INTERNATIONAL STUDENT ACADEMIC SUCCESS: LOOKING AT THE IMPORTANCE OF UNDERPINNING KNOWLEDGE FROM AN EDUCATIONAL SUPPLY CHAIN PERSPECTIVE

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Abstract

Higher Education in the UK appears to be in a state of flux with ever changing policy for the recruitment and funding of home and EU students. As the market becomes more competitive the recruitment of international students studying specialist Master's programmes is expanding, introducing greater variability into the educational supply chain. This study has investigated the factors affecting academic success, and reviewed recruitment from a supply chain perspective. The study has then focused on the importance of having the required underpinning knowledge to study on specialist Master's programmes in achieving academic success.

A quantitative methods approach has been adopted, aligned with a realist ontology and positivist epistemology to carry out the investigation. The current criteria used for entry to the programmes at Northumbria were compared with similar HEIs. Expert opinion was used to determine the underpinning knowledge students were expected to have when enrolling on to specialist Master's programmes and this was verified on newly enrolled post graduate students through the survey method using a test. The results were then used to identify variations in underpinning knowledge in the educational supply chain and investigate the use of a model to predict academic success.

The criteria for entry to specialist Master's programmes was identified as having varying levels of both English and academic qualifications. The level of underpinning knowledge known by graduating Northumbria undergraduate and enrolling international postgraduate students was found to be similar and can be linked to academic success.

This study has contributed to knowledge by confirming that there is a statistically significant positive relationship between underpinning knowledge and academic success. A contribution to practice has been made by using supply chain theory to identify the variation in student underpinning knowledge entering the educational supply chain and providing a test that can be used to predict academic success.

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Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others.

Any ethical clearance for the research presented in this thesis has been approved. Approval has been sought and granted by the Faculty Ethics Committee on 26th May 2010.

I declare that the Word Count of this Thesis, excluding appendices, is 54682 words.

David Bell

Chapter 1 Introduction

1.1 Introduction

The main aim of this research is to investigate the relationship between the underpinning knowledge an international student has when enrolling on a specialist Master's programme and their subsequent academic success and to make a contribution to knowledge and practice based on the investigation. This chapter will introduce the background to the research and the rationale for completing the investigation. The key terms relating to the main aim are identified and the research question and sub questions are presented along with the research objectives used to answer these questions. The structure of the remainder of the thesis is then outlined providing an insight in to each chapter.

1.2 Background to the research

As Associate Dean International in the Faculty of Engineering and Environment at Northumbria University, the author has a great interest in ensuring that the Faculty meets the Vice Chancellor's 'Vision 2025' and the rolling corporate strategies to support it. One of the Key Performance Indicators is to increase the number of international students by 50% from the baseline of 2833 in 2012/13 to 4249 by 2017/18 (Northumbria University, 2014a). Prior to Vision 2025, the Corporate Strategy 2009-14 also highlighted international student growth, but more importantly to "*Improve progression, retention, completion and performance data for international students"* (Northumbria University, 2009). Northumbria University has always engaged in the international student arena for both students on campus in the UK and students off shore at partner institutions. In 1996/97, Northumbria University (1996) had 1082 international students and by the academic year 2007/8 it had 3377

(Northumbria University, 2007). International student numbers at Northumbria have plateaued since then and in the academic year 2011/12 there were 2998 international students. The Faculty of Engineering and Environment was responsible for 894 students, which represents nearly 30% of the overall University total. The largest number of students at Northumbria University has always studied in computing, engineering and business subject areas. The Faculty of Engineering and Environment now comprises the previous Schools of Computing, Engineering and Information Sciences and Built and Natural Environment after a restructuring exercise carried out in August 2012. The work carried out in this research refers to the specialist computing and engineering post graduate (PG) programmes that were delivered in the previous School of Computing, Engineering and Information Sciences. The rationale behind the selection of these programmes is explained below.

In order to meet the target for growth it is imperative that Northumbria continues to recruit an international student body that meet entry requirements, but more importantly leave the University having achieved academic success. Within the Faculty there was concern about the progression of international students on the specialist PG programmes between 2007 and 2009 and feedback from one of the external examiners brought about the need for a review of practice. His feedback was:

> "*There has been a decline in student performance over the last 3 years with too many students failing to pass or complete modules. The University must question whether it is acting responsibly in recruiting so many students who are either incapable or unmotivated to pass or complete the degree programme*" (O'Mongain, 2008).

As far as the academic staff were concerned, the Faculty was still then recruiting students with an equivalent of a second class, lower division (2:2) degree or better and an International English Language Testing System (IELTS) score of 6.5 or equivalent. This was the same criteria that had been used for many years previously and so in essence nothing had changed apart from the growing number of students on particular programmes. The growth in student numbers was mainly from the Indian sub-continent, Nigeria and China and as such came from very different backgrounds and cultures, as well as a growing number of different institutions. The common factor was that they all met the ‘equivalent’ academic entry requirements and English levels required to allow them to study on their Master’s programmes. Despite meeting these criteria there was a great diversity of students due to their individual backgrounds and specific journey through the educational system to get to this point.

In terms of motivation there are many reasons why a student would come to the UK to study and this was emphasised recently by the British High Commissioner to India Sir James David Bevan KCMG, when delivering a speech at Delhi University on UK education. He cited ten reasons why Indian students should come to the UK to study:

1. Quality of education
2. Choice of programmes
3. UK degrees are recognised and respected throughout the world
4. Value for money
5. UK graduates are the most desirable in terms of employability
6. The UK is a global centre and one of the most diverse countries in the world
7. Excellent skills in the English language improve a graduate’s career prospects

8. The UK has strong ties with India
9. Lifestyle in the UK is simply the best in the world
10. The UK wants the brightest and best students.

"*Along with the offer of a visa to work in the UK for three years in a graduate job, the whole package must surely be one of the best motivators to come to the UK to study*" (Bevan, 2014). This is an example of the UK Government assisting UK Universities to grow the number of international students and trying to convince prospective students that the UK still welcomes them. These are good reasons why a student should be motivated to come to the UK to study, but their motivation to study once they are at Northumbria could be down to many factors and would require a study from a psychological perspective and, for this reason, the reference to capability became the focus of this study.

When it comes to the capability to study at PG level, this is currently measured by the English level and the under graduate (UG) qualification that the student requires to enter the programme. The impact of a student's English level on achieving academic success has been explored by many researchers with inconclusive results (Cook, Evans, Love, Mao, Robinson, Scerif, & Sharma, 2004; Graham, 1987; Hartnett, Römcke, & Yap, 2004). The UG qualification has to be at a level of greater than or equal to second class, lower division or equivalent. A student who has achieved this at UG level has successfully completed the programme with the required level of graduate skills and knowledge to study at PG level. It could be argued that all graduates should have similar skills and those most often mentioned are communication, team-working, IT skills, leadership, initiative, problem-solving, flexibility and enthusiasm (Guardian, 2014; University of Kent, 2014). Since all graduates should have similar skills or attributes this theme was not pursued any further, but knowledge is very specific to the discipline that has been studied and this was identified as the area of interest. Within a specific discipline, this knowledge can vary dramatically depending on the country and University that the student has previously studied in. As the market for international student recruitment becomes more competitive and new markets appear, this variability will become more prevalent and ensuring that students have the underpinning knowledge to succeed will become more difficult to identify. The process of recruiting students into a specialist Master's programme can be viewed as a supply chain as used in manufacturing or service industry and, as such, supply chain theory can be used to model the process (Lau, 2007; Murali & Venkata, 2012a; O'Brien & Deans, 1996; Pathik & Habib, 2012). The author's previous background as a Manufacturing Engineer aligns a professional interest with that of an academic, ensuring that any process used should be capable of dealing with the inherent variability of the supply chain. It is recognised that there are many factors that can impact on academic success, such as competency of English language (Abel, 2002; Li, Chen, & Duanmu, 2010), culture (Li et al., 2010; Van Oudenhoven & Van der Zee, 2002) and learning and teaching methods (Bamford, 2008; Spencer, 2003b), but should a student not have the underpinning knowledge at the discipline level then it may well be very difficult to complete or pass the specialist Master's degree (Stacey & Whittaker, 2005).

1.3 Key terms included in the main aim of this study

The main aim of this DBA is to investigate the relationship between the *underpinning knowledge* an international student has and their ability to achieve *academic success* on a Master's programme within their *specialist* discipline and, more broadly, to advance knowledge and improve professional practice in the area of *international student recruitment.*

It is recognised that there are different types of knowledge such as personal, propositional and procedural (Henriques, 2013). Personal knowledge is knowledge by acquaintance and can include possessing some propositional knowledge. Propositional knowledge is defined as having knowledge of facts and procedural knowledge is defined as knowing how to do something. In many situations propositional knowledge is required before procedural knowledge can be used (Henriques, 2013). A good analogy is that before being allowed to take the practical driving test in the UK the driver must have passed the theory test. This ensures that the driver has the knowledge of the rules and regulations of the highway when driving, before they are allowed to drive alone after passing the practical test. de Jong and Ferguson-Hessler (1996) suggest that there are four different types of knowledge when solving problems. Procedural knowledge is defined in the same way as Henriques (2013), as being able to manipulate an equation or carry out a particular action or task. However de Jong and Ferguson-Hessler (1996) break down propositional knowledge into three components; situational, conceptual and strategic knowledge. Situational knowledge is about knowing facts within a domain, for example the concept of friction and the difference this makes when under normal circumstances a car tyre grips the road, but if ice or oil is present the grip is reduced. Conceptual knowledge is exactly what it says, in the sense that it is about having a grasp of concepts such as Newton's Law where force is equal to mass multiplied by acceleration. Strategic knowledge is about knowing the correct stages to go through to solve a problem (de Jong & Ferguson-Hessler, 1996). The investigation of the theory of knowledge based around this study could warrant a DBA or PhD in itself so for the purpose of this study, underpinning knowledge refers to both propositional knowledge which is based around the knowledge of facts and procedural knowledge so that those facts can be used to, for example, solve problems.

The term specialist used in this study is where the student applying to the PG programme must have studied an UG programme in the same subject discipline, which is required to provide the underpinning knowledge, for example in Mechanical Engineering. This is in contrast to a generalist PG programme at Northumbria University such as a Master’s in Computing and IT, where perhaps an engineer may wish to study computing. This type of programme would also be available to a student from any branch of engineering, but they need not have studied computing previously.

The definition of academic success depends on the entity that is viewing it. A good overview of academic success comes from the University of California (2012) which includes meeting the University's expectations for being in ‘good standing’ and making satisfactory progress toward a degree. The University of California also expects the student to identify their own goals for success based on what they want to achieve during their studies, such as a specific grade point average or preparing for a specific career or gaining admission to a particular graduate program after earning a Bachelor's degree. This identifies academic success at the level of the University, employer and student (University of California, 2012). The concept of academic success will be explored further from these stakeholder perspectives in Chapter Two.

Recruitment of individual international students for Master’s programmes carried out by universities appear to follow a common format in that they ask for an appropriate academic and English level for entry to the programmes. These are the factors that are deemed appropriate to predict academic success but may not be the best ones to use. This thesis will review the current predictors of academic success and discuss their suitability.

1.4 Context of this study

This study is based on international students studying on specialist Master's programmes within the Faculty of Engineering and Environment at Northumbria University in the UK. Practice which is currently used at Northumbria for the recruitment of PG students on to specialist Master's programmes is reviewed against a number of other institutions in the UK.

1.5 Research aims and objectives

The research question for this study is:

> What is the relationship between underpinning knowledge and the academic success of international students enrolled on specialist Master's programmes?

A number of research questions are related to this:

- Do other universities use different criteria to Northumbria to recruit international students for specialist Master's programmes?
- What are the factors that can affect academic success?
- What knowledge are students expected to have in order for them to succeed on specialist Master's programmes?
- Are the current criteria that are used for recruitment of international Master's students a predictor of academic success?

In order to answer the research question the following objectives have guided the research process:

- To critically review the existing literature on international student education exploring the factors potentially associated with academic success and determine if these factors can be used to predict academic success;
- To critically review the existing literature on international student education as a supply chain and review this within the context of wider manufacturing and operations management literature with respect to viewing the student going through a manufacturing system;
- To develop an appropriate methodology and methods to determine the relationship between underpinning knowledge and achieving academic success for international students;
- Investigate the level of knowledge that students are expected to have when enrolling on specialist Master's programmes;
- Investigate the level of knowledge that students have when starting specialist Master's programmes with the Faculty of Engineering and Environment of Northumbria University and determine the relationship with academic success;
- To make a contribution to international student recruitment practice to ensure that students have the underpinning knowledge to facilitate academic success.

In order to answer these research questions and carry out the research objectives a positivist approach has been adopted, recognising the fact that both quantitative and qualitative data will be gathered and analysed using quantitative methods. A survey method using multiple choice tests that were created through 'expert opinion' are used to determine the level of knowledge that both graduating UG and incoming PG students have. These data are then used to determine the relationship between underpinning knowledge and academic success.

1.6 Structure of research

This thesis is constructed of seven chapters.

Chapter One provides the main aim and rationale for carrying out the study and guides the reader through the main areas of interest related to the research. The key terms used in the main aim of this study are identified and contextualised and the research aims and objectives are presented. The structure of each chapter is then outlined.

Chapter Two will review the current literature on international student education. The context of international student education within the UK will be discussed so as to inform the reader of the importance of this activity to individual institutions and the UK as a whole. The current problems relating to international student recruitment and their impact on variation within the student supply chain will be identified. The international student experience will be discussed within the framework of the 'International Student Lifecycle' and will determine the factors that affect academic success. The factors previously used to predict academic success will be identified and discussed, followed by the identification of different recruitment activities and how they can impact on variations in student knowledge. Student specifications are then reviewed.

Chapter Three will identify the literature on the Educational Supply Chain and the concept of viewing higher education as a manufacturing system will be presented. The development of the Educational supply chain will be modelled as a transformation process using a basic Input – Process – Output model. The research gap will then be identified and further work suggested to produce a model to determine if students have the appropriate underpinning knowledge to succeed academically on a specialist Master's programme.

Chapter Four will discuss the research methodology and methods used to answer the research questions. The most suitable research philosophy will be discussed leading to a realist ontology and positivist epistemology for this research. The most appropriate research methodology and methods will be identified as deductive approach using surveys to gather data and statistical analysis to analyse them using descriptive statistics, correlation, t- tests and simple and multiple regression analysis. The evaluation of the research will be discussed in terms of reliability and validity and lastly the ethical procedures are discussed.

Chapter Five will present the data and results used to investigate the level of knowledge that students are expected to have when enrolling on specialist Master's programmes. The current entry criteria at Northumbria for specialist Master's programmes will be reviewed and compared to other institutions. Knowledge tests, produced with input from Module Tutors and Programme Leaders and the results from UG graduating students sitting the test, will be discussed and reviewed. Correlation analysis will be carried out to determine the relationship between the students' degree mark and their achievement in the test. Appropriate feedback from the analysis will be identified for the Module Tutors and Programme Leaders.

Chapter Six will investigate the level of knowledge students have when starting specialist Master's degrees. The results from incoming PG students, will be compared to those from the outgoing UG students using their final mark and individual question level using t-tests. The PG results will then be used along with their academic results to determine the relationship between underpinning knowledge and academic success by carrying out correlation and linear regression. A model will be proposed that can be used to inform a suitable recruitment strategy.

Chapter Seven provides the conclusions to the research questions along with the contributions to practice and knowledge. Reflections on the process are discussed and the limitations and suggestions for further work are presented.

1.7 Summary of Chapter

This chapter has identified the general aim of the study followed by the background to the research and how it came about. The key terms in the main aim were identified. The research questions and objectives were then presented identifying the specific areas of work to be carried out. The structure of each chapter, answering the research objectives, was outlined identifying the review of literature on international student education and this follows in Chapter Two.

Chapter 2 International student education and the factors affecting academic success

2.1 Introduction

The main aim of this chapter is:-

> "To critically review the existing literature on international student education exploring the factors potentially associated with academic success and determine if these factors can be used to predict academic success."

The growth of international student education and the importance of international students to the UK in terms of the economy and the universities they study in are reviewed. The need to recruit from developing markets is discussed along with the pressure this puts on institutions to meet ever expanding targets of international student numbers and the diversity of students this creates. International student education is introduced through the 'international student lifecycle' and from this the factors that can potentially affect international student academic success are discussed. Definitions of international student success are explored from the perspective of an employer, university and a student to determine the definition of success used in this research. The factors used to predict academic success are reviewed and are compared to the current predictors of academic qualification and English level which is used by most institutions. The current methods of recruiting international students are discussed and the different methods reviewed with respect to the amount of variation that can occur due to the different recruitment processes used.

2.2 Introduction to international student education in the UK

Increasing the volume of international student education in the UK will result in wider diversification of the qualifications of international students entering specialist Master's programmes due to the economic and legislative pressures placed on Higher Education Institutions (HEIs), emphasising the importance of establishing underpinning knowledge requirements.

International students are defined as Non-European-Union students whose normal residence prior to commencing their programme of study was outside the EU (HESA, 2013a). The international student market is often influenced by external factors beyond the control of HEIs and reported regularly through bodies such as Times Higher Education (THE), World Education Services (WES) and UK Council for International Student Affairs (UKCISA). These can include: demographics; economic growth and decline; government-initiated scholarship programs; the expansion of local higher education systems; immigration policies and regulatory environments of competing host countries; and the emergence of technology-enabled alternatives such as mass open online courses (MOOCs).

In general, student numbers in the UK have continuously grown over the last decade, apart from a small decrease between 2010/11 and 2011/12, and a proportion of this has come from a significant increase in the number of international students studying at UK HEIs. In 2002/3, the total student population, including UK, EU and international, was 2,131,110 and this had increased by 17.15% in 2011/12 to 2,496,645 (HESA, 2013c). UK HEIs contribute a great deal to the UK economy and through their international activities they are one of the UK's fastest growing sources of export earnings, bringing £5.3bn in 2009 which could grow to £17 billion by 2025, bringing with it a greater diversity of students (UK HE International Unit, 2010; Universities UK, 2013).

In the academic year 2002/3, there were 170,489 international students representing just 8% of the total student population, but by 2011/12 this had risen to 302,680 students, representing approximately 12% of the total student population studying in the UK (HESA, 2013a). In absolute terms, the number of international students had grown by 132,191 representing a 77.5% increase and accounted for 36% of the overall student growth between 2002/3 and 2011/12. The most significant trend in this growth was the demand for Master's qualifications, especially in the areas of engineering and technology at PG level. During this time there was also a shift in the most popular regions of origin for international students, with most growth in students coming from Asia and the Middle East. In 2010/11, the top 5 countries for the origin of international students were China, India, Nigeria, USA and Pakistan (Universities UK, 2012). In the year 2000, the top three countries as a destination for international students, were USA (22.9%), UK (10.8%) and Germany (9.0%), whilst in the year 2010 this had shifted to USA (16.6%), UK (13.0%) and Australia (6.6%) (Universities UK, 2012, p8). An interesting point to note is that in the year 2000, the top three providers warranted 42.7% of the market, whilst in 2010 this dropped to 36.2%, showing the influence of the newer and smaller providers and introducing more variation into the educational supply chain.

Despite the UK taking an increase in market share during this ten year period, in 2011/12 international students entering postgraduate degrees fell by 2% from the previous year (Universities UK, 2013). Although in the academic year 2011/12, 35% of all international students studying in the UK came from China and India, the number of Indian students reduced by 23.5% from 39,090 to 29,900 (HESA, 2013b).

