>
<tr>
<td>17</td>
<td>Are you receiving an acceptable level of ICT training for your position?</td>
</tr>
<tr>
<td>18</td>
<td>Is there a supportive school leadership towards the beneficial use of technology?</td>
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<tr>
<td>19</td>
<td>Do you successfully integrate ICT in your workplace?</td>
</tr>
</tbody>
</table>
## Appendix E. Direct Observations.

The following table lists the direct observation photos and explanations for rooms examined in this research.

<table>
<thead>
<tr>
<th>Room</th>
<th>Description</th>
<th>Appendix Page</th>
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</thead>
<tbody>
<tr>
<td>Design Technology</td>
<td>Design Technology Room DS1</td>
<td>1</td>
</tr>
<tr>
<td>Design Technology</td>
<td>Design Technology Room DS2</td>
<td>2</td>
</tr>
<tr>
<td>Design Technology</td>
<td>Design Technology Room DS3</td>
<td>3</td>
</tr>
<tr>
<td>Design Technology</td>
<td>Design Technology Room DS4</td>
<td>4</td>
</tr>
<tr>
<td>Design Technology</td>
<td>Design Technology Office</td>
<td>5</td>
</tr>
<tr>
<td>Design Technology</td>
<td>Design Technology Workshop</td>
<td>6</td>
</tr>
<tr>
<td>Differentiation Support</td>
<td>Differentiation Support Classroom 1</td>
<td>7</td>
</tr>
<tr>
<td>Differentiation Support</td>
<td>Differentiation Support Classroom 2</td>
<td>8</td>
</tr>
<tr>
<td>Differentiation Support</td>
<td>Differentiation Support Classroom 3</td>
<td>9</td>
</tr>
<tr>
<td>Differentiation Support</td>
<td>Differentiation Support Office</td>
<td>10</td>
</tr>
<tr>
<td>Drama</td>
<td>Drama Classroom</td>
<td>11</td>
</tr>
<tr>
<td>Farmhouse</td>
<td>Heads of Learning staff desks</td>
<td>12</td>
</tr>
<tr>
<td>International School</td>
<td>International School Level 1 Room</td>
<td>13</td>
</tr>
<tr>
<td>International School</td>
<td>International School Level 2 Room</td>
<td>14</td>
</tr>
<tr>
<td>Junior School</td>
<td>Prep Classroom</td>
<td>15</td>
</tr>
<tr>
<td>Junior School</td>
<td>Year 2 Classroom</td>
<td>16</td>
</tr>
<tr>
<td>Junior School</td>
<td>Year 4 Classroom</td>
<td>17</td>
</tr>
<tr>
<td>Junior School</td>
<td>Year 6 Classroom</td>
<td>18</td>
</tr>
<tr>
<td>Languages</td>
<td>Junior School Languages Classroom</td>
<td>19</td>
</tr>
<tr>
<td>Library</td>
<td>Library Space for Years 7 to 12</td>
<td>20</td>
</tr>
<tr>
<td>Maths/Art</td>
<td>Maths Classroom</td>
<td>21</td>
</tr>
<tr>
<td>Maths/Art</td>
<td>Maths Classroom</td>
<td>22</td>
</tr>
<tr>
<td>Maths/Art</td>
<td>Art Classroom</td>
<td>23</td>
</tr>
<tr>
<td>Middle School</td>
<td>Year 7 Classroom</td>
<td>24</td>
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<tr>
<td>Middle School</td>
<td>Year 7 Classroom</td>
<td>25</td>
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<tr>
<td>Middle School</td>
<td>Year 8 Classroom</td>
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<td>Middle School</td>
<td>Year 8 Classroom</td>
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<td>Middle School</td>
<td>Year 9 Classroom</td>
<td>28</td>
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<tr>
<td>Middle School</td>
<td>Year 9 Classroom</td>
<td>29</td>
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<tr>
<td>Music</td>
<td>Music Room M1</td>
<td>30</td>
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<tr>
<td>Music</td>
<td>Music Room M11</td>
<td>31</td>
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<tr>
<td>Music</td>
<td>Music Room M12 Technical Space</td>
<td>32</td>
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<tr>
<td>Music</td>
<td>Music Room M13</td>
<td>33</td>
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<tr>
<td>Music</td>
<td>Music Room M22</td>
<td>34</td>
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<tr>
<td>Print Room</td>
<td>Central Print Room for the School</td>
<td>35</td>
</tr>
<tr>
<td>Science</td>
<td>Science Room S2</td>
<td>36</td>
</tr>
<tr>
<td>Science</td>
<td>Science Room S4</td>
<td>37</td>
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<tr>
<td>Science</td>
<td>Science Room S5</td>
<td>38</td>
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<tr>
<td>Senior School</td>
<td>Senior School Classroom TB2</td>
<td>39</td>
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<tr>
<td>Technical Services</td>
<td>Information Technology IT Support area</td>
<td>40</td>
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<tr>
<td>T Block</td>
<td>T Block Classroom T2</td>
<td>41</td>
</tr>
<tr>
<td>T Block</td>
<td>T Block Classroom T5</td>
<td>42</td>
</tr>
<tr>
<td>T Block</td>
<td>T Block Classroom T6</td>
<td>43</td>
</tr>
</tbody>
</table>
Additional Direct observation photos have been hidden for confidentiality reasons.
Appendix F. Reflexivity Journal.

The maintenance of a reflexivity journal is used as one of several strategic qualitative research tools to increase rigor during research. The following information details thoughts and experiences the researcher noticed while undertaking research interviews and direct observations. Dates and times help to accurately identify the timeline for note taking and aid the reader in examining any negative case analysis and rival explanations. Note that time given is interview finish time.

Interview: 1 (Date: 08.04.2016 @ 10:53am).