In recent years there have been many activities that have had an impact on an HEI to grow and sustain student numbers, such as the Browne review (2010) and, more specifically for international student income, changes to the visa system (UKBA, 2011a) along with changes to the Post Study Work (PSW) visa (UKBA, 2011b). The changes to the visa system came about due to a perceived exploitation and this was reported by BBC News (2013a), where a Home Office spokesman stated that "*The student visa route we inherited was open to widespread abuse and neither controlled immigration nor protected legitimate students from poor quality sponsors.*" The changes required higher education institutions to comply with the Tier 4 visa and it is estimated that this compliance cost £67m in the year 2012-13. The aim of this was to ensure that genuine students, who wanted to come to the UK to study, were doing so for the right reasons and did indeed go to bona fide institutions. A study was carried out on 24 institutions by the Higher Education Better Regulation Group (HEBRG) and they found that the average annual cost was £357,948 but more interestingly this ranged from £46 to £2,392 per Tier 4 student. Some institutions did claim benefits such as getting "*more focused and better resourced international students"* with "*improved retention rates, improved progression and fewer lower quality providers"* (BBC News, 2013a). In the same BBC report, a Home Office spokesman also added *"Most recent statistics show a 5% increase in the number of sponsored student visa applications for our World-Class universities while net immigration is at its lowest in a decade"* (BBC News, 2013a). The changes may well have had the desired effect, as students are no longer coming to study with low quality providers and those that do come are serious about their education. However once the students graduate and have achieved academic success, their ability to stay in the UK is limited by the scrapping of the PSW visa in 2012, which allowed undergraduate and postgraduate students to remain in the UK for two years after graduating. At a recent international educational fair in Mumbai, students were not keen to come to the UK and were seen carrying Canadian and Australian university prospectuses. One Indian student told a BBC reporter that:

> *"I know the educational standard of the UK is very renowned, so I would have preferred that, if the visa system hadn't been changed, I want to study, work and maybe settle abroad, and that's why I went for the other countries, because of the issues"* (BBC News, 2013b).

The issues she was referring to was the scrapping of the PSW visa and its replacement with the points based Tier 2 visa which requires graduates to have a job with a minimum £20,500 salary, as well as other criteria which are used to make up the required points for admission. Since the market is highly competitive and the government is committed to "*sustainable growth in a market which the UK excels",* the continual changes to the visa system were identified as a cause for concern by Universities UK and they brought this to the attention of the government through Lord MacGregor of Pulham Market with a parliamentary debate entitled "*…the impact of student visa policy on admissions to universities in the United Kingdom and Northern Ireland"* (Universities UK, 2013). The UKBA has since been disbanded by Theresa May and power returned to the Home Office. During her parliamentary announcement she commented "*We have introduced a limit on economic migration from outside the EU, cut out abuse of student visas and reformed family visas. As a result net migration is down by a third" (Chorley & Doyle, 2013).* It is now hoped that international students may be removed from the net immigration figure as lobbied by Universities UK. This may then remove the pressure on the issuing of visas to bona fide students who are committed to receiving an education in the UK.

The white paper (BIS, 2011) giving good quality students more freedom to choose which institution they would like to attend and the 'removal of the cap' on student numbers could cause an imbalance in the student population, meaning that some institutions offering good quality, value for money programmes, could create even more financial pressure on other institutions (Morgan, 2013). Also, the factors that led to London Metropolitan University having its licence revoked to issue international students with visas leading to a £30m budget deficit, could become more commonplace as institutions fight for survival (Meikle, 2012).

Since the market for international students is very volatile and in constant flux, if institutions want to stay ahead then they must review what is happening across the globe and continually look to diversify their recruitment strategy. They cannot be too dependent on one country or region (Chaudaha, 2013). One such report suggests that institutions need to be strategic, informed and deliberate if they want to stay ahead of the game and offer the following suggestions:

- Invest in emerging markets such as Brazil, Mexico, Vietnam and Saudi Arabia
- Internships will attract students from countries such as India
- Growth in the Bachelor's market will outstrip that of MSc and PhD programmes
- Stringent immigration policies in the UK will divert student to the USA, Australia and Canada (Choudaha & Chang, 2012, p3).

If the growth in the Bachelor's market does outstrip the growth in MSc students, then there will be even more pressure on the recruitment of specialist Master's students from the emerging markets.

As the economy grows in Asia there will be greater opportunities for student mobility as families become wealthier. The socio-economic transformation of Asia will provide an opportunity for many institutions, but "*engaging with Asia will* *require a thoughtful approach that balances quality with quantity*" (Chaudaha, 2014).

International student education is a priority for most UK institutions and brings a great deal to the UK economy, but its ability to attract good quality students is continually at risk through the continual changes in the visa system by the government. Australia and Canada appear to be in an excellent position to take advantage of this unless UK universities can stay one step ahead by adding extra value to their offering and exploring new and emerging markets. However, these new and emerging markets will bring with them an even more diverse and unknown student population introducing more variation into the educational supply chain.

In summary, this discussion has shown that the market for international students is becoming more competitive, growing and changing, and that the term 'International', whilst conveniently describing a market sector, covers a very diverse group. If the market continues to change, the level of diversity a University will have to accommodate will itself inevitably increase. Many factors have been identified that impact on the recruitment of international students on to specialist Master's programmes both from within the UK and the rest of the world and as such make the recruitment process far more competitive. As new markets are explored there is the possibility that new problems are identified, as previously unseen qualifications are reviewed for equivalence. Equivalence is difficult enough, but the knowledge that is included in the qualifications can be even more difficult to determine. Despite all this, universities must ensure that they attract the right quality of students that have the required underpinning knowledge to allow them to achieve academic success during their experience as an international student.

2.3 International student experience

According to Lee (2006), "*While there is considerable investment and effort devoted to attracting international students, far less attention is paid to the experiences of international students once they arrive at the host institution.*" Lee also suggests that there is limited research available on the international student experience and more specifically in adjusting to a new environment. Bartram (2008) also suggests:

> ".....*that much of the research that has been carried out has concentrated on issues such as recruitment and motivation to study elsewhere, and consequently there has been limited in depth academic research about the experience of overseas students"* (Bartram, 2008, p658).

It probably depends on the exact definition used for 'international student experience', but in reality there is an overabundance of information published regarding the international student experience (Arkoudis, 2006; Bamford, 2008; Brown, 2009a; Carson, 2009; Crump, 2004; Hooley & Horspool, 2006; Spencer, 2003a). To complement the research on the international student experience, many universities have published their own guidelines for staff to enhance the international student experience (Carroll & Ryan, 2005; Turner, 2009). There is a plethora of informed research available regarding international students studying in the UK (Bamford, 2008; Bartram, 2008; Lebcir, Wells, & Bond, 2008; Ryan, 2000), Australia (Arkoudis, 2006; Neri & Ville, 2008), New Zealand (Skyrme, 2007) and the USA (Northern, 2007), all of which attract significant numbers of international students. The majority of this research investigates the problems and shortcomings that educational sojourners encounter when undertaking study in another country and the interventions that are put in place to overcome them. These interventions include pre arrival support, adjustments to teaching and learning in the classroom and life outside the classroom, but none of them mention underpinning knowledge. The reason for requiring these interventions could be that it has long been established that international students are different to home students, due to many different factors and require extra support to help them engage with the learning process and ultimately achieve academic success. If students have a lack of underpinning knowledge then this could make engaging with the learning process more challenging as it is then more difficult for example to have an input in to group work which can cause resentment from other students that are more knowledgeable. This was recently highlighted in the UK when a major project was carried out by the Higher Education Academy (HEA) and United Kingdom Council for International Student Affairs (UKCISA), which more importantly was funded by the UK government. The importance of international students to the UK resulted in the development of the international student life cycle.

2.3.1 The international student lifecycle

The international student lifecycle was developed as part of the Teaching International Students Project (TISP) (initially known as Teaching and Learning for International Students (TALIS)), which was a joint initiative between the HEA and UKCISA with funding from the Prime Minister's Initiative 2 (PMI2). The project:

> "*focuses on the ways that lecturers and other teaching staff can maintain and improve the quality of teaching and learning for international students. This is done through providing guidance and information about how to meet the diverse learning needs of international students"* (The Higher Education Academy, 2013b).

The project provided a resources bank that is available via the World Wide Web and is entitled 'The International Student Lifecycle'. This breaks down the lifecycle into easily recognisable blocks that both academic and professional support staff and students can relate to. Figure 2.0 shows the lifecycle and areas that were identified throughout the project which could be improved or interventions could be made to help international students' progress through the 'lifecycle'. The main theme throughout the project was to help international students, but in such a way that they were not alienated or made to feel different. The international student lifecycle identifies a range of interventions from pre arrival to employability. The majority of the material is aimed at identifying adjustments that can be made to overcome 'culture, language and academic shock' by first identifying and acknowledging that they occur and then the interventions that can be made to improve the situation. It would appear that an assumption has been made that the students already have the knowledge they need, but if they are all starting from different knowledge levels this can impact on the student experience and their ability to adjust.

Prior to publishing the conclusions from the TISP project, Carroll and Ryan (2005) also suggested that improving the student experience for international students was to the benefit of all students, through the adoption of approaches that were culturally inclusive. Lee (2006) concluded that *"All members of institutions should be made aware of the added challenges that international students face as well as institutions' responsibilities in creating a welcoming climate for* ***all*** *students"* (Lee, 2006).

The TISP project identified that international students have diverse needs and interventions to help with these shortcomings, could contribute to whether a student achieves academic success. The pre-arrival and pre-sessional support is the area of most interest to this study, as this is clearly the point in time that can be used to determine if students have the required underpinning knowledge to potentially achieve academic success. If they have not, then interventions can take place to ensure that all students are starting from a common knowledge base. The induction phase particularly identifies skills development to aid learning in a new environment, but more importantly this period could also be used to identify variations in underpinning knowledge so that interventions can be introduced to minimise these variations.

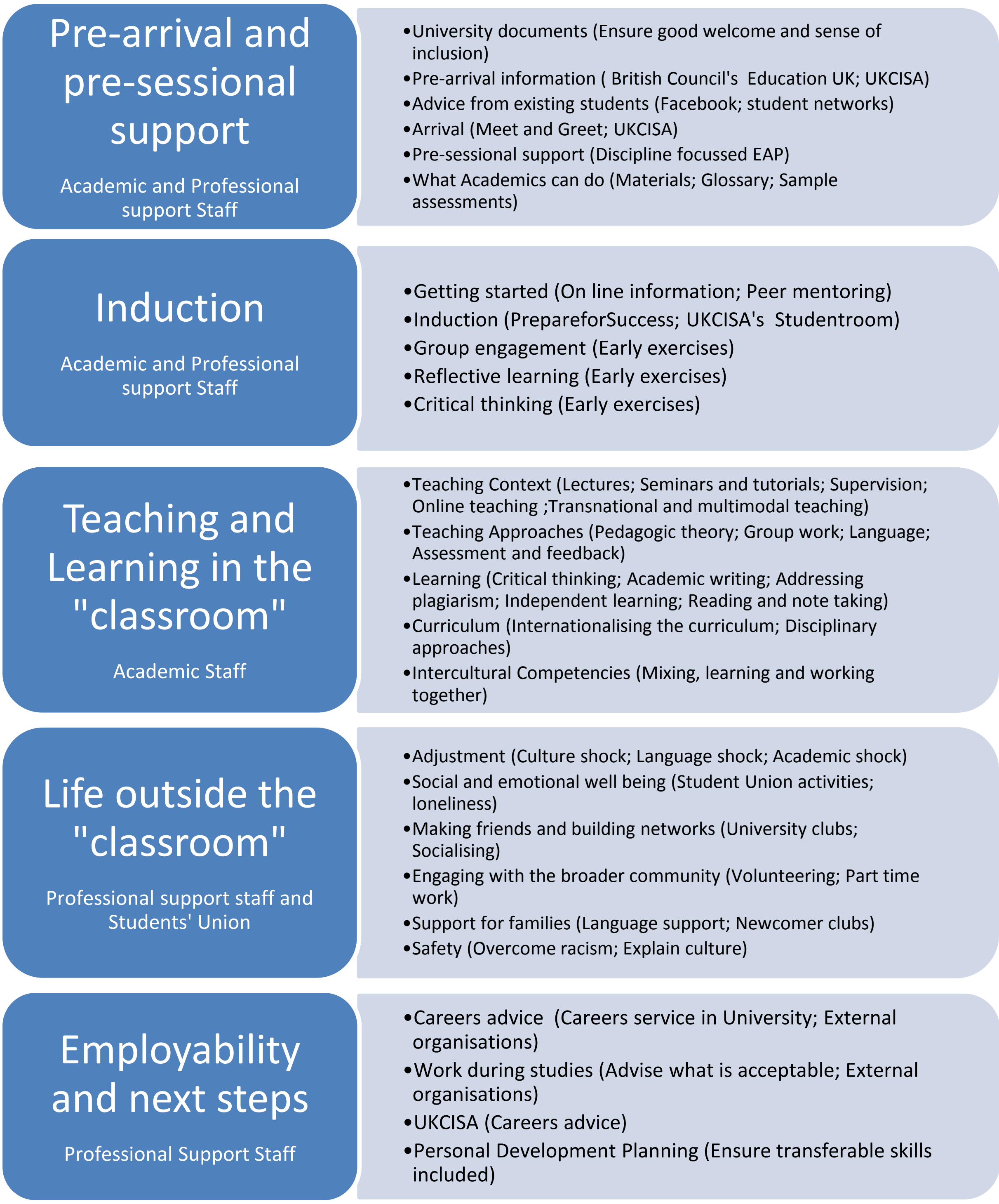


Figure 2.0 The international student lifecycle; adapted from The Higher Education Academy (2013a)

2.4 Factors affecting international student academic success

Academic success is discussed in many different studies and there is lots of advice available on how to achieve it, along with the factors that can impact on it, but the definition is rarely given (Rhodd, Schrouder, & Allen, 2009; Swansea University, 2014). Abel (2002) suggests "*that academic success for the international student flows from the confluence of a number of factors, including language proficiency, learning strategies and classroom dynamics"* (Abel, 2002, p18). Cetinkaya-Yildiz, Cakir, and Kondakci (2011) found that students needed preparation before leaving their own country, and support when in their country of study. Their study focused on the psychological factors and included interaction with local students, perceived discrimination, life satisfaction and language proficiency amongst others. Sherry, Thomas, and Chui (2010) studied the experiences of international students at the University of Toledo and they highlighted the problems that international students had to cope with such as problems with English language, adapting to a new culture, financial problems and the inability of the broader University community to understand them. In order to help improve the situation they suggested that international students be given more opportunity to improve their English skills, raise their profile within the community and offer greater scholarships and financial assistance. Based on their findings they suggested that Universities needed to focus on both academic and non-academic needs of students to help students succeed (Sherry et al., 2010). Many of the non-academic factors are recognised and can be resolved by interventions before they become problems. This can be clearly evidenced by the areas of suggested support provided in the 'Pre-arrival and pre-sessional support' and 'Life outside the 'classroom'' section of the international student lifecycle. However, academic needs tend to be more reactive since deficiencies in underpinning knowledge are often not known until teaching has commenced or diagnostic testing is carried out (Robinson & Croft, 2003).

There are many suggestions and models for improving academic success and these vary depending on the particular subject area and country of study. One area that has been identified many times as having an impact on the academic success of any international student, is the ability to adapt to the culture in their new surroundings (Crumbley, 2010; Jones, 2005; Li et al., 2010; Sarkodie-Mensah, 1998; Van Oudenhoven & Van der Zee, 2002). Failing to adapt to the culture also brings with it deficiencies in social ability and English language proficiency. These particular three areas form a vicious circle as the inability to perform in one naturally inhibits the others and can have an impact on any student no matter how academically strong they are when they enter their programme of study. In order to help the students overcome this, many authors (Bamford, 2008; Carroll & Ryan, 2005; Fuchs & Wößmann, 2007; Spencer, 2003a) have put recommendations forward to change teaching styles and raise lecturer awareness to the needs of the international student. There have also been attempts to predict the academic success of students entering programmes by using their English language level; the probability of retention based on their entry characteristics; using supplementary entry tests over and above their entry qualifications and by getting students to prepare well before they arrive in their host country (Kauffmann, Hall, Dixon, & Garner, 2008; Li et al., 2010; Mathews, 2007a; O'Donoghue, 2009).

The predictability of international student academic success in Higher Education is still difficult to achieve (de Winter & Dodou, 2011) and the majority of literature available characterised as "*at best unimpressive in its ability to reach a consensus*" (Mathews, 2007b, p647).

2.4.1 Preparation before arrival

A recent resource is now available on the World Wide Web and published by 'eLanguages in Modern Languages at the University of Southampton'. This particular project was funded by the Prime Minister's "Initiative for International Education" through UKCISA. Prepare for success is identified as an interactive web learning tool for international students who are getting ready to come to the UK and it is aimed at informing them about the different aspects of academic life in the UK. It specifically identifies 'the skills needed for effective study' which address the differences in learning culture and aims to improve an international student's ability to understand the process of learning (eLanguages in modern languages at the University of Southampton, 2011). Having the appropriate skills is identified as a factor in achieving academic success and in many cases can be defined as procedural knowledge (Henriques, 2013; Levy, 2013). This project does help to prepare students for their arrival and improve their skills, but it does not take into account the variation in underpinning knowledge of students coming from a diverse range of pre entry qualifications.

2.4.2 Language

Crump (2004) found that cultural adjustment problems and poor English language proficiency inhibited the learning process for some new students. Bamford (2008) carried out a study to identify aspects that improved the international student experience and found that for those students who had just met the entry standard for English language, studying at Master's level was very onerous and stressful. Many of the students found that independent study, which is required to engage with the process of learning, at an early stage in the course caused a great deal of stress. For those who were confident in their language ability, they found the support classes too generic and did not include course specific terminology. The stress endured by these students could be exacerbated *"as lecturers can mistake their lack of knowledge regarding technical or even political or cultural terminology as the students having difficulties with language, which is not the case"* (Bamford, 2008). Bamford (2008) also suggested that when the students in a group all have different levels of English, it hinders the educational experience of the whole group, identifying that the process is not capable of dealing with such variation. This implies that process capability is relative to the process relevant characteristics of the transformed resource (Further explained in Chapter Three). With a wide variation in the transformed resource, the implication is that the process must have a similarly wide capability. Given that the key transforming resource is human (the lecturer), then capability is broadened through training and development intervention, whilst attempting to control (minimise) input variation. Such variation in underpinning knowledge could also have the same effect on group dynamics and create resentment between students. In cases like this, the students have to either adapt themselves to the process or the process has to be adjusted so that all individuals are capable of engaging. When Brown (2008) carried out an ethnographic study of international postgraduate students, a major theme emerged around the students' anxiety over their English language skills. The students had met the entry level of IELTS 6.0, but the majority suffered feelings of shame and inferiority and as a result reverted to speaking in their mother tongue to students from their own country. Brown (2008) concluded that the anxiety that students suffered over their English capability was an inevitable part of culture shock but did identify it as a debilitating feature of the academic sojourn. The studies above tend to show that even when students meet the entry requirements for their particular programme, they can still encounter stress and anxiety due to learning in a different language. In order to help overcome this problem, Sovic (2008) suggested that interventions could be to provide language support that was specific to their subject of study and the institution should initiate working in groups with home students.

The ability of all students to use academic English, which helps to transform generic skills to specific process skills, has become a major factor identified by a New Zealand University. Read (2008) examined the rationale behind why his University required all undergraduate students, whether home or international, to take a Diagnostic English Language Needs Assessment (DELNA) so that they could be given extra tuition in academic language support if needed. The rationale was that many of the entrants to the University came from previous less well represented indigenous ethnic or linguistic minority groups, or they were recent migrants or refugees who met the academic criteria and were not required to show an English qualification. The University needed to be very careful not to create any legal or ethical problems by identifying students for extra support based on their ethnicity or other demographics. The DELNA test has no bearing on their entry to the University but is exactly as it says - purely a diagnostic tool to help students identify shortcomings in the use of technical language so that extra support can be provided, therefore helping all students to engage in the learning process. This study would suggest that if international students do not have mastery of the relevant subject specific academic English, then this can hinder their progress.

The above research identifies that mastery of technical language is just as important as meeting the IELTS requirement and if students do not possess this mastery then this can be confused with a perceived lack of knowledge, which may still be the case when the level of knowledge is unknown.

2.4.3 Social

The language problems raised previously can lead to many of the social problems encountered by international students such as isolation from classmates, academic staff and the community at large (Carson, 2009). Institutions should be encouraged to provide social activities for students to encourage the social adjustment that students need to make and they should be encouraged to organise these activities themselves (Bamford, 2008). Social networks are important in helping students feel a sense of identity, not only with their peers but also with the University and their town or city of study. Bartram (2008) agreed with both Carson and Bamford and added further suggestions to help with the social needs of students such as pre-arrival contact with peers, regular personal tutoring, peer support, contact with students across the cohort, personal and emotional support and use of the Virtual Learning Environment (VLE) for social contact. All of these activities are over and above the academic contact that is expected from any University, but sadly it depends on whether the student engages in order to gain the benefit. It could be argued that these interventions could help all students, both home and international. The factors discussed above can no doubt impact on academic success and if a student was also disadvantaged by not having the required underpinning knowledge, this could exacerbate the situation even further.

2.4.4 Cultural

When any person moves to a new environment it can be one of the most traumatic events during their life and is more commonly known as culture shock (Brown, 2008). Carson (2009) reviewed the 'Lived Experience' of students studying at the University of Alberta from 1982 to 1998 and at one point in the study had students from 123 different countries which represented the majority of human cultural traditions. His view was despite international students coming from different areas of the world, their dreams, hopes and concerns were all similar (Carson, 2009). However, the reality was that the international students had difficulties and these were based around academic studies, social life and social relationships. In his dialogue with the students he identified many unanswered problems and instigated another phase "*where the participants sensed they were journeying across cultural, multicultural and intercultural borders"* (Carson, 2009, p2).

Gu, Schweisfurth, and Day (2009) studied the experiences of first year international students at four UK higher education institutions as part of an Economics and Social Research Council funded project and found that:

> "*The research findings challenge the notion that international students' intercultural adaptation is linear and passive (in the sense that it is externally expected) and point to the presence of a complex set of shifting associations between language mastery, social interaction, personal development and academic outcomes. It is the management of this amalgam, as well as the availability of differentiated and timely support which results in intercultural adaptation, and the successful reconfiguration of 'identity'"* (Gu et al., 2009, p19).

There is a lot of published information on the problems of the transition to a new culture but much of it has been found to be retrospective, superficial and descriptive, so it is difficult to draw conclusions from it (Brown, 2008). In light of these findings it is recognised that culture can impact on academic success but there does not appear to be anything relevant to contribute towards the knowledge requirements issue.

2.4.5 Summary of factors affecting international student academic success

The literature reviewed in section 2.4 can be mapped against the international student lifecycle as previously discussed in section 2.3.1 and is shown in Figure 2.1. The majority of the literature reviewed sits in the 'Teaching and Learning in the 'Classroom'' section followed by 'Life outside the classroom' and finally in the 'Pre-arrival and pre-sessional support' section. All of the literature assumes that the students have met the academic and language entry requirements to study in their chosen country of study. There is no doubt that all of this literature is very relevant to any international student studying in a foreign country, but is also very relevant to the academic and professional support staff who are responsible for carrying out some of the interventions required to facilitate the student journey through the international life cycle. The majority of it is carried out once the student has arrived and applies to all students from the very brightest, with a good grasp of underpinning knowledge, to those just making the entry requirements but with great aspirations.

Academic success or performance is mentioned several times with reference to English language (Abel, 2002; Li et al., 2010), culture (Li et al., 2010; Van Oudenhoven & Van der Zee, 2002) and learning and teaching methods (Bamford, 2008; Spencer, 2003b) but none of the authors define what they actually mean by the term academic success.

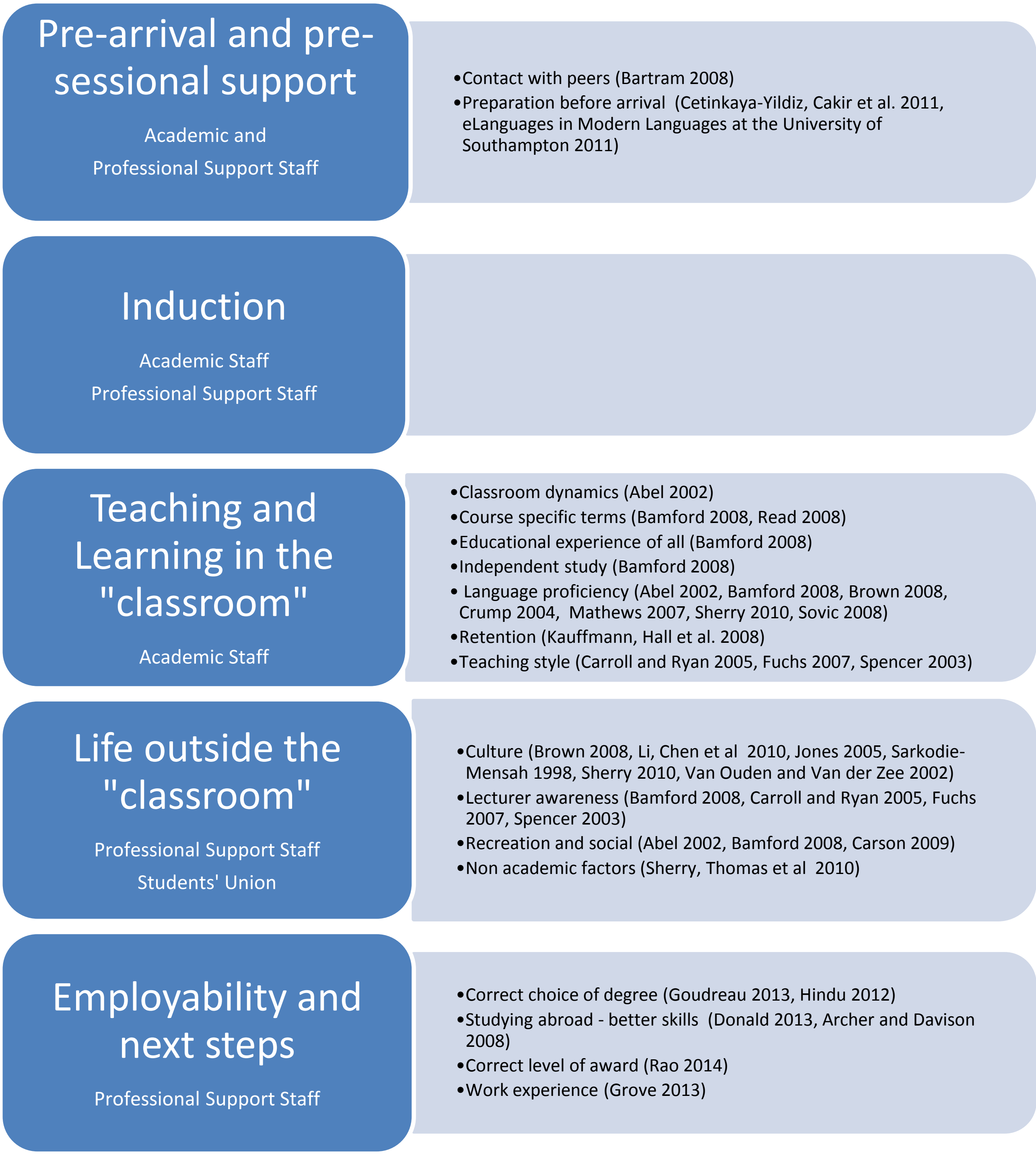


Figure 2.1 The international student lifecycle mapped against international student education literature; adapted from The Higher Education Academy (2013a)

2.5 International student academic success

The definition of 'international student academic success' depends on the perspective adopted. What could be deemed as success by one party or individual could be very different to another. Cuseo (2003) defined student success as a desirable student outcome and identified the most frequently cited indicators of student success as student retention, educational attainment, academic achievement, student advancement and holistic development. From the literature reviewed there was also many other views regarding what constituted international student academic success (Abel, 2002; Kauffmann et al., 2008; Mathews, 2007b; Spencer, 2003b; Yule & Hoffman, 1990).

The views of a student, employer or university could all be very different depending on exactly what the success refers to and what the information is used for.

2.5.1 International student academic success from a student perspective

From a student point of view, there could possibly be many different factors that make the process of international study a success. The ultimate outcome could be that the student actually gets a degree that they can then use to help gain employment, preferably in a more prestigious job than they would have secured without the qualification. On the other hand, the student could see the journey as a holistic experience, developing one's life (Cuseo, 2003).

A recent research report combined information from the US Bureau of Labor Statistics and research carried out by PayScale to predict the top 15 College Majors that were the most valuable in terms of salary and career projections up to 2020. They concluded that the correct choice could set you up for a successful career with high earnings or end up in debt without a way of recovering it. Goudreau (2013) reviewed the data and when it was ranked by median starting pay, median midcareer pay after 10 years, growth in salary and wealth of job opportunities, graduates from engineering and mathematics came out on top. This would suggest that graduates with a good degree in a subject area not currently relevant with employers may not actually be successful after all. The report by Goudreau finally summarised:

> "*that employers reported engineering and computer information systems majors as their top recruits. Also, nearly half of these employers (47%) said the competition for new science, technology, engineering and math talent is steep. That means while other recent grads fight for jobs, these students will likely field multiple offers"* (Goudreau, 2013).

Based on the findings of Goudreau's research, students need to think very carefully before making their choice of programme and the career they wish to pursue once they have graduated. The debate over the validity of the one year MSc awarded by UK institutions is still a problem for some students (Rao, 2014). A student returning to India to pursue his PhD was rejected from an Indian University on the grounds that the one year MSc from Nottingham University Business School was only one year duration. When he enquired with the Association of Indian Universities (AIU), the body that offers certificates of equivalence, it was confirmed that the UK MSc was not deemed equivalent to an Indian two year Master's Degree (The Hindu, 2012). Interestingly, the web page where this was reported is covered with advertisements for one year UK Master's degrees. If international students are returning to their own country, then the fact that they have a UK degree could give them an advantage over someone who has not, but this has to be researched very carefully by the student as shown above. Just the fact they have studied abroad gives them a great advantage and according to Donald (2013) "*it will prove to your potential employer that you have the ability to stand on your own two feet, that you can fit in when placed in different environments, and that you are resourceful and have initiative*" (Donald, 2013). However, this does not take into account the level of degree awarded. Of course they could still get a degree and the outcome could not be successful due to other external factors i.e. financial problems; health issues caused by the stress endured during the process; or a lack of employment due to studying the wrong subject.

2.5.2 International student academic success from an employer's perspective

From an employer's point of view they look for something very different when they are looking for a graduate who will succeed. As early as 2010, employers were already discriminating against any applicant that had less than an upper second (2:1) class degree. In a survey of 200 graduate recruiters, eighty percent of them demanded at least a 2:1 degree and refused to interview applicants with a 2:2 or lower (Clarke, 2010). Currently there does not appear to be any discrimination between the levels of awards at Master's level. Warwick University (2013) make it quite clear to their students what employers are looking for and of course a good degree is paramount, but they have also cited that employers tell them they are looking for students with a good degree; who have fully contributed to University life; who have reflected upon and can articulate their achievements and who have work experience.

In a recent survey carried out by High Fliers Research and reported in Times Higher Education, it was made quite clear that the level of degree awarded was still important, but other factors helped differentiate between many graduates with the same award:

> "*More than a third (36 per cent) of applicants who had done an internship or other vacation work with a graduate employer had received at least one definite job offer by March 2013, compared with just 11 per cent of applicants who had no careers-related work experience whilst at university" (Grove, 2013)*.

Birchall of High Fliers Research summarised the findings and concluded that "*Work experience is no longer an optional extra for university students, it's an essential part of preparing for the graduate job market*" (Grove, 2013).

An i-graduate, International Experience Barometer (IEB) survey gathered data from 233 employers regarding what they look for when employing an undergraduate and the level of award only came 15th in the ranking while 'soft skills' were deemed far more important. Another interesting finding from the same report was that:

> *"Whilst a good degree classification is considered important by 60% of employers, just 38% of employers placed high importance on the reputation of the university itself. When asked to indicate what they considered to be a 'good' degree, 93% of graduate recruiters thought a 2:1 or higher was a good degree"* (Archer & Davison, 2008).

It would appear that the majority of employers seek a 2:1 award or better, along with the soft skills they require, from potentially successful applicants for employment. For those students studying Master's degrees, Dr Bill Weiner the Dean in Residence at the Counsel of Graduate Schools, reported that "*The difference between a bachelor's and a master's degree in job opportunities after graduation is tremendous*" and went on to say that "*studies suggest that workers with master's degrees earn considerable more over the course of their careers*" (Gobel, 2013). However a Master's degree alone is not enough and many employers also look for other attributes such as soft skills and prefer a "*well rounded individual*" (QS TopUniversities, 2009).

The research above shows the importance of obtaining a good undergraduate degree at 2:1 or higher and complementing this with an appropriate Master's qualification and work experience. From an employer's perspective passing the Master's degree would appear to be a measure of success.

2.5.3 International student academic success from a University perspective

The success of a UK University is measured in many different ways such as the National Student Survey (NSS) and the Research Assessment Exercise (RAE), and these results along with many other parameters are used by various organisations to prepare University League tables based on UG education. Such tables are published by The Guardian (2013a), The Complete University Guide (2013a) and Times (2013) to name but a few. One of the key sets of data that is included in these measures is the amount of good awards that a University makes. This may be linked to 'added value' when looking at entry qualifications or just purely as an output. The Complete University Guide (2013b) includes 'Good Honours' as one of nine criteria and defines them as 'The percentage of graduates achieving a first or upper second class honours degree'. Therefore it is in the interest of the University to have as many first or upper second class honours degrees to help their league position and this may be deemed as a successful outcome for the University. Another good reason for doing well in this measure is from a marketing perspective. A student is more likely to attend a University that awards a higher proportion of 'Good Honours' than one that does not, as it is perceived to improve their job prospects since employers are more likely to employ someone with a good degree. Northumbria University (2009a) Corporate Strategy 2009-14 had identified an improvement in the level of good awards achieved by Northumbria students as one of its Performance Indicators (PI). However, Northumbria has now outlined in their Corporate Strategy for 2013-18 an improvement of the specific number of firsts and upper second class honours degrees, showing that this measure is now a much more precise PI to help them work towards their vision of becoming a top 30 University by 2025. Interestingly, the PI for home students is a higher value than the one for international students, demonstrating recognition of the differences between the two and this difference was also identified by several authors (Carroll & Ryan, 2005; Sovic, 2008; Turner, 2009).

There is no equivalent league table for PG education although the Guardian do offer some limited information. University departments are not provided with an overall teaching score, there is no ranking of each university by subject and there is no overall institutional table (The Guardian, 2013b). The tables do include some useful variables including the completion rate which would appear to be the best measure of success available at this level. A student is more likely to choose an institution that has a better completion rate given the choice between the two.

2.5.4 Summary of international student academic success

There have been many investigations and suggestions for improvement put forward to facilitate the academic success of international students (Abel, 2002; Kauffmann et al., 2008; Mathews, 2007b; Spencer, 2003b; Yule & Hoffman, 1990), however definitions of ‘success’ are varied. Kauffmann et al. (2008) discuss predicting academic success based on retention, Mathews (2007b), Stacey and Whittaker (2005) and Light, Xu, and Mossop (1987) investigate language proficiency and academic success, and refer to ‘success’ as the completion of academic studies and gaining credit hours, whilst Abel (2002) offers no definition at all but bases his ‘success’ on language, learning and classroom dynamics. According to Morrison, Merrick, Higgs, and Le Métais (2005) there is very little published research on the actual academic outcomes of international students, and in their view the majority of literature is based on their ‘experience’ rather than their ‘outcomes’, which could easily be an indicator of success.

According to the Oxford dictionary (2013) the definition of success is “*the accomplishment of an aim or purpose.*” In this context the aim or purpose can differ quite dramatically, so a definition of success related to this research would be for the student to ‘successfully complete a programme of academic study’ and obtain the award that the student had registered for. However, the degree of success depends on whether it is viewed through the eyes of the student, university or employer. Since one of the key criteria reported in the Guardian, for post graduate studies, is completion of the programme then this would support that the successful completion of a programme of academic study is a good definition to use. This may or may not be in the correct subject area or at a sufficient level for the employer but it meets the criteria required for this research. Currently the level of award at Master's, such as pass, commendation or distinction is all subsumed in to the one figure of completion, so it is difficult for the external audience to determine different levels of perceived academic success for an institution, which is easily done at UG level through the published quantity of good awards.

2.6 Predicting academic success

There have been many attempts to predict academic success using several different variables including English level, previous academic performance, retention rates and entry tests. From the literature reviewed there appears to be reference to knowledge in some of the studies but not specifically using knowledge.

2.6.1 English language level as a predictor of academic success

In order to study at a UK University, international applicants, or those students whose first language is not English, are required to show a competency at a level that the institution decides is required to be able to engage with the programme of study. Each University normally has an English language centre that employs professionals who teach English as a second language, and they would normally provide advice based on current practice within the sector and from published literature. Graham (1987, p506) however suggests that "*this literature will reveal that the relationship* *between English language proficiency and academic success is murky indeed.*" She also reviewed many studies investigating the predictive power of English language that had been carried out during the years 1965-1987 and found results at both extremes, concluding that "*the relationship between English proficiency and academic success is complex and unclear and that language scores should not play a disproportionate role in admissions decisions"* (Graham, 1987, p506). Cook et al (2004) carried out a study of international students at Nottingham University where they numbered in excess of 4,000 at the time of the study. They investigated whether international students had sufficient English language skills to achieve academic success and they concluded that *"language skills at entry* ***can*** *have a bearing on the academic success of international students"* (Cook et al., 2004). They found that the IELTS score of students on entry to a PG food management programme was a "*significant predictor of final results"* but for UG students on a psychology course "*IELTS scores were not found to correlate with academic performance"* (Cook et al., 2004). Hartnett et al. (2004) identified that:

> *"Whilst English language difficulties might be assumed to be the main problem facing international students, this has not been confirmed by recent research and the investigation of other possible explanatory variables has been strongly recommended*" (Hartnett et al., 2004, p168).

Abel (2002) investigated the effect of the English language levels on entry to an American university and suggested that "*the correlation between academic success and language proficiency, as measured by the Test of English as a Foreign Language (TOEFL) is low in magnitude but nevertheless positive and significant"* (Abel, 2002, p13). Yen and Kuzma (2009) investigated the validity of using IELTS as a means of assessing whether candidates were ready to study in the medium of English language. They used a homogenous sample of Chinese students who were studying business and found significant positive correlations between IELTS scores and Grade Point Averages and confirmed IELTS as a predictor of student academic performance.

Light et al. (1987) carried out a study of 376 international graduate students at the State University of New York who studied there between 1980 and 1985 and found that TOEFL score on entry was not an effective predictor of academic success, which was measured using Grade Point Average in their first semester. The entry level was 550 TOEFL and they concluded that all students with a TOEFL entry score between 400 to 677 were "*generally successful in their academic work*" (Light et al., 1987, p259). The cut-off point of 550 had no rationale, since most of the international students admitted with TOEFL scores below 550 were successful in their graduate programmes and on average their GPAs were higher than those of students with TOEFL scores of 550-569. It was not made clear how students with TOEFL scores less than 550 were admitted to the programmes in the first instance or what other factors were taken in to account in making that decision. In summary they concluded that "*criteria for academic success other than GPA and credit hours earned should be examined*" and in addition other predictive variables including "*previous knowledge of a field of study,*" should be investigated (Light et al., 1987, p259).