Largest issue is lack of space for working. Inefficient work space, often double and triple handling of devices due to high workload. Desktop computer and self-training offered as no time and funds for off-site training possible. Knows, funding, time and training needed! Not sure about financial commitment towards IT from senior leadership.

Obstructive ICT: Staff attitude towards IT Services staff.

Working area: Air-conditioned, small office in central school location.

Demeanour: Relaxed and happy to offer information.

Interview: 2 (Date: 08.04.2016 @ 12:56pm).

Largest issue is lack of space for working. Inefficient work space, often double and triple handling of devices due to high workload. Desktop computer and self-training offered as no time and funds for off-site training possible. Knows, funding, time and training needed! Note that this employee has numerous other roles other than IT... timetabler work, Head of Rugby, Deputy fire warden, complaints officer, infirmary replacement, OHS officer.

Obstructive ICT: More space for work area. Noticed some web-filtering issues for students.

Working area: Air-conditioned, small office in central school location.

Demeanour: Relaxed and happy to offer information.

Interview: 3 (Date: 08.04.2016 @ 2:44pm).

Largest issue is lack of space for working. Inefficient work space, often double and triple handling of devices due to high workload. Desktop computer and self-training
offered as no time and funds for off-site training possible. Knows, funding, time and training needed!

Obstructive ICT: Security restriction for staff.

Working area: Air-conditioned, small office in central school location.

Demeanour: Relaxed and happy to offer information.

*Interview: 4 (Date: 12.04.2016 @ 12:41pm).*

Not looking for more technology funding as believes current teaching method is quite good. Graphing software used in maths was an innovation to using older physical calculators. Might look at wireless interactive data projector usage. Senior member of teaching and learning acknowledges reactive rather than proactive approach to IT support due to lack of funds. Also recognises the school talks about innovation but does not implement innovation technology due to lack of funding. (Lots of thinking and no practice)

Obstructive ICT: Web filtering.

Teaching area: Air-conditioned classrooms. Reasonably well-resourced for Maths studies.

Demeanour: Relaxed and happy to offer information. Considered power-user for IT.

MC Interview: Acknowledged issue with lack of time for even MC interview. Also noted concern of not receiving enough funding, but more so enough time to research and tinker on your own... expected to do this at home in your own time.

*Interview: 5 (Date: 12.04.2016 @ 1:46pm).*

Lack of resources NOT evident as funding has been quite good in this area of the school. Printers and finishing units, plus large format printers and professional guillotine supplied.

Obstructive ICT: Web filtering, but can work around.

Working area: Air-conditioned, large office in main admin building.

Demeanour: Relaxed and happy to offer information.

*Interview: 6 (Date: 12.04.2016 @ 5:16pm).*

General need for more funding and time for testing IT usage in classrooms with the aim to improve teaching and learning. Need to focus more on the ICT strategic plan.
Believes that we need to do more in terms of implementing technology that is innovative.

Obstructive ICT: Time and money for innovation.

Teaching area: Air-conditioned classrooms. Well-resourced for Library areas.

Demeanour: Relaxed and happy to offer information.

Member Checking: Between initial interviews and the member checking process, there was a high-level meeting held involving implementing the ICT strategic plan and money to spend on JS iPads for example (This interview participant was part of that meeting). Due to lack of funds this implementation will be undertaken in a less-expensive way, such as 6 iPads per classroom rather than 30 per classroom or 1:1. After hearing this, the response to questions such as Q16 and Q18 changed from Yes for financial commitment and supportive school leadership changed from a solid 'Yes' to 'Maybe' and possible leaning towards 'No'. Participant agreed with 'Maybe'.

Interview: 7 (Date: 13.04.2016 @ 8:54am).

Lack of resources not evident for classroom teaching. Some work needed for change of AV equipment usage, otherwise building is relatively new and a lot of money was spent on fit-out when building was replaced around 8 years ago. Believes in supportive leadership and financial commitment due to new building usage and well-resourced at time of construction.

Obstructive ICT: Web Filtering.

Teaching area: Air-conditioned classrooms. Well-resourced for science studies.

Demeanour: Relaxed and happy to offer information.

Delayed second member checking interview due to ill health. Was happy to perform the member checking as last interviewee - dated: 19.10.2016.

Interview: 8 (Date: 13.04.2016 @ 1:16pm).

Lack of resources, especially money and training needed. Would love to move across to digital portfolios.

Obstructive ICT: Reliability of old technology.

Teaching area: Hot in summer - no air-conditioning, large class sizes in general. However, current classroom is one of only two in this area of the School with air-conditioning.

Demeanour: Relaxed and happy to offer information.
Interview: 9 (Date: 13.04.2016 @ 3:29pm).

This department does well out of the areas provided without much in the way of technology. Could possibly do with upgraded desktop power for Adobe suite usage and possibly better printers for colour printing. More about mindset and the process than the final product, though products produced are quite outstanding.

Obstructive ICT: Software and hardware issues.

Teaching area: Large classrooms that are well-resourced in terms of Art materials, but not so much in terms of technology.

Demeanour: Relaxed and happy to offer information. Not sure if this department really needs or could make use of technology as much as other areas? Wondering if this participant does not really see the need for more money for that reason?

Interview: 10 (Date: 14.04.2016 @ 11:04am).

Always requesting more resources in terms of Apple products to support Music curriculum. Enthusiastic about how to use the technology. MDM however, shows a lot of personal apps used by all Music staff where the device was purchased as a staff device only. Some confusion over Apple licensing and staff thinking the school supplied device is their own to use however they feel fit. Makes it hard when money is tight and staff wish to buy equipment and apps and leave for IT to pay.

Obstructive ICT: Web filtering.

Teaching area: Air-conditioned classrooms. Reasonably well-resourced for Music but could be better.

Demeanour: Relaxed and happy to offer information. Enthusiastic.