Seelen (2002) carried out a study in at the University of Lesotho, situated in southern Africa. Entry to University is dependent on applicants achieving a high level of proficiency in the English language and even if their academic scores are excellent, they will not be admitted if they do not meet the criteria for English language. From the study carried out, it was clear that the students' previous academic performance was a strong predictor of their university performance and the English had very little predictive value. Since the study only included those students meeting the English entry criteria, Seelan suggested that this level of entry should be slowly relaxed and the academic performance of the students monitored. Van Nelson, Nelson, and Malone (2004) investigated the retention and completion rates of international students seeking a Master's degree at an American University and included TOEFL scores amongst others, as a predictor variable to identify those criteria that had predictability to help admissions staff to screen applicants for graduate study. From their study they concluded that it was "*clear that the TOEFL is not a predictor of whether or not an international student will complete a Master's degree"* (Van Nelson et al., 2004).

It is clear from the evidence above that the ability of English to act as a predictor of academic performance is not conclusive. Some authors suggest that the link is not clearly established (Cook et al., 2004; Graham, 1987; Hartnett et al., 2004), some argue against using English language as a predictor of academic success (Light et al., 1987; Seelen, 2002; Van Nelson et al., 2004) and others who have found the ability of English level to predict academic success as limited but nevertheless significant (Abel, 2002; Yen & Kuzma, 2009). This would suggest that each case needs to be investigated on a case by case basis.

For this study the important findings from the above research identified "*that language scores should not play a disproportionate role in admissions decisions"* (Graham, 1987, p506); "*the investigation of other possible explanatory variables has been strongly recommended"* (Hartnett et al., 2004, p168); "*previous knowledge of a field of study,*" should be investigated (Light et al., 1987, p259). These key findings suggest that underpinning knowledge could be used as a better predictor of academic success than English language.

2.6.2 Factors affecting retention

Tinto first carried out research in 1975 and proposed a model for predicting retention, which has been tested many times since (Brunsden, 2000; Mannan, 2007; Martin, 1988; Murtaugh, Burns, & Schuster, 1999). Brunsden (2000, p301) "*suggested that Tinto's perspective may not be the most appropriate for attrition research*" whereas Martin (1988, p294) found that "*With several modifications, Tinto's model appears to have been effective in facilitating the identification of those variables which contribute substantially to predicting completion, dropout, and persistence.*" Martin (1988) identified four different constructs which included 14 different variables which explained 25.86% of the variance. Mannan (2007) on the other hand, had 5 constructs with 27 different variables and managed to extract five factors that accounted for 52.2% of the variance.

The variables used to predict attrition can be many and varied, whilst the correct choice of these would appear to have a significant impact on the outcome of predicting persisters, completers or dropouts.

From the literature reviewed, looking at retention as a factor of completing studies is very complex with varied results of success, suggesting that each case needs to be reviewed individually. Research into retention investigates many different factors mainly around social integration of the students with their peers and academic staff, but does not appear to take underpinning knowledge into account. Factors affecting retention do not appear to be the most suitable method for predicting academic success.

2.6.3 Entry tests as a predictor of academic success

Although the Graduate Management Admissions Test (GMAT), Graduate Record Examination test (GRE) and Graduate Medical School Admissions Test (GAMSAT) are widely used as admissions criterion they test skills rather than knowledge.

The tests identified above are pre-entry tests that are universally recognised. The GMAT is used for entry to business and management programmes worldwide, the GRE for entry to graduate schools in the USA and GAMSAT for entry to medical schools in Australia, Ireland and the UK (Australian Council for Education Research, 2013; ETS, 2011; Graduate Management Admission Council, 2011).

Both the GMAT and GRE test verbal reasoning, quantitative reasoning and analytical writing skills. Neither of these tests assumes any detailed knowledge of the subject area and are simply investigating the ability of an individual to understand and analyse information presented in written and sometimes tabular form. The GMAT which is administered by the Graduate Management Admission Council has been in existence for over 50 years and is used by the leading business schools around the world. They claim that the GMAT test has been:

> "*Accepted by more than 5,800 business and management programs worldwide, for nearly sixty years, the GMAT exam has been the test of choice by the world's business leaders to get into the world's leading business schools for one reason – it works. Quite simply, no other exam lets you showcase the skills that matter most in the business school classroom and in your career*" (Graduate Management Admission Council, 2011).

The GMAT also offers the following advice:

> "*Applicants come from different countries, cultures, academic backgrounds, and levels of work experience. Using the GMAT exam gives admissions professionals a consistent, objective measure of skills above all these application variables*"(Graduate Management Admission Council, 2011).

It can be clearly seen from their statement that they recognise that students come from a great variety of sources and do acknowledge the fact that they have different academic backgrounds, but their test is giving an objective measure of skills disregarding the other variables. This research is however more interested in one of the variables it omits regarding their different academic background, rather than testing their skills. The GMAT may be an accepted test but it only gives prospective students the opportunity to showcase their skills that are required for study and employment, and does not test underpinning knowledge.

There have been numerous studies investigating the reliability of the GRE to predict graduate school success (ETS, 2011). The findings have shown results from one extreme to the other with "*little if any predictive validity to finding a strong correlation between GRE scores and graduate school achievement"* (Orlando, 2005). Educational Testing Service (ETS) provide many guidelines on the use of the GRE as an admissions measure and recognise its limitations by offering the following guideline. "*Regardless of the decision to be made, multiple sources of information should be used to ensure fairness and balance the limitations of any single measure of knowledge, skills or abilities"* (ETS, 2011). This comment appears to be suggesting that other measures should be used such as knowledge or ability and not just the skills that it is testing. From the studies researched by Marks, Watt, and Yetton (1981) they suggested that the GRE was slightly weaker at predicting Graduate Cumulative Grade Point Average (GCPA) than the GMAT and in fact both of them were recognised as being imperfect in their ability to predict GCPA.

The GAMSAT is used to identify students with academic excellence that come from a humanities or social sciences background that could succeed in the study of medicine and they claim:

> "*GAMSAT evaluates the nature and extent of abilities and skills gained through prior experience and learning, including the mastery and use of concepts in basic science as well as the acquisition of more general skills in problem*

solving, critical thinking and writing" (Australian Council for Education Research, 2013).

The GAMSAT is looking at prior experience and learning and because of the nature of it, has to test basic knowledge in chemistry and biology as these students are from a social sciences background. However it also tests for the usual skills expected as in the GMAT and GRE such as reasoning and written communication. The GAMSAT therefore differs in what it is testing for compared to the GMAT and GRE which only test skills.

Mathews (2007b) investigated how students were chosen for Turkey's Higher Education Council (YOK) programme to sponsor thousands of students for graduate study, in order to get highly qualified staff who had been educated abroad for 24 of their new universities. In order to improve their success, which was based around their ability to complete their programme of study, a high foreign language proficiency was imposed on them but it was found to have the opposite effect in terms of their success. She finally recommended that the test for prospective students should be a "*centralised written exam*" and that it should include "*the testing of both content based knowledge and GRE style math/analytical/logic skills"* (Mathews, 2007b, p651). More importantly Mathews (2007b, p668) identified that "*The problem with using solely the GRE style test as a means of choosing students, who will be sent abroad to study in a foreign language, is that it fails to consider the significance of content knowledge."*

The GMAT provides a measure of skills whilst disregarding all the other variables and the GRE make the point that the test should not be used in isolation without taking other factors into account, such as knowledge. Both GRE and GMAT were found to be imperfect in their ability to predict GCPA (Marks et al., 1981). The importance of underpinning knowledge was recognised in the research of Mathews (2007b) who proposed an exam that included testing skills and knowledge which could provide a better prediction of academic success.

2.6.4 Previous academic performance as a predictor of academic success

Robinson and Croft (2003) carried out diagnostic testing of all engineering students in their first week of study at Loughborough University, to identify those students who were deemed at risk, despite them all meeting the entry requirements in mathematics. Previous studies had shown that approximately 15% of the students on the programmes failed mathematics in the first year. The diagnostic test consisted of a multiple choice questionnaire paper consisting of basic number and algebra and the average score was 70.5%. Those below 50%, which equated to approximately 15% of the sample were identified as at risk and were provided with different forms of support. The support provided, depending on their result, was either a "bridging" group or a personal action plan. Early indications from the study proved that the early intervention was proving beneficial, but their further work was how to identify and help those that "*passed the diagnostic test but failed mathematics"* (Robinson & Croft, 2003, p181).

Alias and Zain (2006) carried out a study of students entering a Master in Technical and Vocational Education (MTVE) programme from various disciplines, based on the Cumulative Grade Point Average (CPA) score. They concluded that "*students who come in with high UCPA (Undergraduate Cumulative grade Point Average) tend to graduate with high GCPA (Graduate Cumulative grade Point Average)"* but based on this evidence "*strongly suggest that UCPA should no longer be used as the sole criterion for entry for admission in to the MTVE programme"* (Alias & Zain, 2006 p378). This was based on the fact that the variance accounted for in predicting GCPA only accounted for 28% of the UCPA and hence left 72% of the variance unexplained. de Winter and Dodou (2011) investigated the effect of high school exam scores on predicting first year GPA (Grade Point Average) in BSc programmes at a Dutch university and found that "the *Natural Sciences and Mathematics factor was the strongest predictor of the first year GPA and BSc completion, the Liberal Arts factor was a weak but significant predictor and the language factor had no predictive value"* (de Winter & Dodou, 2011, p1343). Their final recommendation was to select engineering students based on their ability in physics, chemistry and mathematics rather than the grand average of all high school scores.

Stacey and Whittaker (2005) carried out a study of 171 international Master's students in an American dental school to predict the factors that had the greatest influence on academic success and clinical competency as required by US standards. The five factors that were taken into account previously were National Board Part I, National Board Part II, dexterity measures, TOEFL and a Faculty interview. Thirty percent of the National Board Part II addressed basic science subject matter, confirming their underpinning knowledge. Their findings confirmed that National Board Part II and dexterity were the main predictors of academic success and clinical competency. The National Board Part I added little predictive assistance to the academic success and clinical competency and they concluded that "*TOEFL added no additional significant help to the prediction of academic performance and clinical competency,*" but more interestingly "*The faculty interview did not contribute to the prediction of academic performance and clinical competency of international students*" (Stacey & Whittaker, 2005, p280) despite it being seen as one of the most important parts of the admissions process.

Alias and Zain (2006) suggested not using UCPA as the sole predictor of academic success, de Winter and Dodou (2011) found mathematics, physics and chemistry as the best predictors for engineering programmes whilst Stacey and Whittaker (2005) found that National Board part II which tested underpinning knowledge was the best predictor of academic success.

2.6.5 Summary of predicting academic success.

A great deal of research has been carried out investigating criteria that can be used to predict academic success with varying results. When using the level of English language as a predictor variable, it can be a significant predictor in one subject area and can be totally different in another so any relationship is not straightforward (Cook et al., 2004). The most popular tests such as GMAT, acknowledge the fact that they are only testing skills and appropriateness to study business and management and ignore previous academic background and would have limited relevance for specialist engineering programmes (Graduate Management Admission Council, 2011). Mathews (2007b) found that the most successful predictor of academic success included a test which investigated the level of previous knowledge and this was also confirmed by Stacey and Whittaker (2005) when they included, as a predictor, a test for the basic sciences. Robinson and Croft (2003) carried out diagnostic tests once the students were recruited and were able to provide successful interventions for students who displayed a lack of subject knowledge, based on their test results. The admissions process at Northumbria University takes into account the academic qualification and English level and these are currently used as the 'predictor' of academic success, in that any student that meets the criteria is accepted on to their chosen programme. This may be different at other institutions and is explored in the next section.

2.7 Recruitment process for international students in UK

In 2011/12 there were 123,520 international PGT students studying in the UK from a total of 302,680, representing 40.8% of the international student population. The top five countries for international students were China, India, Nigeria, USA and Malaysia whilst the top five recruiters were Manchester, UCL, Nottingham, Edinburgh and Warwick (HESA, 2013b). The recruitment process for international students attending a UK university is fairly standard across the sector and Northumbria is no different. Most institutions offer a range of PG programmes based around their areas of expertise and research activity. There are many strategies and activities carried out to recruit International students to study in the UK. The main recruitment activities carried out by Northumbria appear to be no different to any other institution that recruits large numbers of international students.

When recruiting from around the world an excellent website is a necessity as this can be the first impression that a prospective student gets of a university and it gives them a great opportunity to review what is on offer and investigate the criteria for entry. University of Manchester (2013a) ask international students to "*Choose from one of the largest selections of taught postgraduate degree courses in the UK and discover why students have made The University of Manchester the number one choice.*" They also claim "*The breadth and depth of pioneering research at Manchester is a magnet for world-leading minds. We have more Nobel Prize winners on our current staff than any other British university*" (University of Manchester, 2013a). These would appear to be two accolades that help them to be the largest international recruiter in the UK and be in a position to select the students they want. The application procedure is to complete the online application and make sure they have met the criteria for entry. This of course means that in theory a student can apply from anywhere in the world and come from any institution that delivers a degree in that particular subject area, without taking specific knowledge content in to consideration.

In order to maximise recruitment in key markets, many universities now have their own office in country. Northumbria University (2013b) has regional offices in China, India, Malaysia, Thailand and Vietnam and these are used to promote the university in country, as well as assist academic staff when on specific recruitment missions. The regional offices use the service of agents to recruit individual students who receive commission payments for each student recruited. It is debatable to what is the prime driver for the agents – 'the most suitable programme for the student' or 'which institution pays the most commission'? University of Nottingham (2013) is probably the one institution that is different to the rest of the top recruiters, in that they also have a campus in China and Malaysia which they attract international students to, as well as to their UK campus. The activities mentioned above are where the majority of students are recruited from at PG level but a lot of institutions also have partnerships with overseas institutions and the students come in groups to study the same programme. This occurs at both UG and PG level. A typical example would be what is known as an Articulation Agreement which is defined by QAA (2013) as:

> "*A formal agreement whereby an awarding institution judges part, or all, of a programme provided by another institution to be equivalent to components of one of its own programmes, so enabling direct entry by students to year two, three or four of the programme at the awarding institution"* (QAA, 2013).

This then ensures that the previous knowledge and level of the students are known and in theory are all starting from the same level minimising variation in the student knowledge. One step further than this is the augmented articulation agreement where the two institutions actually share teaching material and the students get the same material delivered. This method minimises variation even more than the standard articulation agreement.

PG recruitment, through some of the methods discussed above, can tend to lead to lots of individual students from different countries and backgrounds and this in itself can cause many problems. When the articulation and augmented articulation routes are used in recruitment the variation in student knowledge is minimised.

2.7.1 The impact of different recruitment activities

When PG students are recruited on an ad hoc basis as described above it can lead to a very fragmented cohort due to the previous different programmes of study undertaken by the students. Although all the students, in theory, meet the entry criteria, there could be for example thirty students all from different countries, who have all studied Mechanical Engineering and all had different themes running through their programmes. This then means that all the students are starting from a different position of knowledge and possibly skills. Even within country, the content of programmes can differ dramatically depending on the research interests and speciality of the institution. Manchester Metropolitan University (2013a) offer a Mechanical Engineering degree with the promise "*You will learn about dynamics, heat and aerodynamics, structural analysis and finite element analysis through applications such as vehicle suspensions, engines, wind turbines and building structures*." In contrast Northumbria University (2013c) suggest that "*Through our highly acclaimed, industry-led Centre for Rapid Product Development you will get practical experience of working with cutting edge technology specialising in 3D Digital design, Product Performance Analysis and Rapid Prototyping.*" From the descriptions of these two programmes alone, the difference is very easy to see. Although both programmes are accredited by the Institution of Mechanical Engineers for partial fulfillment of the academic requirements to become a Chartered Engineer, they both do it through different processes and use different content knowledge, providing students to different specifications.

2.7.2 Student specifications

According to Turner (2009, p9) "*Admission to the University presumes that the minimum background requirements for study have been met and a very good chance of success exists."* The minimum background referred to here would be the entry criteria that define the specification of the students they are looking to recruit and in meeting that specification have identified that the student has a very good chance of succeeding on their programme. Since the specification is already identified at Northumbria all that has to be done is to confirm that a prospective student meets the level of degree required they have studied in a cognate area and that they meet the English requirements required for the particular programme. The English can be confirmed through IELTS or TOEFL scores (ETS, 2013; IELTS, 2002) and the academic level is relatively easy to confirm through NARIC (UKNARIC, 2011), but the content of the cognate degree is an unknown unless the details of every module or credit can be investigated. Even when this is done, although the syllabi might look the same on the surface, they could be very different as to the breadth and depth that has actually been studied, as discussed in 2.7.1. In this instance the specification is too broad and many of the students can fall outside the tolerance of the required underpinning knowledge. Since some of the students do not meet the specification in terms of their underpinning knowledge then the current specification of English level and correct academic level in a cognate area may not be the best predictor of academic success.

2.8 Summary of existing literature on international education and factors used to predict academic success.

There is no doubt that the subject of international students in Higher Education is a contentious issue and is the subject of great debate, from the funding they provide to UK Higher Education institutions and being alienated as potential immigrants, but more importantly recognised as being different when they flow through the international student life cycle. The importance of them to UK PLC has been recognised by the Government by supplying funding through the Prime Ministers Initiative and academics such as Jeanette Ryan have become known the world over for their work in trying to understand students' needs and facilitate their transition to the UK, through bodies such as the Higher Education Academy and their work on the international student life cycle. Despite the plethora of information available regarding international students, the author has been unable to identify any literature investigating the underpinning knowledge requirements of UG students pursuing a specialist PG programme of study. The recruitment process used by Universities does not appear to take into account the specific knowledge that a student needs or has, when they apply and in the majority of cases it is based on level of award and their English language ability. The support provided to international students once they have been accepted onto a programme is generally aimed at improving skills, adjustments for culture differences and learning methods to make up identified deficiencies and attempts to get all students to a common level where they can learn on an equal footing with other students. The examples of support provided before students arrive can be excellent and are attempting to minimise variation between students before they start on their programme and provide them with the ability to go through a process of learning. There is a mixed view regarding the performance of students and how the variables identified for entry such as English level, academic level, pre entry tests etc., are used to try and predict their success whether that be in academic terms or just completion of the programme of study. This has been investigated across many different academic disciplines and at different levels producing results of great variability and hence no strong consensus in either direction. In many of the studies where prediction was not successful and, even in some that had weak but statistically significant results many comments were made regarding the significance of knowledge. Light et al. (1987) suggested investigating the previous knowledge of a field of study; Robinson and Croft (2003) tested for a lack of knowledge and implemented interventions; de Winter and Dodou (2011) identified that the levels of knowledge in physics, chemistry and mathematics were the best predictors for engineering students; Stacey and Whittaker (2005) identified a test that included basic science knowledge as a significant predictor for success and Mathews (2007b) identified that the current specification for entry to her programme of study failed to consider the significance of content knowledge.

The introduction to this chapter identified that the international student market was growing in complexity, increasing the levels of variability that are likely to be encountered by a recruiting university. The analogy of a manufacturing process suggests that to address this, a university is likely to have to adjust their processes in some way to enable an enhanced learning experience for international students and their fellow students. The key questions remain, however, what adjustments to make and for whom?

Since the significance of content knowledge has been recognised as a possible predictor of academic success, this area of research is worthy of further study. Considering the background of the author’s manufacturing expertise, the problem is viewed from a 'manufacturing system' perspective using supply chain theories to determine the relationship between underpinning knowledge and academic success. This perspective is discussed further in the next chapter.

2.9 Summary of chapter

This chapter has reviewed international student education in the UK and its importance to UK universities as a source of income, which was identified in light of the changes taking place in the home market and the visa system. The international student experience was reviewed through the 'international student lifecycle' and from this the factors that affected international student academic success were identified. The definition of international student success for this research was defined and the factors used to predict academic success were identified and reviewed with mixed success. Several of the studies confirmed that academic knowledge should be investigated as a predictor of academic success. The current methods of recruiting international students to Northumbria were found to be no different to any other university and the impact of different recruitment methods identified variation in the student's academic knowledge that can occur due to the different recruitment processes used. The significance of underpinning knowledge in predicting academic success was identified for further study in the context of a manufacturing system and the student flowing through the supply chain.

Chapter 3 Education as a supply chain

3.1 Introduction

The main aim of this chapter is :

> "To critically review the existing literature on international student education as a supply chain and review this within the context of wider manufacturing and operations management literature with respect to viewing the student going through a manufacturing system".

The concept of student specifications and viewing higher education as a manufacturing system is discussed along with the supply chain required to support it. Educational supply chain management literature is then reviewed identifying the development from manufacturing through to the service industry, education and finally the student. The research gap is identified and further research proposed.

3.2 Looking at the Higher Education process as a manufacturing system

When determining if the students meet specification, it is very much akin to a simple manufacturing system and how it operates, using the 'Input - Process – Output' model, as described by Evans (1997). Bozarth and Handfield (2008) view operations as a transformation process, that takes inputs (the transformed resource) and in some way transforms them to outputs, which can be either goods or services that are valued by the customer. The transformation process is shown below in Figure 3.0.

Figure 3.0 Viewing operations as a transformation process (Bozarth & Handfield, 2008, p5)

A key point is that operations are highly dependent on the quality and availability of the inputs, so much so that if the materials delivered as inputs are of incorrect quality then they are stopped from entering the process and the transformation process has to stop and the materials have to wait until they are returned to specification. This is more difficult to achieve in a service operation where the inputs are intangible and are much more prone to variation due to the inputs being individual students that have come from different educational institutions. The underpinning knowledge that the students have will also differ due to the variability in the educational institutions that the students are supplied from. At the basic transformation level the supply chain for this type of system would look like Figure 3.1 below.

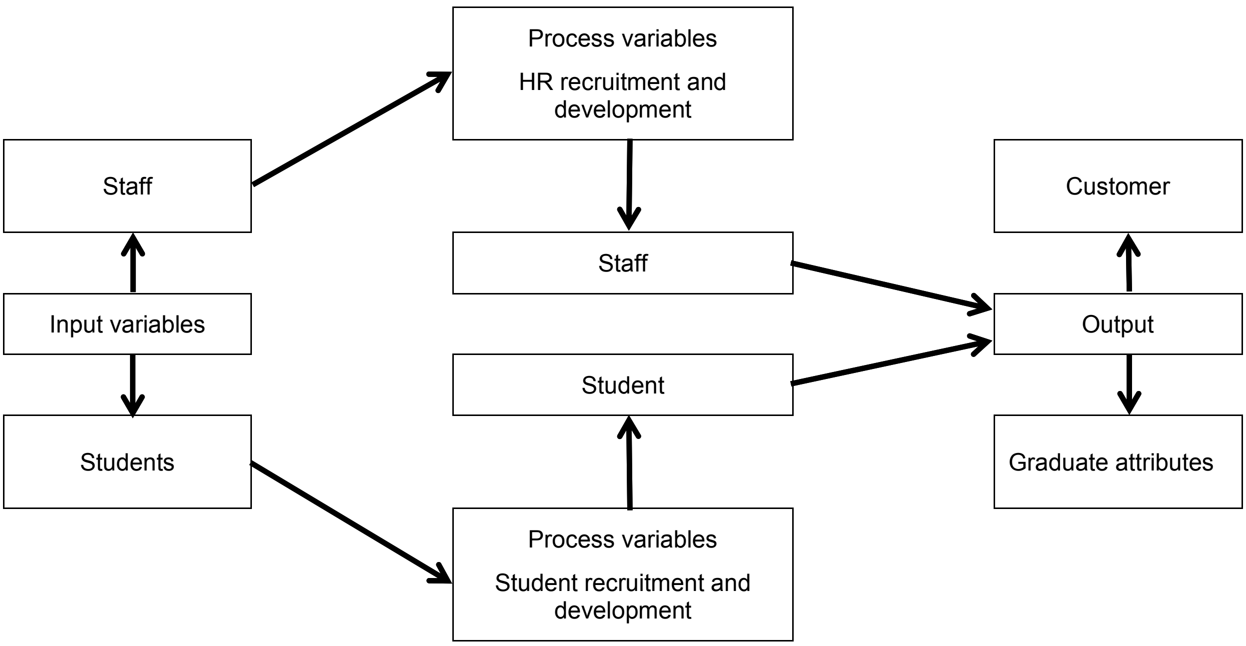
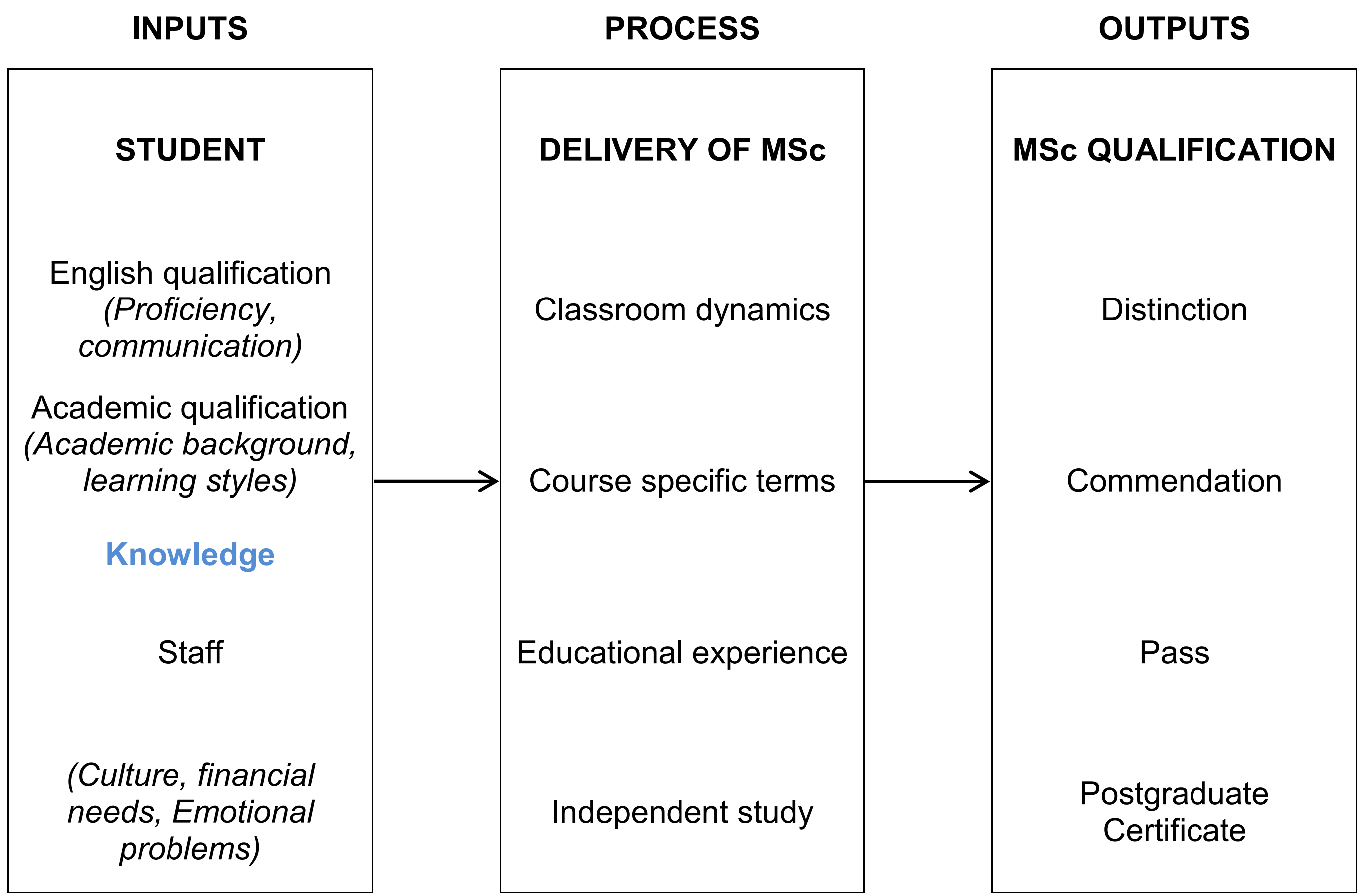


Figure 3.1 Transformation process for a student flowing through an educational supply chain

From Figure 3.1 it is clear to see that as the variation entering in to the system increases, the process variables have to expand in order to have adequate process capability. If the variables can be minimised on entry then there is less pressure on the need to expand process capability. Vorley and Tickle (2002, p42) state that "*before allocating a job to a given process, it is necessary to establish whether the* *process is capable of meeting the specification"* and this depends on the 'inputs' supplied to the system along with the 'capability' of the process in how it deals with the variation in these inputs. The main type of variation in a manufacturing transformation is 'process' variation and typically this would include "*the effect of environmental fluctuations such as temperature and humidity, variations in raw materials, variations in operator attention, variations from shift to shift and so on"* (Vorley & Tickle, 2002, p40). With this analogy the student becomes part of the process variation due to them being an input into the system. According to Bicheno (2004, p125) "*Variation is the enemy"* and if it can be minimised, reduces the chance of producing poor quality goods. The variables of a prospective student are many and are highlighted by Turner (2009) as 'issues' such as English proficiency, communication, cultural differences, academic background, learning styles, emotional problems, financial needs etc. These variables can be incorporated into the transformation process described by Evans (1997) and Bozarth and Handfield (2008) which has been adapted by the author for the transformation of prospective students to graduates and can be seen in Figure 3.2.

As a service provider, rather than a manufacturer where there is much greater opportunity for minimising variation, there is significant variability in all these areas and many of them can be addressed through, for example; academic staff adjusting their teaching style (Carroll & Ryan, 2005; Fuchs & Wößmann, 2007; Spencer, 2003b), providing extra language support (Bamford, 2008; Crump, 2004; Sherry et al., 2010) and providing support by student services (Cetinkaya-Yildiz et al., 2011). A manufacturing organisation would seek to 'assure' these process variables by, for example, ensuring that adjusting teaching style is not just down to the individual teacher but supported by professional development interventions by the institution.



Items in italics identified by Turner (2009) Adapted from Evans (1997), Page 11

Figure 3.2 Components of "manufacturing system" for producing specialist MSc graduates

From the author's research carried out in the previous chapter, this support has been researched by several author's and discussed in Chapter Two. What is less commonly addressed is the student's knowledge, as this appears to be assumed satisfactory (or meeting specification) from the defined entry standard as laid down by each institution (Turner, 2009).

3.2.1 Looking at the recruitment process as a manufacturing system

As previously stated, the specification for entry to a specialist Master's in Engineering and Environment is an UG degree at 2:2 or better in a cognate subject area and an IELTS of 6.5. The problem is that all degrees are not the same and there is significant variability in their content and provision of techniques to use the propositional knowledge learned. If the students do not conform to specification, then in manufacturing terms, they can be treated as non-conforming material (BSI, 2008). The challenge, however, is determining the specification in the first instance. In manufacturing industry, if an input (raw material) entering a process does not meet the specification then it must be 'quarantined' and action must be taken to bring it back into specification. This may be done by reworking the material or performing extra operations to ensure the material conforms and if it does not, then it is rejected (Bozarth & Handfield, 2008; BSI, 2008). When viewing students as the raw material in an education system, there could be a number of choices if the student does not meet the specification, for example; directed learning; extra induction; a bridging programme or rejection. These actions would occur prior to the student entering the programme learning process, the precise mix and content dependent on how far from specification the student was. Alternatively, additional processes could be added to run parallel to the main learning process, e.g. additional language provision (Read, 2008; Sherry et al., 2010; Sovic, 2008), additional subject content sessions

(Robinson & Croft, 2003). A third option could be to make adjustments in-process, e.g. changes to teaching and learning delivery (Carroll & Ryan, 2005; Fuchs & Wößmann, 2007; Spencer, 2003b), which may rely heavily on the skills of the individual teacher, which will in turn rely on the professional development provided by the institution. Some institutions provide extra support to overcome this variation (Exeter University, 2013; Glasgow University, 2014; University of Manchester, 2013c).

In manufacturing, such options would suggest that the supply processes providing the inputs were beyond the legitimate control of the receiving organisation and the symptoms were being dealt with rather than determining the root cause of the problem. Root cause analysis is a tool that is generally used in engineering to determine why something has failed and it can be defined as "*one of multiple factors (events, conditions or organizational factors) that contributed to or created the primary/proximate cause and subsequent failure and if eliminated, or modified, the failure would not have occurred*" (Bhaumik, 2010, p225). If the root cause of the failure is not determined then the symptoms are just treated and the problem can reoccur requiring the process to be continually adjusted.

Since Engineering and Environment take students from many different institutions in various countries this could be viewed the same as using many different suppliers and as a consequence is prone to high variability. At UG level the Faculty, in an attempt to apply legitimate control, has an 'augmented articulation' where both the customer (Northumbria) and the supplier (Nanjing Normal University) work very closely together to ensure that both parties fully understand each other's requirements and needs, and hence the variability is very small with excellent results in terms of academic success. This model has allowed the University English requirement to be reduced from the standard IELTS 6.0 to IELTS 5.5 through a variation order, without affecting academic success. In a report submitted to University Student Learning and Experience (SLE) committee to support the renewal of the augmented articulation agreement, of the twenty one students gaining a 1st/2:1 classification in the BEng(Hons)Electrical and Electronic Engineering programme, twelve of them were from the partner (supplier) representing 57%, where the rest of the cohort, which included UK and other international students, represented 43% (Hayden, 2010). A model in between is the 'articulation' route (Northumbria University, 2013a) where Northumbria has a link with another institution (supplier) and can expect a number of students to transfer from their current programme in to a similar programme at Northumbria. Students who come through this process have their curriculum mapped for suitability against the Northumbria programme (specification) and again this reduces the variability, by ensuring the applicants meet the specification required. When students apply on an individual basis the normal procedure is for a member of staff to review their application form and check to see if they have the appropriate entry requirements, i.e. English level, first degree in a cognate subject area and perhaps key modules, but not down to the curriculum level. In terms of a manufacturing system this would be very similar to a limited goods inward inspection system, relying on the measurement of one or two variables, when it is acknowledged many variables contribute to success. The importance of knowledge and more specifically the variation of it do not appear to be recognised in the literature and is therefore identified for further investigation. The transformation process deals with all aspects of operations carried out within the plant itself or by the service provider, but the link to its suppliers, distributers and customers are equally as important and this is known as the supply chain.

3.3 Supply Chain Management

A supply chain typically consists of all parties directly or indirectly involved in fulfilling a customer request and covers all activities from the initial placing of an order to the delivery to the customer (Chopra & Meindl, 2004). Supply Chain Management has been associated with manufacturing industry since the latter part of the 1990s and used traditional models such as Porter's Value Chain Model (Porter Michael E., 1985) or the Supply Chain Operations Reference model (SCOR) (Supply Chain Council, 2014), but both of these models mainly focused on profit and level of quality and service. However, many service industries are not for profit, and tend to have more human interaction than traditional manufacturing supply chains (Drzymalski, 2012). Sengupta, Heiser, and Cook (2006, p4) found that "*the majority of existing supply chain research focuses exclusively on the manufacturing sector".* In order to address this matter, they investigated applying traditional manufacturing supply chain strategies to both service and manufacturing sectors and compared their operational and financial performance. They did find similarities but, concluded that "*effective supply chain strategies in one sector may not be appropriate in the other sector".* (Sengupta et al., 2006, p4). The use of supply chain management in the service sector is still a reasonably new phenomenon and Kathawala and Abdou (2003) recognised that when they applied manufacturing supply chain techniques on the service industry it is characterised differently to manufacturing as sales are intangible, and depend more on people's experience, education and ethics. Their conclusion was that "*the characteristics and principles of the services industry were shown to be a hybrid of the different types of manufacturing sectors"* (Kathawala & Abdou, 2003, p148). There is also now research available based specifically on

Integrated Educational Supply Chain Management (IESCM) but is limited to a number of authors identified in section 3.4.

3.4 Educational supply chain management

The application of supply chain management in the service sector is still in its infancy, but the concept of an educational supply chain was first postulated by O'Brien and Deans in 1996 when they investigated:

> "*the concept of an educational supply chain, in which a university works in close collaboration with schools, further education colleges, its present students, university staff and employers of its graduates in designing the selection of courses it offers"* (O'Brien & Deans, 1996, p34).

The main purpose of O'Brien and Deans' (1996) Educational Supply Chain was to ensure the employers (customers) had an input into the supply chain and ensured they worked with the University to provide goods (graduates) that were fit for purpose when they entered society. This appears to be the first attempt to ensure that the customer in the higher education supply chain gets what they wanted, but the question is 'Who is the customer?' Al-Turki, Duffuaa, Ayar, and Demirel (2008, p214) comment on "*customer-supplier duality"* suggesting that in fact the suppliers (the students) are also the customers, who provide *"their bodies, minds, belongings or information as inputs to the service processes"* (Habib & Jungthirapanich, 2008). Within the supply chain, goods and services are very different and it has been recognised that the four qualities that are unique to the service industry and hence higher education are *"intangibility, inseparability, heterogeneity and perishability*" (O'Brien & Deans, 1996, p35). Intangibility is probably the most obvious difference between goods and services since services cannot be tasted, touched seen or smelt. A service cannot be separated from its source and is usually sold prior to its consumption unlike goods which are normally produced then sold. Goods are prone to perish whereas a service cannot be stored for future use and as such cannot perish. Heterogeneity is a particular concern for this research, as service performance can vary dramatically due to the variability associated with labour intensive processes (O'Brien & Deans, 1996).

Lau (2007) carried out a case study at the University of Hong Kong and investigated educational supply chain management within the university sector. As part of investigating the supply of goods to the University he also looked at the student supply chain. Lau recognised that there were direct and indirect student services used to process the student, which he defined as ‘raw material’ and also recognised that the student was both supplier and consumer, although it could be argued that the previous educational institution was actually the supplier. Included in the direct student services was ‘student sourcing and selection’ although there is no further detail regarding this activity, Lau identified that:

> “*Finally every student should be designed and developed critically. Every student should be assigned a professor, which supervises the student development process throughout the supply chain. It is because the student is non-identical and the university cannot set up one supply chain process for all students. Customised supply chain processes for each student is suggested to ensure student quality” (Lau, 2007, p24).*

Lau recognised that the student intake was a heterogeneous group of individuals and as such could not be all treated the same. This is one approach to dealing with inherent variability in a service system, as originally identified by Morris and Johnston (1987). Here the strategy would be to provide the facility to ‘diagnose’ individual customer requirements and customise the operation to meet those needs. However, if it is not possible to set up customised supply chains for every student then another option would be to reduce the variability.