Interview: 11 (Date: 14.04.2016 @ 2:30pm).

Lack of resources not critical for classroom teaching. Would like to see more iPads or reliable laptops and use of cameras for stop-motion video etc... Students learn what they want to learn when they decide to learn... very much self-directed learning model in year 6.

Obstructive ICT: Reliability of old technology.

Teaching area: Hot in summer - no air-conditioning, large class sizes.

Demeanour: Relaxed and happy to offer information. Quite casual attitude, easy-going nature.
Interview: 12 (Date: 18.04.2016 @ 10:08am).

General need for more funding and time for testing IT usage in classrooms with the aim to improve teaching and learning. Some more resources such as iPads would be welcomed. Has been given classroom in newer building with lots of languages resources. Could also do with replacement interactive data projector. Would love to move across to digital portfolios.

Obstructive ICT: Money and Time.


Demeanour: Relaxed and happy to offer information. Very grateful for IT support.

MC Interview: Happy to accurately cover each question. Very supportive of IT and issues.

Interview: 13 (Date: 18.04.2016 @ 1:56pm).

Lack of resources evident more for a non-teaching area in terms of property maintenance and management issues rather than technology. Office is supplied with new desktop and appropriate software.

Obstructive ICT: Money for ongoing maintenance.

Working area: Air-conditioned, large office in great location.

Demeanour: Relaxed and happy to offer information.

Member Checking : Realisation that there is not as much commitment to ensuring staff are accountable and therefore has changed answers from 'Yes' to leadership having supportive nature to 'Maybe' instead.

Interview: 14 (Date: 18.04.2016 @ 3:30pm).

Area does not require a lot of technology. Desktop and two monitors, with the use of a school mobile phone is required as staff member is also on-site caretaker.

Obstructive ICT: Staff attitude towards change.

Working area: Air-conditioned, small office in main admin building.

Demeanour: Relaxed and happy to offer information. Does not have a great knowledge of technology or teaching and learning in general. Is enthusiastic however towards area of risk and compliance... very happy to learn.
Member Checking: More money was given to department, so money is not such an obstructive behaviour now! (05.09.2016)

Interview: 15 (Date: 22.04.2016 @ 12:12pm).

Lack of resources not that obvious. Happy with DT equipment in workshop area. Building is only relatively new and was well fitted-out when built with machinery and technology. Looking for 8 x large TVs, otherwise, happy with resources provided. Not using laptops as much as previously implemented. More emphasis on the process of design thinking rather than the end product or tools used for the educational journey.

Obstructive ICT: Web-Filtering.

Teaching area: Air-conditioned classrooms. Well-resourced.

Demeanour: Relaxed and happy to offer information.

Member Checking: Financial questions difficult to answer as staff member (even learning manager or curriculum leader position) does not know if there is money available but senior leadership is deciding to allocate funds to other areas such as sport/music or grounds & maintenance or even pay off debt.

Interview: 16 (Date: 25.04.2016 @ 2:53pm).

Lack of resources, especially money seems obvious. More technology, but also more time for tinkering and the right professional development aimed at increased use of technology in the classroom.

Obstructive ICT: None.

Teaching area: Hot in summer - no air-conditioning, large class sizes. Four x ESL students and 4 x Students with greater learning needs (ASD...)

Demeanour: Relaxed and happy to offer information.

Note: Revisited via member checking and found error in Q18... should have been "No" to both Money and Time rather than Yes! - Fixed!

Interview: 17 (Date: 03.05.2016 @ 4:21pm).

Lack of resources not evident for classroom teaching. Mainly software for accounting and business studies required and this has been provided and is utilised. Hardware issues relate more to student laptops and ineffective usage or implementation in studies. IT Services have worked on open-book and especially closed-book exams for students and the process that works best for all involved.
Obstructive ICT: Reliability of old technology.

Teaching area: Air-conditioned class-rooms. Well-resourced for business studies.

Demeanour: Relaxed and happy to offer information. Happy with longer interview/time.

MC Interview: Spent walking around on Duty at 8:00am to 8:15am. Happy to chat and covered all questions again thoroughly!

Interview: 18 (Date: 04.05.2016 @ 1:26pm).

Lack of resources not that obvious. Happy with DT equipment in workshop area. Building is only relatively new and was well fitted-out when built with machinery and technology. Not using laptops as much as previously implemented. More emphasis on the process of design thinking rather than the end product or tools used for the educational journey.

Obstructive ICT: Money needed.

Teaching area: Air-conditioned classrooms. Well-resourced.

Demeanour: Relaxed and happy to offer information. Loves to self-tinker but needs more time to experiment.

During member checking was relaxed and enthusiastic about thinking of new ways to teach. Lower powered laptops maybe better for general usage and use labs for higher-powered graphics and music work. (06.10.2016)

Interview: 19 (Date: 05.05.2016 @ 8:41am).

This department can make use of technology but does not at the moment. Will have more opportunity soon with new Drama rooms completed soon and new performing arts building allowing implementation of more equipment.

Obstructive ICT: Money for purchasing more equipment in general.

Teaching area: Non-air-conditioned classrooms. Probably least well-resourced department in the school. Does not use a great deal of technology, however, will start to with the implementation of the new building they are about to use (end of 2016) for drama purposes.

Demeanour: Relaxed and happy to offer information. Has an idea of what technology is also useful for catering for students with high needs.

Interview: 20 (Date: 05.05.2016 @ 12:00pm).
Does not see the use of technology helping that much at the moment. Some high-end technology could be useful in the future. (Video analysis and feedback tools)

Obstructive ICT: None. Does not see technology as that useful... the technology that is currently used in the sports department.

Teaching area: Mixture of Air-conditioned and non-A/C classrooms and Office area. Well-resourced in terms of sporting equipment and external sport contractors.

Demeanour: Relaxed and happy to offer information. Been at the school teaching for 15 years and was a past student.

MC interview: No changes to initial responses!

Interview: 21 (Date: 05.05.2016 @ 1:28pm).

Not looking for more technology funding as believes current teaching method is quite good. Graphing software used in maths was an innovation to using older physical calculators. Might look at wireless interactive data projector usage. Senior member of teaching and learning acknowledges more money is needed for technology at school.

Obstructive ICT: Money for purchasing more equipment in general.

Teaching area: Air-conditioned classrooms. Reasonably well-resourced for Maths studies.

Demeanour: Relaxed and happy to offer information. Easy-going staff member within senior level of school staff.

Interview: 22 (Date: 06.05.2016 @ 10:23am)

This year level makes the most of the funding provided. Choice of using outdated and older equipment in the JS lab or using a handful of iPads with no budget given for apps. (Maybe $50 for all six iPads)

Obstructive ICT: Web filtering and physical security for classrooms to keep technology.

Teaching area: Non-air-conditioned classrooms. Well-resourced as a younger Junior School classroom, but not enough technology provided. Teacher also has an aid to help.

Demeanour: Relaxed and happy to offer information. Frustrated with lack of funding.

Interview: 23 (Date: 06.05.2016 @ 11:18am).
Lack of resources, especially money and training needed. Looking for a technology device to enable group work between students with various higher learning needs. Needs to negotiate more time around busy curriculum.

Obstructive ICT: Web Filtering and sounds distracting in classrooms.

Teaching area: Classrooms have air-conditioning. Reasonable area but needs sound proofing as current teaching space is only one large room separated by cupboards.

Demeanour: Relaxed and happy to offer information. Very willing to look for technology to help with teaching and learning and in particularly students with higher learning needs.

Member Checking: Not particularly happy with teaching progress in some classrooms (high needs children), however, fine otherwise for IT and budgets, so should not affect outcome at all of questions.

*Interview: 24 (Date: 06.05.2016 @ 3:32pm).*

Lack of resources, especially money and training needed. Would love more iPads in the classroom.

Obstructive ICT: Web Filtering and Reliability of old technology.

Teaching area: Hot in summer - no air-conditioning, large class sizes.

Demeanour: Relaxed and happy to offer information.

MC interview: Aware of and confident with own ability to use ICT.

*Interview: 25 (Date: 06.05.2016 @ 4:20pm).*

Lack of resources not evident for classroom teaching. Some work needed for change of AV equipment usage, otherwise building is relatively new and a lot of money was spent on fit-out when building was replaced around 8 years ago. Believes in supportive leadership and financial commitment due to new building usage and well-resourced at time of construction. Short answers provided - not sure, if happy to divulge concerns maybe?

Obstructive ICT: Web Filtering and Operating System compatibility.


Demeanour: Relaxed and seemed a little rushed to offer information. Quite short answers provided and maybe not willing to offer information... maybe short for time on day of interview?
MC Interview: More willing to express concerns over lack of funding and time given.

Direct Observation : Design & Technology Rooms
This is a newer building with a high level of equipment for design technology use. The building is air-conditioned and there is access to data projectors, monitors and 3D printing technology. There is always a need for more funding to upgrade equipment, however, staff member is not very concerned about funding as classroom areas are modern and well resourced. Office area for design technology is quite spacious and well-resourced for staff.

Direct Observation : Differentiation Rooms
Older building with air-conditioning. Only issue observed here that may require more funding is the need for sound proofing between classrooms. The higher needs students in these classrooms require areas where there are no distractions from teaching. The only divider between classrooms is filing cabinets and cupboards. It is understandable this research participant does not have a high requirement for additional funding.

Direct Observation : Junior School Classroom F8
This is an older classroom with no air-conditioning. Reasonable level of resources for teaching in the classroom despite the uncomfortable temperature in summer where classroom activities are difficult to manage in more than 36 degrees. Classroom is located on slightly higher ground location where breezes blow more often through louvers. Can certainly understand why there is a need for more funding due to lack of air-conditioning.

Direct Observation : Junior School Classroom F11
This is an older classroom with no air-conditioning. Reasonable level of resources for teaching in the classroom despite the uncomfortable temperature in summer where classroom activities are difficult to manage in more than 36 degrees. Classroom position is lower where breezes are often blocked. Can certainly understand why there is a need for more funding due to lack of air-conditioning.
Direct Observation: Junior School Classroom F13

This is an older classroom with no air-conditioning. Reasonable level of resources for teaching in the classroom despite the uncomfortable temperature in summer where classroom activities are difficult to manage in more than 36 degrees. Classroom position is lower where breezes are often blocked. Can certainly understand why there is a need for more funding due to lack of air-conditioning. Classroom has some wireless internet issues which need to be investigated.

Direct Observation: Junior School Classroom F20

This is a new air-conditioned classroom with reasonable level of teaching resources and more desktop computers for students. This would explain why this research participant was happy with funding as their teaching classroom is modern, well-funded and provides a pleasant teaching environment especially during the hot summer months. Due to the steel construction, each of the two classrooms have their own individual wireless access point which results in great coverage.

Direct Observation: Junior School Classroom F3

This is an older classroom with no air-conditioning. Reasonable level of resources for teaching in the classroom despite the uncomfortable temperature in summer where classroom activities are difficult to manage in more than 36 degrees. Classroom position is located in a higher position, however, is surrounded by other buildings making natural cooling very difficult during summer months. Can certainly understand why there is a need for more funding due to lack of air-conditioning, however, reasonably well resourced classroom.

Direct Observation: Library

This is an older building which has been renovated. It is well resourced and the level of ICT equipment is quote high. This research participant is part of a high group or ICT steering staff who may see not enough funding to support additional ICT equipment. The higher requirements for increased funding may be a result of this knowledge rather than funding for local work area for teaching.