Al-Turki et al. (2008) recognised the work of O’Brien and Deans, but applied a much more rigorous approach to ensuring that the customers in the supply chain became much more involved in the final product. One area that was particularly identified was the long lead time that was required to produce the final product due to the fact that a Bachelor's degree can take three to four years to complete. During this time the market can have changed significantly, and there could be a mismatch between the graduates and what employers are looking for. To help prevent this, they suggested that the universities should work very closely with major employers to ensure the graduates had the correct knowledge and skill they required and could perhaps provide a sponsorship scheme so that students knew exactly what their outcome, in terms of employment, would be. They also suggested another way this problem could be mitigated was to apply 'mass customisation' and 'late differentiation' as used in manufacturing, but this would require a change in the way that degrees were delivered. Mass customisation is used by many companies in manufacturing industry such as car manufacturers like Nissan and computer suppliers like Dell, but to apply this to the education sector would need very close cooperation with employers. Transferable skills and basic knowledge would be required in the early years to provide mass customisation, and specialisation in the final year to give late differentiation. Since the employers had been involved in specifying the late differentiation phase this would ensure that students had the knowledge and skills that the employers were looking for.

Habib and Jungthirapanich (2008) proposed an Integrated Educational Supply Chain Management (IESCM) model for Universities, identifying the three decision levels of operating, planning and strategic that are carried out by university management. Interestingly they take a holistic view of the whole process based on the Input - Process - Output model as described by Evans (1997) where the students are classed as one of the inputs (raw materials) and the 'Graduate with desirable quality' is the output for society. The main purpose of the model was to provide:

> "*a novel approach for decision makers of each supply chain component to review and appraise their performance towards the fulfilment of the ultimate goals i.e. producing high calibre graduates for the betterment of society"* (Habib & Jungthirapanich, 2008).

These approaches have resonance with the approach to Manufacturing Strategy developed by Hill (1993). In this model corporate objectives are set, and a marketing strategy developed to attract 'customers'. Part of the latter will be based on identifying why 'customers' will choose a particular organisation over another, in Hill's terms identifying the "*order winning*" criteria (Hill, 1993, p41). The model then argues that in order to be successful, the corporate objectives and marketing strategy must align to the capability of the operational process and the infrastructure that supports it. Given the discussion in the previous chapter about the increasing variability in the International student market, this model would argue that a university learning process, and the support offered to international students through the university infrastructure, must be able to deliver against whatever has been identified as order winning. The importance of this model is in providing an overall design context without which students may become dissatisfied with a process ill-equipped to deal with high levels of variability. Murali and Venkata (2012a) also agreed with Habib and Jungthirapanich (2008) that "*One of the main goals of an educational supply chain is to improve the wellbeing of the end customer to society"* but more importantly for the purpose of this current research identified that "*There is insufficient feedback from Colleges/Universities to the high schools on the progress and short comings of students, the high school supplied"* (Murali & Venkata, 2012a, p279). They also identified that the educational supply chain did not provide any quality control for admission to each stage of the process. In a system where products were manufactured, the supply chain would be integrated so that feedback on any shortcomings was provided to the supplier and improvements made through the use of continuous improvement tools such as cause and effect analysis (Bozarth & Handfield, 2008). A typical supply chain for delivering a specialist Master's programme could look like Figure 3.3 below.

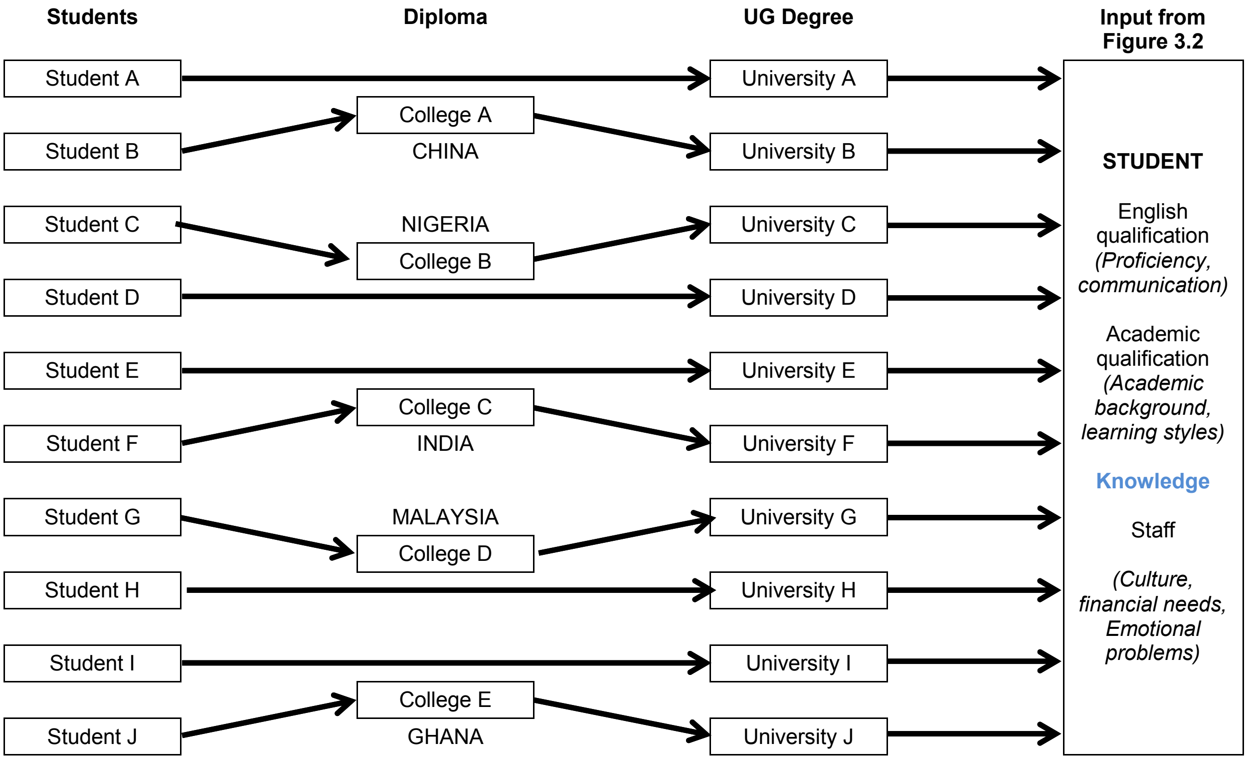


Figure 3.3 Supply chain for ad hoc recruitment to a specialist Master's programme

This supply chain would feed directly in to the 'Input' identified in Figure 3.2. Although this only shows ten students, it attempts to show the inherent variability when ad hoc recruitment is used. There is not just the variability in underpinning knowledge but also all the other variables identified by Turner (2009), shown in the 'input' box. If an augmented articulation agreement was in the supply chain it would look very different as shown in Figure 3.4. The type of supply chain shown in Figure 3.4 shows quite clearly how the introduction of an augmented articulation supply chain can significantly reduce the variability in the system.

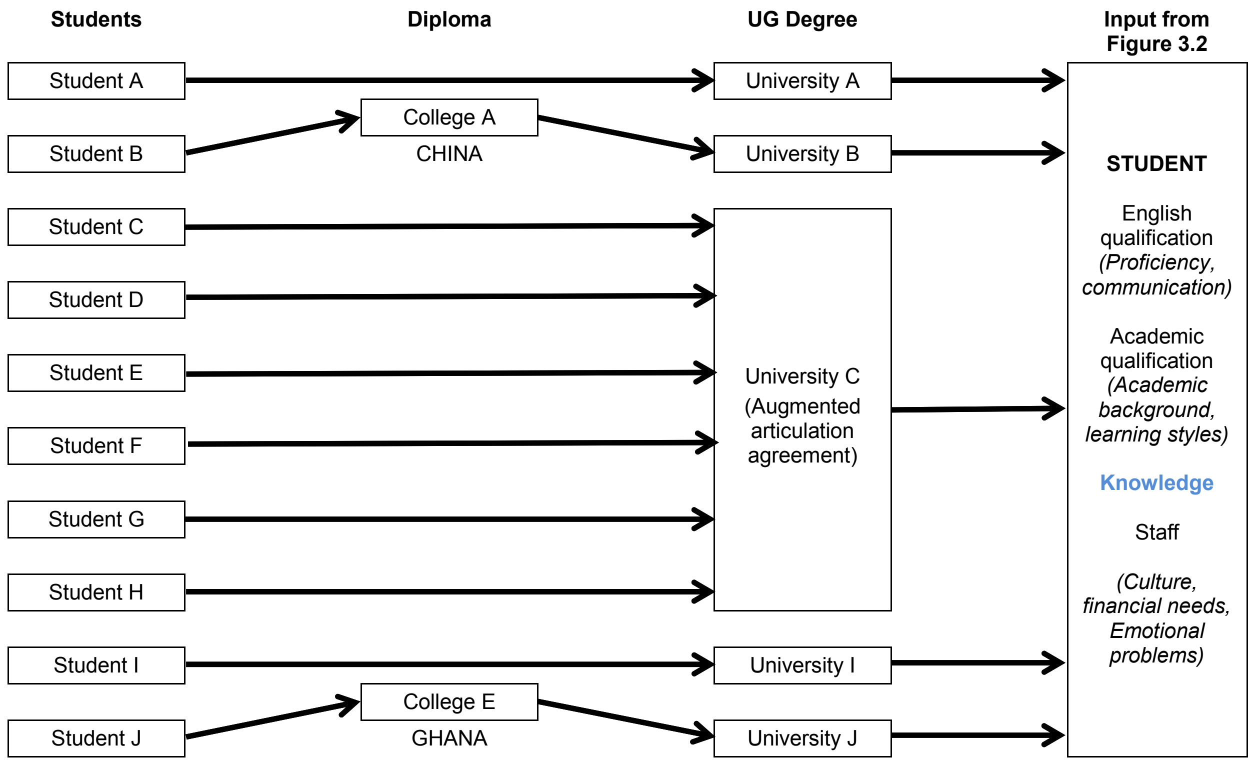


Figure 3.4 Supply chain for ad hoc and augmented articulation recruitment to specialist Master's programme

Murali and Venkata (2012b) investigated the role of information flow in the educational supply chain and proposed a model that would allow the stakeholders to review their performance towards the ultimate goal, which they described as profitability. They defined the educational supply chain alongside a basic supply chain, but in the form of an Input – Process – Output model as previously described by Evans (1997) and shown in Figure 3.5.

Pathik and Habib (2012) proposed an Integrated Tertiary Educational Supply Chain Management (ITESCM) model also based on the rationale that "*One of the main goals of an educational supply chain is to the betterment of the end customer or the society*" and in order to achieve this, the institutions need to have knowledge about the partners in the supply chain including suppliers, customers and society.

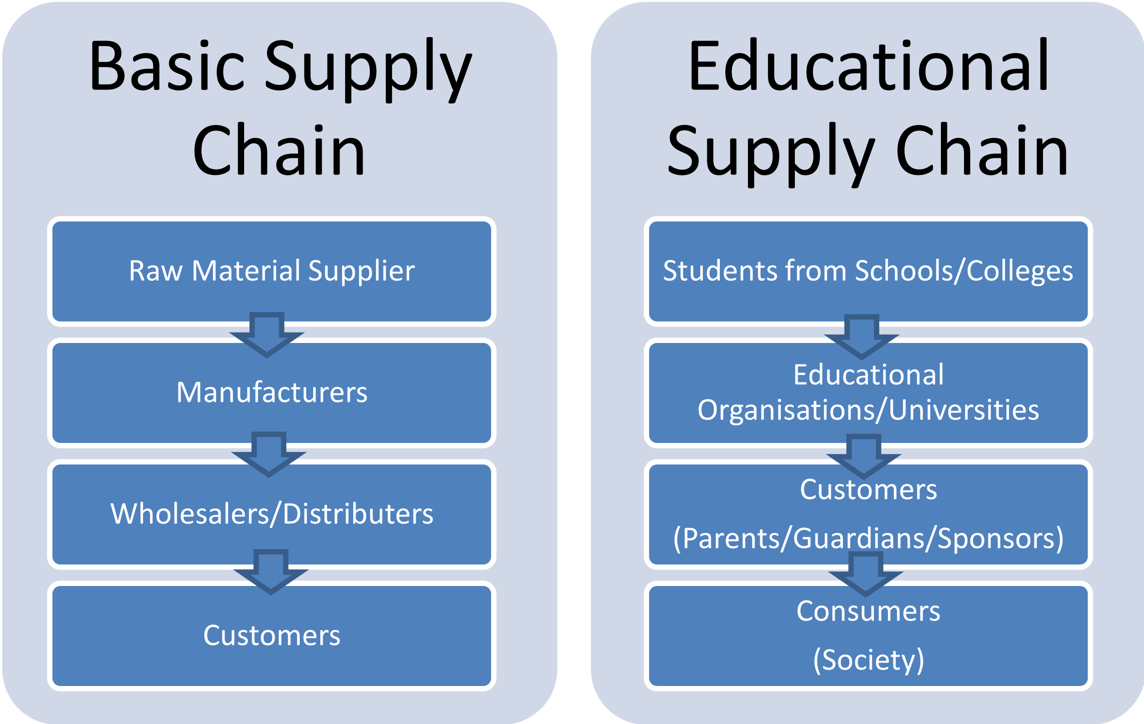


Figure 3.5 Input – Process – Output model; adapted from Murali and Venkata (2012b)

Their proposed model recognised the importance of the students as being supplied and suggested that "*Universities should have a prerequisite, like entrance exam or admissions test, to justify the quality of intake students"* (Pathik & Habib, 2012, p10).

3.5 Summary of educational supply chain literature

There is no doubt that a supply chain model can be used in the service industry and more specifically in the educational sector. O'Brien and Deans (1996) were the first to recognise that an educational supply chain was different due to the variability in the system and Lau (2007) took this a step further by suggesting that, due to heterogeneity, every student required a customised supply chain. This customised supply chain could involve the provision of customised supplementary knowledge or training in order to develop the best quality graduates. Habib and Jungthirapanich (2008) looked at the problem as a typical manufacturing system using the Input – Process – Output model and Murali and Venkata (2012a) recognised that there was no feedback to the colleges or suppliers on the shortcomings of the knowledge that the students had when they left the College and entered higher education. The integrated model proposed by Pathik and Habib (2012) suggested an entrance exam or admissions test to justify the quality of the student intake, although it is not clear what definition of 'quality' they were referring to.

3.6 Research Gap

Within the current higher education system, it is very difficult to determine the propositional and procedural knowledge that has been delivered on a programme in an institution anywhere in the world. The best information available is based on 'level' of academic achievement and the comparability of overseas qualifications can be complex. UKNARIC (2011) provide a service whereby qualifications from outside the UK are compared to the UK qualifications framework, but only for the equivalent level (QAA, 2008). The entry requirement for specialist PG students into the Faculty of Engineering and Environment is a 2:2 (or better) or equivalent at UG level. This level is based on an UG student who would have completed their degree within Engineering and Environment or any other UK university. Members of Northumbria teaching staff have previously questioned the suitability of some students on the PG programmes and whether they have the required underpinning knowledge as well as the skills. Comments have also been made by external examiners: "*there are concerns over the analytical abilities of some students*" (Neal-Sturgess, 2008); "*students have not been strong in the practical aspects of applying their knowledge"* (O'Mongain, 2008). The assumption by O'Mongain is of course that they have the propositional knowledge in the first place.

The aim of this current research is to fill the research gap identified and investigate the possibility of providing a model that can identify whether the students have the underpinning knowledge required to meet the specification required to succeed academically on the programme. Once identified, there is a possibility to get to the root cause of the problem and then carry out remedial activities, until the problem can be solved at the source i.e. with the supplier. The majority of information discussed in Chapter Two was identifying student needs before they travelled to their country of study, problems once they were in the country of study or how to help the students once they were actually at college or university. There was very little on ensuring that when they were the output of one supply chain, international students had met the correct specification to enable them to enter the programme, or input to the next supply chain. The literature on supply chain management looked at the problem using an Input – Process – Output model as used in manufacturing and acknowledged that when students are seen as inputs they have high variability, and to ensure a successful output, were identified as needing their individual supply chain. The definition of a 'successful output' related to this research is for the student to 'successfully complete a programme of academic study' and obtain the award that the student had registered for as described in section 2.5.4. It was also identified that there was no feedback to the suppliers of the students which would have helped minimise the variability.

3.7 Summary of the chapter.

This chapter has considered how supply chain theory has been adapted for use in the Educational Supply Chain and identified that every student required a customised supply chain, confirming the variability in the supply of raw material into the system.

The amount of variability in an educational supply chain was demonstrated by viewing two different recruitment methods for international students on to a specialist Master's programme. The chapter explained the aim of the customised supply chain would be to ensure that all the raw material conformed to the specification and the actions required to carry this out would depend on the individual supply chain. The development of an appropriate methodology and methods to determine the relationship between underpinning knowledge and academic success, when viewed as an educational supply chain, is presented in the next chapter.

Chapter 4 Research Methodology

4.1 Introduction

The main aim of this chapter is to:

> "Develop an appropriate methodology and methods to determine the relationship between underpinning knowledge and academic success."

After identifying the research gap in the previous chapter, the most suitable research philosophy is debated leading to a realist ontology and positivist epistemology as the most appropriate approach for this research. A positivist philosophy is confirmed as the best approach for this study based on similar work reviewed in the literature in Chapter Two. The research methodology identifies the different approaches available and those chosen within a positivist philosophy along with the quantitative methods used to answer the research questions. The data are gathered in both quantitative and qualitative forms and analysed quantitatively using descriptive statistics, correlation and linear regression. The individual methods chosen are then discussed with respect to answering each of the research questions. The evaluation of the research is then discussed with regard to reliability and validity, followed by confirmation of the ethical procedures used in carrying out the research.

4.2 Research philosophy and theoretical perspective

There are many different approaches to research, especially when it comes to choosing the most appropriate methodology and methods, but the most important factor is to justify the chosen approach (Easterby-Smith et al., 2008). Before any research is carried out it is imperative that the researcher asks many questions to ensure that the correct method(s) and methodology(ies) are selected and once they are, how that choice is justified (Crotty, 1998). In answering these questions the researcher is led towards a particular theoretical perspective (Crotty, 1998). The development of this approach leads to the four questions that Crotty (1998) suggests need to be answered before any research is carried out:-

- What *methods* do we propose to use?
- What *methodology* governs our choice and use of methods?
- What *theoretical perspective* lies behind the methodology in question?
- What *epistemology* informs the theoretical perspective (Crotty, 1998, p2)?

Methods refer to the different ways that data can be gathered and/or analysed and should not be confused with the methodology which encompasses the overall approach aligned to the particular paradigm associated with the research from the theoretical underpinning to the gathering and analysis of the data (Collis & Hussey, 2003; O'Leary, 2004). Despite the warning given by Teddlie and Tashakkori (2009) that individuals will use the terms methods and methodology interchangeably and confusingly, the definitions used by the authors above are very similar and recommend starting from a similar position. The four elements alluded to by Crotty (1998) are shown in Figure 4.0 and should be in place before any research starts.

Element	Definition
Methods	The techniques or procedures used to gather and analyse data related to some research question or hypothesis
Methodology	The strategy, plan of action, process or design lying behind the choice and use of particular methods and linking choice and use of methods to the desired outcomes.
Theoretical perspective	The philosophical stance informing the methodology and thus providing a context for the process and grounding its logic and criteria.
Epistemology	The theory of knowledge embedded in the theoretical perspective and thereby in the methodology

Figure 4.0 The four elements of research; adapted from (Crotty, 1998, p3)

Crotty (1998) suggests that there is no need to explicitly introduce ontology in to the philosophical debate since ontological issues and epistemological issues usually arise together and become subsumed with each other. Bryman and Bell (2003) agree with this position and argue that when conducting business research, questions of social ontology cannot be separated as the ontological assumptions will frame the research questions and how the research is carried out. However, in general, ontology and epistemology influence the methodology that is chosen, which then informs the researcher to the choices that are available for the actual research design and the instruments that are used to carry out the research. See Figure 4.1 below that shows the foundations of research according to Sarantakos (2005) and this was the path that was followed to carry out this research.