Direct Observation: Maths classrooms
Older building in need of additional funding for classroom renovations. Head of learning in this area would more than likely require more funding for this improvement. This older building does not have air-conditioning, however, head of learning staff area is air-conditioned. This may explain why there was a result of 'maybe' for additional funding required.

Direct Observation: Art classrooms

Older building in need of additional funding for classroom renovations. Learning manager in this area does not seem to be too concerned about the level of renovations or level of ICT equipment in this area. This area probably needs better wireless access and some additional funding for art printers and higher end desktops for Adobe software products. This would explain some results of 'maybe' for additional funding requirements.

Direct Observation: Print room

Newer building. Brick and glass constructed building. No external windows, room inside middle of main admin building. Reasonable amount of natural light – This room is well-resourced with sufficient storage provided. (Air-conditioning)

Two monitors provided for increased operator efficiency. High-end desktop provided for graphics work. Fast Black/White copier with additional finisher options including square-fold trimmer added. Fast Colour copier with additional finisher options including square-fold trimmer and RIP added. Wide format colour printer with banner capability provided. Professional guillotine provided.

Direct Observation: Drama building

This is one of the oldest buildings on the campus. Very poorly funded for theatre equipment. The building has no air-conditioning and is in great need of improved equipment. Size and location is reasonable. New building currently under construction has helped to improve outlook for teaching years in the future. Otherwise, funding requirements would have been even worse.

Direct Observation: Farmhouse
One of the original buildings on the campus may be old, but it has been renovated with air-conditioning and newer furniture. Heads of learning are generally happy with funding, especially for funding in their own staff room work areas. Possibly more critical for other teaching areas that are in need of funding.

**Direct Observation : International School**

Modern building with air-conditioning. Very well resourced and not much requirement for funding. A lot of staff members would use this building for teaching other subjects other than those for SPIS. Therefore, research participants may lower their expectations for funding if they think of this area for teaching and learning?

**Direct Observation : Middle School (Year 7) KC1**

Older building. Brick and glass louvered/windowed room. (Year 7 Classroom) Reasonable amount of natural light - IWB protected on wall sideways to main area of natural light. (However, this room does appear to receive more natural light than other classrooms. Even more important to have higher ANSI lumen ratings for data projectors)

Interactive whiteboard and Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are not easily accessible. (Front of classroom on thin flat surface with back to class) Ducting run on outside of wall (White, square tubing).

**Direct Observation : Middle School (Year 7) KC3**

Older building. Brick and glass louvered/windowed room. (Year 7 Classroom) Reasonable amount of natural light - IWB protected on wall sideways to main area of natural light. (However, this room does appear to receive more natural light than other classrooms. Even more important to have higher ANSI lumen ratings for data projectors)

Interactive whiteboard and Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are not easily accessible. (Front of classroom on thin flat surface with back to class) Ducting run on outside of wall (White, square tubing).
Direct Observation: Middle School (Year 7) KC5

Older building. Brick and glass louvered/windowed room. (Year 7 Classroom)
Reasonable amount of natural light - IWB protected on wall sideways to main area of
natural light. (However, this room does appear to receive more natural light than other
classrooms. Even more important to have higher ANSI lumen ratings for data
projectors)

Interactive whiteboard and Epson Data Projector Technology installed Jan 2016.
Teacher connection points to ports are not easily accessible. (Front of classroom on
thin flat surface with back to class) Ducting run on outside of wall (White, square
tubing).

Direct Observation: Middle School (Year 7) KC6

Older building. Brick and glass louvered/windowed room. (Year 7 Classroom)
Reasonable amount of natural light - IWB protected on wall sideways to main area of
natural light. (However, this room does appear to receive more natural light than other
classrooms. Even more important to have higher ANSI lumen ratings for data
projectors)

Pole-mounted Epson Data Projector Technology installed Jan 2016. Teacher
connection points to ports are not easily accessible. (Front of classroom on thin flat
surface with back to class) Ducting run on outside of wall (White, square tubing).

Direct Observation: Middle School (Year 8) KC9

Older building. Brick and glass louvered/windowed room. (Year 8 Classroom)
Reasonable amount of natural light - IWB protected on wall sideways to main area of
natural light. (However, this room does appear to receive more natural light than other
classrooms. Even more important to have higher ANSI lumen ratings for data
projectors)

Pole-mounted Epson Data Projector Technology installed Jan 2016. Teacher
connection points to ports are not easily accessible. (Front of classroom on thin flat
surface with back to class) Ducting run on outside of wall (White, square tubing).

Direct Observation: Middle School (Year 9) KC14
Older building. Brick and glass louvered/windowed room. (Year 9 Classroom) Reasonable amount of natural light - IWB protected on wall sideways to main area of natural light. (However, this room does appear to receive more natural light than other classrooms. Even more important to have higher ANSI lumen ratings for data projectors)

Pole-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are not easily accessible. (Front of classroom on thin flat surface with back to class) Ducting run on outside of wall (White, square tubing).

Direct Observation : Middle School (Year 9) KC15

Older building. Brick and glass louvered/windowed room. (Year 9 Classroom) Reasonable amount of natural light - IWB protected on wall sideways to main area of natural light. (However, this room does appear to receive more natural light than other classrooms. Even more important to have higher ANSI lumen ratings for data projectors)

Pole-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are not easily accessible. (Front of classroom on thin flat surface with back to class) Ducting run on outside of wall (White, square tubing).

Direct Observation : Music M1

Older building. Brick and glass windowed room. Reasonable amount of natural light – This room has sufficient work space for activities. (Air-conditioning)

Pole-mounted Data Projector Technology installed prior to 2011. Teacher desk has access to ports. Some wall plates and cabling needs additional repairs. Ceiling space difficult to run cables due to lack of space. Ducting run on outside of wall (White, square tubing).

Direct Observation : Music M12

Older building. Brick and glass windowed room. Reasonable amount of natural light – This room could use some more space, however, it is sufficient. (Air-conditioning)

Large screen TV provided for student use in recording. Apple Mac computers used for audio work. Additional equipment provided including mixer, additional monitors and
recording cables and associated equipment.

Direct Observation : Music M13

Older building. Brick and glass windowed room. Reasonable amount of natural light –
This room has sufficient work space for activities. (Air-conditioning)

Pole-mounted Data Projector Technology installed prior to 2011. Teacher desk has
access to ports. Some wall plates and cabling needs additional repairs. Ceiling space
difficult to run cables due to lack of space. Ducting run on outside of wall (White,
square tubing).

Direct Observation : Music M14

Older building. Brick and glass windowed room. Reasonable amount of natural light –
This room has sufficient work space for activities. (Air-conditioning)

Ultra-short throw Data Projector Technology installed prior to 2011. Teacher has no
easy access to ports. Some wall plates and cabling needs additional repairs. Ceiling space
difficult to run cables due to lack of space. Ducting run on outside of wall (White,
square tubing).

Direct Observation : Music M22

Older building. Brick and glass windowed room. Reasonable amount of natural light –
This room has sufficient work space for activities. (Air-conditioning)

Ultra-short throw Data Projector Technology installed prior to 2011. Teacher has poor
access to ports. Some wall plates and cabling needs additional repairs. Ceiling space
difficult to run cables due to lack of space. Ducting run on outside of wall (White,
square tubing). Rack space has been removed meaning to access IT equipment, storage
has to be disassembled and moved away.

Direct Observation : Science S2

Newer building. Brick and glass windowed room. (Year 7 to 12) Reasonable amount
of natural light and well-lit rooms - Data projector protected not affected by flood of
natural light.
Ceiling-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are easily accessible. (Front of classroom on main desk area) Cables run on inside/outside of walls. Does need more ducting. Very well resourced classroom and laboratory.

**Direct Observation : Science S4**


Newer building. Brick and glass windowed room. (Year 7 to 12) Reasonable amount of natural light and well-lit rooms - Data projector protected not affected by flood of natural light.

Ceiling-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are easily accessible. (Front of classroom on main desk area) Cables run on inside/outside of walls. Does need more ducting. Very well resourced classroom and laboratory.

**Direct Observation : Science S5**


Newer building. Brick and glass windowed room. (Year 7 to 12) Reasonable amount of natural light and well-lit rooms - Data projector protected not affected by flood of natural light.

Ceiling-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are easily accessible. (Front of classroom on main desk area) Cables run on inside/outside of walls. Does need more ducting. Very well resourced classroom and laboratory.

**Direct Observation : T-Block T2**


Pole-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are easily accessible. (Front of classroom on desk area) Room contains air-conditioning. Not a very large space for students – smaller rooms.

**Direct Observation : T-Block T5**

Pole-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are easily accessible. (Front of classroom on desk area) Room contains air-conditioning. Not a very large space for students – smaller rooms.

Direct Observation : T-Block T6


Pole-mounted Epson Data Projector Technology installed Jan 2016. Teacher connection points to ports are easily accessible. (Front of classroom on smaller desk area) Room contains air-conditioning. Not a very large space for students – smaller rooms.

Direct Observation : Technical services staff member 1

Older building. Brick, cement and glass windowed room. Reasonable amount of natural light and well-lit rooms – needs more storage space to support almost 2000 devices.

Staff given two monitors, surface pro and mobile phone. More storage space is needed in technical services. More space is needed for imaging more device at once. Larger front counter for servicing more users at once.

Direct Observation : Technical services staff member 2

Older building. Brick, cement and glass windowed room. Reasonable amount of natural light and well-lit rooms – needs more storage space to support almost 2000 devices.

Staff given two monitors, surface pro and mobile phone. More storage space is needed in technical services. More space is needed for imaging more device at once. Larger front counter for servicing more users at once.
Direct Observation: Technical services staff member 3

Older building. Brick, cement and glass windowed room. Reasonable amount of natural light and well-lit rooms – needs more storage space to support almost 2000 devices.

Staff given two monitors, surface pro and mobile phone. More storage space is needed in technical services. More space is needed for imaging more device at once. Larger front counter for servicing more users at once.

Direct Observation: TB2 Classroom

Newer building. External windows, well protected from flooding natural light on whiteboard. Aging equipment. Faceplate okay, but method of connecting via Calypso unit can be troublesome.

Older ceiling-mounted data projector of 5+ years vintage ~ 2000 ANSI lumens, but no troubleshooting issues. Speakers and sound requires some troubleshooting. Speakers old.

Whiteboard may need replacing for future interactive usage - may not be flat!
Appendix G. Ethics Approval.

4 December 2015

Mr Trevor Smith
School of Computing and Mathematics
Charles Sturt University
WAGGA CAMPUS

Dear Mr Smith,

Thank you for the additional information forwarded in response to a request from the Business Faculty Human Research Ethics Committee.

The Business Faculty Human Research Ethics Committee has approved your proposal “Educational Technology Management: Balancing Infrastructure and Innovation” for a twelve month period from 4 December 2015.

The protocol number issued with respect to this project is 260/2015/27. Please be sure to quote this number when responding to any request made by the Committee.