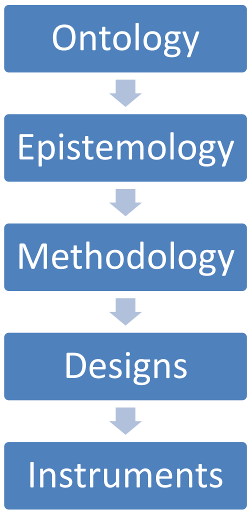


Figure 4.1 The foundations of research. (Sarantakos, 2013, p29)

4.3 Ontology

Ontology and epistemology are two intertwined terms that are used by many authors to explain the rationale for choosing a particular methodology for conducting research (Easterby-Smith et al., 2008). Ontology is about the nature of reality and existence and refers to how social scientists approach their particular subject and the assumptions they make about the nature of the social world and the way in which they will go about their investigations (Crotty, 1998; Easterby-Smith et al., 2008). The particular stance taken will depend on the assumptions that the researcher makes such as "*whether 'reality' is a given 'out there' in the world, or a product of one's mind*" (Burrell & Morgan, 2005, p1). As previously discussed, ontological and epistemological issues regularly emerge together and some authors have difficulty in keeping the two apart, often confusing the terminology used (Crotty, 1998). Bryman and Bell (2003) for example refer to "objectivism" and "constructionism" as ontological positions, which are referred to as epistemologies by others (Burrell & Morgan, 2005; Crotty, 1998) and discuss the question of "*whether social entities can and should be considered objective entities that have a reality external to social actors, or whether they can and should be considered social constructions built up from the perceptions and actions of social actors*" (Bryman & Bell, 2003, p22). Easterby-Smith et al. (2008) take a different view and recognise that amongst philosophers of science the choice is between "Realism" and "Relativism" with two extra positions known as "Internal Realism" and "Nominalism." See Table 4.0 below from Easterby-Smith et al. (2008) which gives an overview of four ontologies and their associated philosophies.

Ontology	*Realism*	*Internal Realism*	*Relativism*	*Nominalism*
Truth	Single truth	Truth exists but is obscure	There are many "truths"	There is no truth
Facts	Facts exist and can be revealed	Facts are concrete but cannot be accessed directly	Facts depend on viewpoint of observer	Facts are all human creations

Table 4.0 Four different ontologies (Easterby-Smith et al., 2008, p19)

Realist ontology takes the view that the social world, external to an individual's cognition, is made up of hard structures and exists as empirical entities. The social world has a reality of its own and it is seen as being prior to the existence or consciousness of any human being (Burrell & Morgan, 2005). It is generally recognised that there are two types of realism the first being direct or empirical realism, which through our senses gives an accurate view of the world and through using appropriate methods reality can be understood. Internal realism, on the other hand, argues that we actually experience the sensations and images and not the thing directly and as such we have to be able to identify the structures that generate those events if we want to change them (Bryman & Bell, 2003). This research will be informed by realism in the fact that we can only confirm something as being real by measuring or observing it (Johnson & Duberley, 2000) and that *"facts exist and can be revealed*" (Easterby-Smith et al., 2008, p19).

4.4 Epistemology

Epistemology is concerned with the study of theory, knowledge or the nature of the world and what we accept as being valid knowledge. In essence, authors in this area (Collis & Hussey, 2003; Easterby-Smith et al., 2008; Matthews & Ross, 2010) are in agreement with each other and discuss how individuals view the world and how knowledge is produced or "*how we know what we know*" (Crotty, 1998, p8). The specific number of epistemologies actually varies from author to author depending on how blurred the edges are.

Crotty (1998) recognises that there is a range of epistemologies and then offers the main three of objectivism, constructionism and subjectivism, but also recognises that they must "*not be seen as watertight compartments*" (Crotty, 1998, p9). O'Leary (2004) defines epistemology as "*the land of isms"* and offers five different stances; positivism, empiricism, interpretivism, constructivism and subjectivism. Some of these are viewed differently by other authors; positivism is seen as a theoretical perspective by Crotty (1998) and constructivism is viewed as an ontological, rather than epistemological, position by Bryman and Bell (2003). Easterby-Smith et al. (2008) distinguishes between positivism and social constructionism as the two binary opposites, but suggests that no philosopher ascribes one hundred per cent to one particular view and that in management research the methods are often combined from both traditions. Teddlie and Tashakkori (2009) take the view that the researcher should view the philosophy used in a particular study as a continuum rather than polar opposites and at some points "*the knower and the known must be interactive, while at others, one may more easily stand apart from what one is studying*" (Tashakkori & Teddlie, 1998, p26). In business research where there can be a number of research questions to be answered, the most appropriate stance must be taken to answer that particular question and a combination of the most appropriate stances may be adopted (Collis & Hussey, 2003).

Positivism is the philosophy that will inform this research and is shown below in Figure 4.2 as a mapping along with the fundamental philosophies against their most appropriate ontologies. The positions are meant to be indicative and not absolute mappings and are an indication of how the boundaries can be blurred.

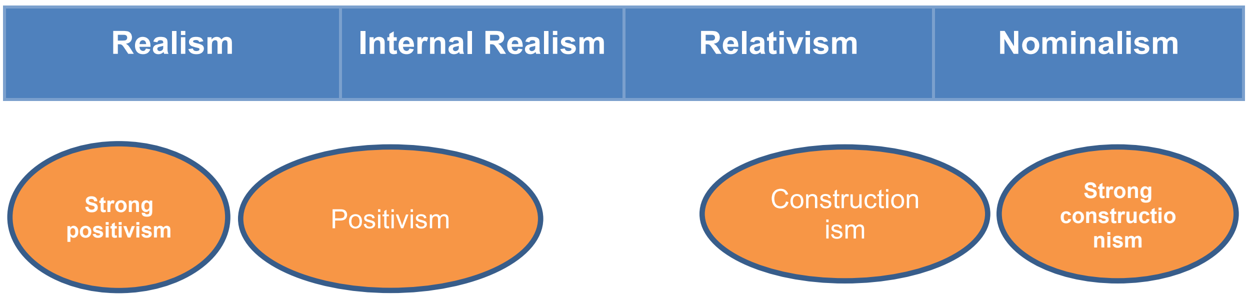


Figure 4.2 Mapping of epistemologies against ontologies. Adapted from Easterby-Smith et al. (2008, p33)

Positivism will inform this research with its roots in the natural sciences and, when adopted by the social scientists, is used to seek the causes or facts of social phenomena ignoring the subjective state of the individual. Burrell and Morgan (2005) articulate that a positivist approach "*seeks to explain and predict what happens in the social world by searching for regularities and causal relationships between its constituent elements"* (Burrell & Morgan, 2005, p5). A positivist view in social science usually takes the form of a deductive approach towards the relationship between research and theory and then the testing of theories (Saunders, Lewis, & Thornhill, 2009). Once the literature has been reviewed, a research gap or unanswered question can be identified and then the research question posed, such as "*do variations in X explain variations in Y*" (Ghauri & Grønhaug, 2010, p17)? The research question, based on the research gap, can then be tested using data. Where the data is numerical, this is normally referred to as 'quantitative', whereas data that is non-numerical such as words and pictures etc. is referred to as 'qualitative' (Saunders et al., 2009).

From the subject literature reviewed, it is apparent that there is an equal mix of quantitative and qualitative approaches adopted in the study of international student experience, depending on the nature of the research question being investigated. For example, studies looking at problems associated with language, culture and social aspects are without exception carried out from a social constructionist point of view using qualitative approaches (Bamford, 2008; Brown, 2009a; Carson, 2009; Crumbley, 2010; Grey, 2002; Lee & Rice, 2007) and these use a variety of data gathering techniques including case studies, focus groups, semi structured interviews and observation. Where authors have tested a model, attempted to predict academic performance or retention, then a positivist approach has been adopted (Brunsden, 2000; Kauffmann et al., 2008; Mathews, 2007a; Neri & Ville, 2008) and these tend to use questionnaires for data gathering and statistical packages to analyse it.

In order to answer the research questions, which are attempting to predict academic performance, this study will adopt a positivist approach.

4.5 Research Methodology

The use of the words methodology and strategy are often used as meaning the same thing when it comes to the overall approach to the research process. For most authors the choice appears to sit in two camps and is shown in Table 4.1 using the alternative terms that are used to describe the two different approaches and the features normally associated with each approach.

Author	Approach 1	Approach 2
Bryman and Bell (2003, p28)	Quantitative	Qualitative
Collis and Hussey (2003, p55)	Positivistic	Phenomenological
Easterby-Smith et al. (2008, p39)	Positivist	Constructionist
Ghauri and Grønhaug (2010, p16)	Deductive	Inductive
	Features	
	Uses hypothesis testing	Concerned with building theories
	Uses large samples	Uses small samples
	Reliability is high	Reliability is low
	Validity is low	Validity is high
	Generalises from sample to population	Generalises from one setting to another
	Data is highly specific and precise	Data is rich and subjective
	Generally produces quantitative data	Generally produces qualitative data

Table 4.1 Different terms used for the main two approaches to research and their features.

The research in this study draws on the features in Approach 1 shown in Table 4.1, since the research is adopting a positivist approach. Although both qualitative and quantitative data will be collected, they will be analysed using quantitative methods following the positivist approach. The collection of qualitative data is required to allow the production of the quantitative data needed to answer the research questions below:-

- Do other universities use different criteria to Northumbria to recruit international students for specialist Master's programmes?
- Are the criteria that are used for recruitment and selection of international Master's students a predictor of academic success?
- What are the factors that can affect academic success?
- What knowledge are students expected to have in order for them to succeed on specialist Master's programmes?

The approach of deduction has several important features and the first "*is the search to explain causal relationships between variables"* whilst "*the researcher should be independent of what is being observed"* and "*it is necessary to select samples of sufficient numerical size"* (Saunders et al., 2009, p125). When investigating if underpinning knowledge is a predictor of academic success, analysis will be carried out to determine if there is a relationship between the identified variables. However, the sample size in this study is limited to the cohorts of students studying on the UG and PG programmes being investigated.

4.6 Methods

The research question for this study is:

> "*What is the relationship between underpinning knowledge and the academic success of international students enrolled on specialist Master's programmes?"*

When a research question is identified, the role of the method is to ensure that a solution or answer can be provided. The correct choice of method can only be arrived at when the research problem is fully understood (Ghauri & Grønhaug, 2010). The methods associated with a positivist approach, which has been adopted to answer the research question above, tend to involve the collection of numerical data that can be analysed quantitatively. The data must be collected by the most appropriate method and analysed with methods that are consistent with the philosophical and methodological assumptions that underpin the study (Easterby-Smith et al., 2008). One of the most common methods is surveys and *"In many instances, quantitative researchers employ qualitative methods in their studies, adjusted to meet the criteria of quantitative research"* (Sarantakos, 2005, p50).

4.6.1 Surveys

The main aim of a survey is to collect data, which can then be analysed for patterns and comparisons. The main purpose of using the survey method is to gather information from a sample of the population and then analyse the information by the most appropriate method to identify any relationships between variables to answer a research question (Pickard, 2007). Bryman and Bell (2003) suggest that the main purpose of survey research is "*to collect a body of quantitative or quantifiable data in connection with two or more variables (usually more than two), which are then examined to detect patterns of association."* (Bryman & Bell, 2003, p56).

The variables in this case included the results from the survey (test) which were then used in conjunction with; PG students' entry qualifications, marks awarded whilst studying the specialist Master's degree, if English was the students' first language and the students' age, to look for any relationships.

4.6.1.1 Survey types

It is generally recognised that there are two types of survey, namely a 'descriptive survey' and an 'explanatory survey' and they are both suited to a different purpose. According to Burns (2000) "*The descriptive survey aims to estimate as precisely as possible the nature of existing conditions, or attributes of a population"* whereas the explanatory survey, which is also known as the analytical survey (Collis & Hussey, 2003), "*seeks to establish cause and effect relationships, but without experimental manipulation*" (Burns, 2000, p566). This cause and effect relationship can never be absolute and will normally provide some level of correlation or covariance. Explanatory surveys tend to search for more complex understandings in an attempt to determine cause and effect relationships (O'Leary, 2004). This research used the explanatory survey technique so that any relationships between variables could be identified and the explanation of any relationship used to support or refute the research questions (Pickard, 2007).

4.6.1.2 Survey method

There are many different forms of surveys including self-completion questionnaires, postal questionnaires, web based surveys, interviewer-administered questionnaires, telephone interview surveys and many others (Easterby-Smith et al., 2008). There is a lot of information available on the production of questionnaires and how questions should be asked to ensure the data answers the question. For this study to contribute to answering the research question a test was used and according to

Teddlie and Tashakkori (2009, p236) "*Tests are various techniques used to assess knowledge, intelligence or ability.*" In this case the tests were testing underpinning knowledge and took the form of an achievement test which measures acquired knowledge or facts that are already known (Teddlie & Tashakkori, 2009). Gray (2004) used a survey in the form of a test when carrying out a study on the impact of question order in multiple choice physics questions and administered it in a classroom situation. According to Collis and Hussey (2003, p173) "*A positivistic approach suggests that closed questions should be used.*" The purpose of the test is to determine if a student has the required underpinning knowledge and each question only has one correct answer, therefore the questions will be 'factual' with one correct choice and three incorrect choices. Since this is testing underpinning propositional knowledge, the student will either know the answer or not, but may also need to have the appropriate procedural knowledge in order to do a simple calculation or manipulation to get the correct answer. Easterby-Smith et al. (2008) suggests that self-completion questionnaires can be a problem where "*response rates can be very low*" and a *"20% response rate would be regarded as good"* (Easterby-Smith et al., 2008, p230). In this study the test took the form of a self-completion questionnaire and was completed when the students were in class, in an attempt to maximise the response rate. Compared to structured interviews these type of questionnaires have many advantages such as the use of closed questions, cheaper and quicker to administer, no interviewer effects and are much more convenient for the respondent (Bryman & Bell, 2003).

4.6.2 Sample population

The samples that were chosen for this study must be *"representative of the population and unbiased"* (Collis & Hussey, 2003, p156). There are many methods available for identifying the sample population in probability sampling designs such as random, stratified, natural, systematic, cluster, and multi-stage, (Collis & Hussey, 2003; Easterby-Smith et al., 2008) depending on the exact nature of the research being carried out.

The sample populations were defined as natural clusters when answering the main research question, ‘What is the relationship between underpinning knowledge and the academic success of international students enrolled on specialist Master’s programmes?’ This appeared to be the most appropriate since clusters can include “*classes”* and “*groups with a common identity”* (Sarantakos, 2005, p161) and natural refers to where the researcher has little influence on the composition of the sample (Collis & Hussey, 2003). The cohorts of students identified for this study were finite and identified as natural clusters. If every student in each cohort was included in the sample population, the whole population would be included and this would be defined as a census rather than a survey (Muijs, 2011). Any findings from the analysis will be specific to the populations surveyed but depending on the outcomes could be used to infer generalisations on other similar populations.

In order to answer the research question ‘Do other universities use different criteria to Northumbria to recruit international students for specialist Master’s programmes?’ a competitor group of universities that was already defined by Northumbria’s corporate planning team was used. This was a coherent group of similar universities to Northumbria based on various criteria including turnover, number of students, ranking, percentage of international students etc. and were already used to carry out statistical analysis and comparisons at corporate level, so appeared to be a good rationale for not changing the group.

4.6.2.1 Sample size

The determination of sample size is very complex (Easterby-Smith et al., 2008; Sarantakos, 2005). A lot depends on the degree of uncertainty that can be accepted in the conclusions that are drawn from the analysis. In general, increasing the size of a sample increases the precision of the sample but a large sample cannot guarantee precision and it is recognised "*that increasing the size of a sample increases the likely precision of a sample"* (Bryman & Bell, 2003, p195). The actual size of a sample can be calculated online (Creative Research Systems, 2013) by entering the population, desired confidence level and the confidence interval. At the end of the day there has to be a compromise between cost of gathering the data and the precision required. The more precise the greater cost, time and analysis becomes. For this study, the full population of the 'competitor set' was used when investigating the entry criteria and this population was deemed as being representative of similar institutions to Northumbria University by Northumbria's corporate planning team. For the remainder of the research, the students present in the classroom at the point of data collection were used.

4.6.3 Data

Data can be collected in many forms and is generally known as primary, which is collected at source and secondary which already exists in the form of written materials such as published statistics, organisations' websites, etc. (Collis & Hussey, 2003).

For this research a number of data gathering techniques were used. The gathering of documentary secondary data provided the details of the entry criteria used by the competitor universities. These data were collected from the organisations' websites and can be described as written materials (Saunders et al., 2009). The data were then used to determine if Northumbria was asking for anything different in terms of its published entry criteria for PG programmes. Primary data was produced from the results of the students answering the test papers in order to answer the main research question regarding underpinning knowledge and academic success. Quantitative data are normally collected in numerical form and are either classified as continuous or discrete. Discrete data can be measured precisely and statistical analysis can be carried out on such data, where care has to be taken with continuous variables (Saunders et al., 2009). In this research the answers to the test questions are binary (true/false) so therefore discrete, but when analysis is carried out the collective results become continuous variables.

4.6.4 Statistical analysis

Once the quantitative data has been collected it is generally recognised that two actions are carried out; summarise the data and therefore identify the features that best explain it and then look for patterns that can be used to draw conclusions from the research questions (Easterby-Smith et al., 2008). This is commonly referred to as "*summarising*" and looking for *"inferences"* (Easterby-Smith et al., 2008, p245). Quantitative methods generally use statistical methods to analyse any data which have been collected and they normally take one of two forms; exploratory data analysis which uses methods such as descriptive techniques investigating mean, median, mode, standard deviation, skewness and kurtosis etc. and inferential statistics and their confirmatory techniques investigating association, differences and forecasting (Hussey & Hussey, 1997). When data are available for different groups it is possible to carry out comparative analysis such as investigating the difference in the 'mean' values. There are a number of techniques available but this research will use the *t-test* to investigate difference between the means of two similar groups with continuous variables. The test statistic is not the important part but the "*significance level*" of that result (Muijs, 2011, p115). Techniques used for investigating inferences are typically correlation analysis and simple and multiple regression depending on the data and the number of variables being investigated (Collis & Hussey, 2003). The method used to analyse the relationship between two continuous variables is to determine the correlation coefficient which is called Pearson's r (Muijs, 2011) and this technique will be used in this research. The coefficient varies between plus one and minus one indicating a perfect relationship at these extremes and no relationship when equal to zero. However care must be taken as Pearson's r assumes a broadly linear relationship (Bryman & Bell, 2003). This research will be using descriptive statistics, t-tests, correlation analysis and regression analysis to answer the research questions.

4.7 Research methodology put in to practice

The theory behind the research methodology is critically important but so is the ability to put the theory into practice. The particular methods used to help answer each research question are discussed in detail below.

4.7.1 Do other universities use different criteria to Northumbria to recruit international students for specialist Master's programmes?

As previously mentioned, Northumbria has a competitor group that has been identified in the annual planning process, which is taken as one group within a larger sample, providing a representative cross section of the 166 Higher Education Institutions in the UK, of which 116 are classed as Universities (Universities UK, 2008). The Competitor set were chosen by Northumbria's corporate planning team, as it represents similar institutions in terms of turnover, number of students, ranking, percentage of international students etc.. It is used on an annual basis to benchmark against the KPIs used in the annual planning process. The main purpose of reviewing the entry requirements is to determine if Northumbria does anything different to its peers and if so identify the differences in the recruitment process, in terms of what each institution ask for entry to similar programmes to those at Northumbria. All the specialist PG programmes at Northumbria within Computing and Engineering were identified as:-

1. MSc Mechanical Engineering
2. MSc Electrical Power Engineering.
3. MSc Microelectronics and Communications Engineering
4. MSc Computer Network Technology
5. MSc Computer Science.