Please note the following conditions of approval:

- all Consent Forms and Information Sheets are to be printed on CSU letterhead. Students should liaise with their Supervisor to arrange to have these documents printed;
- you must notify the Committee immediately in writing should your research differ in any way from that proposed. Forms are available at http://www.csu.edu.au/research/ethics_safety/human/chrc_managing;
- you must notify the Committee immediately if any serious and or unexpected adverse events or outcomes occur associated with your research, that might affect the participants and therefore ethical acceptability of the project;
- amendments to the research design must be reviewed and approved by the Faculty Human Ethics Committee or if no longer minimal risk by the University Human Research Ethics Committee before commencement. Forms are available at the website above;
- if an extension of the approval period is required, a request must be submitted to the Faculty Human Ethics Committee or if no longer minimal risk by the University Human Research Ethics Committee before commencement. Forms are available at the website above;
- you are required to complete a Progress Report form, which can be downloaded as above, by 4 December 2016 if your research has not been completed by that date;
- you are required to submit a final report, the form is available from the website above.

You are reminded that an approval letter from the BFHREC constitutes ethical approval only.

If your research involves the use of radiation, biological materials or chemicals separate approval is required from the appropriate University Committee.

http://www.csu.edu.au
The Committee wishes you well in your research. Please do not hesitate to contact me on telephone (02) 6933 2696 or email bramudu@csu.edu.au should you wish to discuss this matter further.

Yours sincerely

[Signature]

Dr. Ramudu Bhanugopan
Chair
Faculty of Business Human Research Ethics Committee
Direct Telephone: 6933 2696
Email: bramudu@csu.edu.au

cc: ceo@csu.edu.au
Appendix H. Interview Participation Information Sheet.

Introduction

You are invited to participate in a research study on ‘Educational Technology Management: Balancing Infrastructure and Innovation’.

The study is being conducted by Mr. Trevor Smith from the School of Computing and Mathematics at the Charles Sturt University as part of the Doctor of Information Technology program.

Before you decide whether or not you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish.

What is the purpose of this study?

The purpose of the research is to explore the management of ICT infrastructure and the use of innovation in education by Teaching and Learning staff. This involves exploring the sorts of innovative technology Teaching and Learning staff require for their classroom pedagogical practices. This study will also involve examining typical parameters which constitute ICT infrastructure budgets in order to maximize efficient expenditure. Part of this balance involves maintaining a stable and secure ICT infrastructure while lessening the obstructive behavior often portrayed by IT departments in schools.

Do I have to take part?

It is completely up to you whether or not you decide to take part in this study. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you have to complete it. You are free to withdraw at any stage without giving a reason. A decision to withdraw at any time, or a decision not to take part at all, will impact this study timeline. Therefore, it will be appreciated if you can notify of your withdrawal from the study as soon as possible.

What will happen to me if I take part?

The research is based on a sample of 20 to 25 participants from various areas of a private school, teaching students from pre-prep to year 12. The study will involve your participation in the followings:

1. Participate in a one (1) to two (2) hour interview involving open-ended and in-depth questions relating to innovation in education. Mr Trevor Smith will be presenting further information about his research and clarifying any questions that you may have. The interviews will be recorded via digital audio (no video) and transcribed at a later date. The interviews will take place at a mutually
convenient time, either during spare lesson time during the day or during the afternoon after the school day has finished.

2. Approximately 6 months later, shorter interviews will take place to present a summary of the findings from the research to obtain comments and feedback. This will allow for confirmation of results and the inclusion of additional information before the paper is formalized. Please note that individual transcribed notes from interviews will be summarised from all research participants and individual transcribed notes will not be shared with other research participants.

**What are the possible benefits of taking part?**

By participating and sharing your experience in this study you will be contributing to a paper that is aimed to be published in an academic journal. Therefore, acknowledging the contribution to the efficient use of ICT infrastructure and the ability to afford innovative technology in classroom activities.

**What are the possible disadvantages, risks or side effects of taking part?**

None

**How will my taking part in this study be kept confidential?**

Names, age or any personal details will not be disclosed in the report. Report will not be distributed for any commercial reasons and will be used solely for academic purpose. Information contained in this research will be destroyed at the end of the study and retained no longer than a period of 5 years.

**Who will be accessing this study?**

This research will be conducted by the doctorate student/researcher, Mr. Trevor Smith, who will be working closely with Dr Tanveer Zia, from Charles Sturt University. The report will be written by the researcher and accessed by the university supervisor/assessor.

**Who can I contact if I have any questions?**

If you would like further information or would like to discuss any details personally, you can contact the researcher in writing by email:  t.smith@stpauls.qld.eu.au or ..............

*Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please feel free to contact.*

Thank you very much for reading this information and giving consideration to taking part in this study.
Appendix I. Interview Consent Forms.

Thank you for participating in this study. Please be aware that Charles Sturt University’s Human Research Ethics Committee (for minimal risk projects list the Faulty that approved the research) has approved this project. Please read the statements below and sign where indicated. Thank you for your time and contribution.

I, the undersigned,

........................................................................................................

as......................................................................................... of

........................................................................... hereby freely agree to take part in the study entitled [Educational Technology Management: Balancing Infrastructure and Innovation]

1. I confirm that I have been given a Participant Information Sheet (a copy of which is attached to this form) giving particulars of the study, including its purpose, the names and contact details of key people and, as appropriate, the risks and potential benefits, and any plans for follow-up studies that might involve further approaches to participants. I have been given details of my involvement in the study. I have been told that in the event of any significant change to the aim(s) or design of the study I will be informed, and asked to renew my consent to participate in it. Agree / Disagree

2. I have been assured that I may withdraw from the study at any time without disadvantage or having to give a reason. Agree / Disagree

3. I have been told how information relating to me (data obtained in the course of the study, and data provided by me about myself) will be handled: how it will be kept secure, who will have access to it, and how it will or may be used. Agree / Disagree

4. I understand that a digital audio recording will be made during the session. I grant the ‘Trevor Smith’ permission to use the recordings for the purposes of note-taking and waive my right to review or inspect these recordings. Agree / Disagree

5. I have been told that I may at some time in the future be contacted again in connection with this or another study. Agree / Disagree

Signature of participant.................................................................Date.................

Name ........................................................................ of Researcher
..................................................................................................................................
Signature of Researcher

……………………………………………Date………………

NOTE: If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee through the Executive Officer:

The Executive Officer

Human Research Ethics Committee

Tel: (02) 6338 4628

Email: ethics@csu.edu.au

Any issues you raise will be treated in confidence and investigated fully and you will be informed of the outcome.
Appendix J. Certificate of appreciation.
Appendix K. Internet Usage.

K.1 Internet Usage Jan 2012 to Dec 2016

- **Legend:**
  - Vertical scale is 0 to 10 (100’s of GB/Day)
  - Horizontal scale is time axis (January 2012 to December 2016)
  - Half way up the scale is 500GB/Day of downloads
  - **Blue** – Downloads
  - **Red** - Uploads
K.2 Internet Usage Jan 2012 to Dec 2012

- **Legend:**
- Vertical scale is 0 to 1 (10’s of GB/Day)
- Horizontal scale is time axis (January 2012 to December 2012)
- Half way up the scale is 50GB/Day of downloads
- **Blue** – Downloads
- **Red** - Uploads
K.3 Internet Usage Jan 2013 to Dec 2013

- **Legend:**
  - Vertical scale is 0 to 1.25 (10’s of GB/Day)
  - Horizontal scale is time axis (January 2013 to December 2013)
  - Half way up the scale is 62.5GB/Day of downloads
  - **Blue** – Downloads
  - **Red** - Uploads
K.4 Internet Usage Jan 2014 to Dec 2014

- **Legend:**
  - Vertical scale is 0 to 2.5 (10’s of GB/Day)
  - Horizontal scale is time axis (January 2014 to December 2014)
  - Half way up the scale is 125GB/Day of downloads
  - **Blue** – Downloads
  - **Red** - Uploads
K.5 Internet Usage Jan 2015 to Dec 2015

- **Legend:**
- Vertical scale is 0 to 10 (100’s of GB/Day)
- Horizontal scale is time axis (January 2015 to December 2015)
- Half way up the scale is 500GB/Day of downloads
- **Blue** – Downloads
- **Red** - Uploads
K.6 Internet Usage Jan 2016 to Dec 2016

- **Legend:**
- Vertical scale is 0 to 10 (100’s of GB/Day)
- Horizontal scale is time axis (January 2016 to December 2016)
- Half way up the scale is 500GB/Day of downloads
- **Blue** – Downloads
- **Red** - Uploads
Appendix L. Photocopier and printer statistics during 2016.
Appendix N. Hyper-convergence storage capacity.
Appendix O. Helpdesk tickets average more than 2000 per year from 2012-2016.
Appendix P. Initial interview data before member checking.

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Appendix Q. Interview data after member checking – highlighted changes in blue.

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Appendix R. Direct observations of print room.

Admin Building – Print Room (Direct Observations)

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<th>Location</th>
<th>Admin Building: Print room</th>
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<tr>
<td>Physical Description</td>
<td>Newer building. Brick and glass constructed building.</td>
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<tr>
<td>Classroom Description</td>
<td>Reasonable amount of natural light and lighting – This room is well-resourced with sufficient storage provided. (Air-conditioning) No external windows, room inside middle of main admin building.</td>
</tr>
<tr>
<td>Technology Description</td>
<td>Two monitors provided for increased operator efficiency. High-end desktop provided for graphics work. Fast Black/White copier with additional finisher options including square-fold trimmer added. Fast Colour copier with additional finisher options including square-fold trimmer and RIP added. Wide format colour printer with banner capability provided. Professional guillotine provided.</td>
</tr>
</tbody>
</table>

Photo 1 (Admin Building)  

Photo 2 (Print room operator space)  

Photo 3 (Colour copier with finisher & RIP)  

Photo 4 (Wide format printer & Guillotine)
Appendix S. Direct observations of classroom.

Junior School – Room F8 (Direct Observations)

<table>
<thead>
<tr>
<th>Location</th>
<th>F8: Junior School Classroom (Year 6)</th>
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<tr>
<td>Physical Description :</td>
<td>Older building. Brick and glass louvered room.</td>
</tr>
<tr>
<td>Classroom Description :</td>
<td>Reasonable amount of natural light - IWB protected on wall opposite to main area of natural light. (However, this room does appear to receive more natural light than other Junior School classrooms. Even more important to have higher ANSI lumen ratings for data projectors) (No air-conditioning)</td>
</tr>
<tr>
<td>Technology Description :</td>
<td>Interactive whiteboard and Epson Data Projector Technology installed Sep 2014. Speakers. Laptop trolley for 1:1 laptop program. Teacher desk has new printer and easy access to ports. Some wall plates and cabling needs additional repairs. Ceiling space difficult to run cables due to insulation. Ducting run on outside of wall (White, square tubing).</td>
</tr>
</tbody>
</table>

Photo 1 (Junior School Building)  Photo 2 (Classroom – data projector)  Photo 3 (Teacher desk area)
Appendix T. Direct observations of Differentiation Support.

Differentiation Support – Staff area (Direct Observations)

<table>
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<th>Location</th>
<th>Staff Area: Differentiation Support</th>
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<td>Physical Description:</td>
<td>Older building. Brick, cement and glass windowed room.</td>
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<tr>
<td>Classroom Description:</td>
<td>Reasonable amount of natural light. Reasonable space for storing records and work-related activities. (Air-conditioning)</td>
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<tr>
<td>Technology Description:</td>
<td>Provided one or two monitors for increased work efficiency. Docks provided for teaching tablets where needed.</td>
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Photo 1 (Learning Support Building)  Photo 2 (Teaching staff area)  Photo 3 (Support Staff area)