The academic entry requirements, English levels and any special conditions were reviewed on the Northumbria website so that a reference point was available when cross referencing with the other institutions. The programmes at each institution were first identified by similar name and if there was any doubt about the programme similarity then the curriculum content was reviewed online. The same information was then collected as had been for the Northumbria programmes so that the appropriate analysis could be carried out. The analysis consisted of comparing both academic and English requirements for entry to the programmes to that of Northumbria. This was identified as either being lower, the same or higher.

4.7.2 What knowledge are students expected to have in order for them to succeed on specialist Master's programmes?

The programme leaders of the five specialist programmes listed above in 4.7.1 , were asked to identify the knowledge, using their expert opinion, that they would expect students from a UK undergraduate degree enrolling onto their programme to have. Without exception they all advised that the students should have a good honours degree in a similar subject area as shown in the published entry criteria for the programmes. On further investigation this varied quite dramatically and can be seen in section 5.1.1. None of the programme leaders had ever been responsible for the introduction of the programmes and had been asked to take responsibility as Programme Leader for them, as part of their workload.

The programmes had apparently been introduced over time to complement the UG programmes and the areas of expertise of the research active staff, to provide progression for those students wanting to study at PG level. Each programme was designed with 120 credits material that was taught and 60 credits for the dissertation. In most cases 100 credits contained the subject specific technical material and 20 credits were project management and research preparation. Since none of the Programme Leaders had been responsible for the development of the programmes, the author asked them to produce twenty questions, with input from the Module Tutors, that could be used to test the students underpinning knowledge that in their "*expert opinion*" (Heffner Media Group, 2011) was required to enter the programme. The questions requested were 'closed' questions with a set of four fixed alternatives, only one of which was the correct answer (Bryman & Bell, 2003). This test was then used to determine if a student had the perceived underpinning knowledge before entering the programme. In order to provide some consistency it was suggested that the Programme Leaders in conjunction with the module tutors of the 100 credits subject specific material, provide two questions per 10 credits of technical material. These could be a mix of propositional knowledge and combined propositional and procedural knowledge questions. The principle is shown in Figure 4.3.

20 Credits, Subject A	→ Question 1-4
20 Credits, Subject B	→ Question 5-8
20 Credits, Subject C	→ Question 9-12
20 Credits, Subject D	→ Question 13-16
20 Credits, Subject E	→ Question 17-20
20 Credits, Project Prep	
60 Credits, Dissertation	

Figure 4.3 Diagram to show how questions were provided for tests

Although the diagram in Figure 4.3 was suggested to the Programme Leaders, in conjunction with the Module Tutors, some of them suggested that they would prefer to provide some fundamental questions that any graduate from their particular discipline should be capable of answering and would feed in to the majority of the modules being studied. An example question taken from the Mechanical Engineering programme is shown below:-

Q19 The feature in **Figure 3** would normally be created from a:

a. Sweep
b. Loft
c. Extrude
d. Revolve

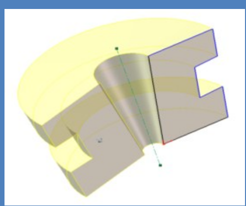


Figure 3

This type of question is used to determine if the student has the underpinning knowledge in the use of 3D design software, as this is required to study EN0510 Solid Modelling and Prototyping and EN0536 Materials Process Modelling.

The questions required for the tests except MSc Computer Science were completed using the same principle. The Programme Leader for Computer Science felt they were unable to provide any suitable questions so no test paper was produced for this programme.

4.7.2.1 Confirmation of lecturing staff expectations of students graduating from UG programmes that act as feeders for the specialist PG programmes

Since the specialist PG programmes were developed for students to progress from the current UG portfolio, the tests were given to the final year students of the programmes identified in Table 4.2.

Under Graduate Programme	Post Graduate Programme
BEng(Hons) Mechanical Engineering	MSc Mechanical Engineering
BEng(Hons) Electrical and Electronic Engineering (Heavy current pathway)	MSc Electrical Power Engineering
BEng(Hons) Electrical and Electronic Engineering (Light current pathway)	MSc Microelectronics and Communication Engineering
BSc(Hons) Computer and Network Technology	MSc Computer Network Technology

Table 4.2 Details of feeder programmes from UG to PG

In an attempt to get the maximum response, the author had arranged to meet the students in their last week of study before final examinations in April 2010. However this did not happen as the author was delayed in South Korea on a business trip due to the volcanic eruption in Iceland and the subsequent grounding of the majority of aircraft in the northern hemisphere in Europe, due to the ash cloud (BBC News, 2010). Despite regular promises of flights back to the UK by the airline the author did not return to the UK until the Saturday after teaching had finished and he therefore missed the opportunity to make any alternative arrangement to carry out the survey. The next best alternative after that was to attend the beginning of one of the final year examinations, explain what the research was about and then distribute the tests with ethics forms and return envelopes. The tests were given to all the students studying on the four UG programmes listed in Table 4.2. In total over 200 forms were distributed and only 10 were returned rendering the data worthless. Since this was the last time the students were at the University there was not another chance to evaluate the tests while the students were on campus. The tests could have been sent out again in the post but since only 10 returned them when the author attended personally to explain the research, it was felt unlikely that the postal response rate would be any better. *"Response rates of 10 per cent or less are not uncommon"* (Hussey & Hussey, 1997, p163) and at best this would provide twenty responses, which would still be insufficient data to carry out any meaningful analysis. The next option to ensure a good response was to wait until the next academic year in May 2011. This time the tests were actually given to the students in the last week of their semester before taking final exams. It was agreed with each of the programme leaders that the author could have 20 minutes of a lecture in the last week of teaching for the students. Details are shown in Table 4.3. This also ensured that the every student who turned up for the lecture had the opportunity of completing the test, maximising the response rate. After listening to the rationale behind the research and then reading the ethics form the students were offered the opportunity not to complete the test if they did not want to. Nobody declined the opportunity to take the test and the majority were very interested to receive their results once they had been marked. The test was then carried out under examination conditions, in that students were not allowed to discuss the paper with each other. Once the papers had been completed by the students they were marked for correctness out of twenty and this was then converted to a percentage.

Programme	Cohort size	Sample size	Percentage
BEng(Hons) Mechanical Engineering	51	38	74.5%
BEng(Hons) Electrical and Electronic Engineering (EEE Heavy current pathway)	75	29	38.7%
BEng(Hons) Electrical and Electronic Engineering (EEE Light current pathway)	12	11	91.7%
BSc(Hons) Computer and Network Technology (CNT)	22	10	45.5%

Table 4.3 UG students taking test identified by programme.

This result was then returned, via e-mail to the students that had requested their mark. Descriptive statistical analysis was carried out and any questions that had particularly high or low marks were identified for further investigation and this information was fed back to PG Programme Leaders and Module Tutors. Once the students had graduated, their final degree mark was obtained from the student record system and compared to the mark they had achieved in the test to investigate for any relationship between the two variables using correlation analysis.

4.7.2.2 Comparison of the results of the test given to the graduating UG students and the PG students entering their specialist Master's programme

In September 2011, the tests were given to the new cohorts of students starting the four specialist PG programmes. The author was allowed access to one of the lectures in the second week of teaching (to allow for those enrolling late) and, after explaining the research rationale to the students, they were then given the ethics form to read and the option of completing the test. The details of the programmes and student numbers are shown in Table 4.4.

Programme	Cohort size	Sample size	Percentage
MSc Mechanical Engineering	27	15	55.6%
MSc Electrical Power Engineering	31	21	67.8%
MSc Microelectronics and Communication Engineering	19	16	84.2%
MSc Computer Network Technology	22	5	22.7%

Table 4.4 PG students taking test identified by programme.

It was recognised that the students may have felt pressurised in completing the test by the perceived academic status of the author. In order to make this position clear to the students it was emphasised that they were actually helping another ‘student’ carry out their research and nobody declined to do the test. The PG students completed the test under examination conditions on three of the programmes, but the MSc Computer Network Technology students were omitted due to a very small sample size. The MSc CNT programme was no longer considered in this research at the point when the low sample size was discovered. The results for the UG and PG students were then compared for any significant statistical differences between the means using the independent *t-test*.

4.7.2.3 Monitoring the progress of the PG students by semester and using the data collected in 4.7.2.2 above to determine if there is any correlation between the test and the results achieved on the PG programme by semester

The students who had completed the test were then monitored through their relevant MSc and the results noted after semester 1 and semester 2. The results percentage they obtained for both semesters was used to determine if there was any relationship between what they scored in the test and the percentage they achieved on the programme. Other variables that were readily available and identified as predictors of success in the literature review were also used, such as the percentage of their degree on entry (Alias & Zain, 2006; de Winter & Dodou, 2011; Robinson & Croft, 2003; Stacey & Whittaker, 2005) and if English was their first language (Abel, 2002; Cook et al., 2004; Graham, 1987; Hartnett et al., 2004; Light et al., 1987; Seelen, 2002; Van Nelson et al., 2004; Yen & Kuzma, 2009), were added to the data. Multiple linear regression analysis was then used to identify the variables that could be used to produce a model. A model was then proposed in 6.5.1 that could be used to determine if an appropriately qualified PG applicant had sufficient underpinning knowledge to start the programme.

4.7.2.4 Evaluation of the model for reliability in predicting whether a student would be successful on the programme and then use of this information to identify where the knowledge weaknesses are and what could have been done to prevent them

The proposed model was then applied to the data that had been gathered for the initial investigation and each student reviewed on an individual basis to determine if the model predicted the correct outcome. As previously discussed, the measure of success in this instance is that the student was capable of completing the programme with the minimum of a pass. The data gathered were then used to identify if there were any shortcomings in the student knowledge and the impact this had on their studies. The test was also given to another cohort of Electrical Power Engineering students (*n=10).* However, it was not appropriate to give the tests to students on the other programmes as the cohorts were too small to provide any meaningful data.

4.8 Evaluation of the research

When evaluating business and management research, three of the most important criteria are "*reliability, replication and validity*" (Bryman & Bell, 2003, p40).

Reliability is a measure of how repeatable and stable the results from a piece of research are across locations and over time. The indicator of reliability gives an assurance that the tools being used will generate consistent findings (O'Leary, 2004). Of course, if the tools do not answer the research question they will be consistently wrong. One method of testing for reliability is to use the 'test-retest' method where the questionnaire is given to the same respondents twice and the answers should be expected to remain consistent (Muijs, 2011). The test could have been given to the same group of students twice to check for reliability but this was not carried out due to the lack of available time for the students to complete it without interfering with their studies. The students were given feedback on their results after the first test and, had a retest then been carried out, the results would be expected to improve, since it is questioning their knowledge and this would be expected to improve with continuous feedback and over the course of their studies.

If another researcher were to gather the data regarding the entry criteria from the competitor universities using the same process as described previously, the reliability may be only valid if the data were extracted at the same point in time since the Universities have the right to change their entry characteristics at any time. That is why it is important that a timeline is provided when data is collected.

Replication or replicability is concerned with the ability to replicate the work of another researcher (Muijs, 2011). This can only be done if the research methods and procedures are discussed in great detail and indeed can then be replicated (Hussey & Hussey, 1997). Matthews and Ross (2010) suggest that experiments with two chemicals can be replicated as long as the same procedures are followed, but when it comes to people, because of their subjective nature the results may not be so replicable. The PG students used will be renewed with every cohort and come from different educational backgrounds so the results can be expected to differ from cohort to cohort due to them being a heterogeneous group of individuals.

The perspective of validity varies depending on the epistemological stance of the researcher from a strong positivist point of view such as "*Do the measures correspond closely to reality?"* and from a strong constructionist view of "*Does the study clearly gain access to the experiences of those in the research setting?"* (Easterby-Smith et al., 2008, p71). Content validity is concerned with the ability of a test to represent all of the content of a particular construct but it is difficult to determine content validity notwithstanding expert opinion (Heffner Media Group, 2011). The programme and module leaders were viewed as "experts" to provide the questions to test the underpinning knowledge. Universities currently use the outcome of specific tests such as A level scores and GMAT to decide how likely students are to successfully complete their chosen course of study and any test used for this purpose "*should therefore predict academic success" (Muijs, 2011, p58).*

Predictive validity is important to this research in that any predictions based on the correlation between underpinning knowledge and academic success are only valid if they are shown to be significantly statistically related (Ghauri & Grønhaug, 2010). The most important aspect of validity is ensuring that what is actually being measured is what is expected to be measured otherwise any analysis done afterwards is worthless if this is not the case (Muijs, 2011). According to Bryman and Bell (2003) *“although reliability and validity are analytically distinguishable, they are related because validity presumes reliability. This means that if your measure is not reliable, it cannot be valid”* (Bryman & Bell, 2003, p168). This study has taken great care to ensure that any results are reliable and hence the results are also valid.

4.9 Ethics

During the last thirty years research has become more accountable and systematic and codes of ethics have been formulated within universities and professional institutions ensuring that research is conducted according to ethical and professional standards (Bryman & Bell, 2003). When applied to research, ethics identify the most important principles as those of ‘informed consent’ where the researcher must make sure that the research participants fully understand what they are agreeing to and where ‘anonymity’ is offered, the researcher must ensure that no one individual or organisation can be identified (Matthews & Ross, 2010). In management and business studies the importance of ethical issues is a growing concern with increasing debates on consumer wellbeing and social responsibility and if it is perceived there is a lack of awareness regarding ethics, then business research could lose its credibility (Ghauri & Grønhaug, 2010). There are many ethical codes and procedures available. There is a push for all universities to adopt definite ethical codes and practices around a common set of principles and Bell and Bryman (2007) carried out a content analysis of the ethical principles of nine social science associations and found ten principles identified by more than half of them. The first seven are about protecting the research participants and the last three are intended to ensure accuracy. These are shown in Table 4.5.

1	Ensuring that **no harm** comes to participants
2	Respecting the **dignity** of research participants
3	Ensuring a fully **informed consent** of research participants
4	Protecting the **privacy** of research participants
5	Ensuring the **confidentiality** of research data
6	Protecting the **anonymity** of individuals or organisations
7	**Avoiding deception** about the nature or aims of the research
8	Declaration of affiliations, funding sources and **conflicts of interest**
9	**Honesty and transparency** in communicating about the research
10	Avoidance of any **misleading** or false reporting of such research findings

Table 4.5 Key principles in research ethics (Easterby-Smith et al., 2008, p95)

Northumbria University has clear published guidelines and procedures on ethics (Northumbria University, 2014c) and have published a separate ‘Research Ethics and Guidance Handbook’ (Northumbria University, 2014) for students and staff who undertake research within, or on behalf of, the University. The guidelines are very clear and are used by Faculty ethics committees to grant or decline approval.

For this research, informed consent was obtained from the institution and the individuals concerned. The institution approval was obtained from the former Dean of CEIS in writing and can be found in Appendix 1. The proposal was explained to any students involved in the research before they were asked if they wished to participate. If they agreed, they were asked to sign the appropriate consent form and an example is shown in Appendix 2. At no time were any of the participants asked to take part in the study against their wishes. All data were made anonymous, but collected in the first instance using the university student identification number. Care was taken with small cohorts, where there may have been a chance for individuals to be identified. All data were kept on a memory stick that was password protected with three attempts at gaining access before all data on it would be erased. In summary, the research complied with the University guidelines. Approval was sought from NBS School Ethics Committee and confirmed on 16th June 2010 and this can be seen in Appendix 3.

4.10 Summary of chapter

This Chapter has discussed the research philosophy and an ontological position towards realism was confirmed along with a positivist stance. The research methodology identified that both qualitative and quantitative data were required to answer the research questions but they were analysed using quantitative techniques. Written documentary secondary data were identified as the qualitative data and the primary data were gathered through the survey method using test papers constructed from multiple choice closed questions. The sample populations were identified as the competitor university group already used by Northumbria and the cohorts of students studying on specific UG and PG programmes identified for the research. Appropriate statistical analysis was identified as descriptive techniques exploring the mean, mode, median, standard deviation, skewness and kurtosis. Other techniques were identified for investigating the differences in means and association of variables using correlation analysis and multivariate analysis. The methodology was then put into practice to show its appropriateness in answering the research questions. The evaluation of the research was then discussed in terms of reliability and replication, and both content and predictive validity were discussed in the context of the knowledge test. Ethics were discussed and procedures identified to ensure this research was carried out without breach of any aspect.

Chapter 5 Confirmation of knowledge of graduating UG students

5.0 Introduction

The main aim of this chapter is to:

> "Investigate the level of knowledge that students are expected to have when enrolling on specialist Master's programmes".

The entry criteria for the identified specialist programmes at Northumbria are reviewed and compared to the competitor set for any major differences in terms of English language and academic level requirements. The rationale for the compilation of the tests is presented and the finalised test papers produced. The results of the test papers completed by appropriate graduating students are presented and discussed to identify any anomalies such as low or high scoring questions and then correlation analysis is carried out between the test scores and final UG degree results.

5.1 Results from the analysis of whether other universities use different criteria to Northumbria to recruit international students for specialist Master's programmes

As discussed previously Northumbria University has a competitor group that has been identified in the annual development planning process, which are taken as one group within a larger sample, providing a representative cross section of the 166 Higher Education Institutions in the UK of which 116 are classed as Universities (Universities UK, 2008). The main purpose of this analysis is to review if Northumbria University does anything differently to its peers when recruiting international students for specialist Master's programmes in computing and engineering and identify any differences in the recruitment process in terms of what each institution asks for entry into similar programmes to those identified at Northumbria.

5.1.1 Entry requirements for programmes identified at Northumbria

The specialist PG programmes offered at Northumbria within computing and engineering were identified along with their entry requirements and are shown in Table 5.0 below:

PG Programme	Academic requirements	English requirements	Comments
MSc Mechanical Engineering	Lower second or above	IELTS 6.5 or equivalent	Physics or engineering undergraduate background
MSc Electrical Power Engineering	A 2.2 honours degree or above or equivalent.	IELTS 6.5 or equivalent	Applicants will normally have an Engineering undergraduate background, or experience in this area.
MSc Microelectronics and Communications Engineering	A minimum of a lower second class degree	IELTS 6.5 or equivalent	In a subject related to their proposed area of study.
MSc Computer Network Technology	Minimum lower class (2:2)	IELTS 6.5 or equivalent	Computing / IT or Engineering background
MSc Computer Science	Normally a good honours degree (2:2 or above) or equivalent,	IELTS 6.5 or equivalent	Normally in a computing-related discipline. This will normally have included study in: • Programming in an Object Orientated Language, ideally Java • System Analysis and Design • Databases (including SQL), ideally Oracle or similar • Computer Operating Systems and Networks

Table 5.0 Requirements for entry to specialist programmes at Northumbria University. Source Northumbria University (2013e)

When the entry requirements were reviewed via the course search function on the Northumbria web page it was interesting to note that the academic level of a 2:2, 2:1 or 1st was the same for each programme, but the language used to describe the classification was different in every case as shown in Table 5.0.

From an external point of view and as a potential student this would be viewed more professionally if the same language were used consistently and there would be no chance for any misunderstanding by any potential applicant. When reviewing the correct terminology to use, it was noted that many different institutions tend to use their own language and there does not appear to be a standard. Nottingham University (2013) for example use the terms $\mathrm{I}, \mathrm{II}-1, \mathrm{II}-2$ and III to represent the classifications whilst MMU (2013b) use the terms ‘First class’, ‘Class two, Division one (Upper second)’, ‘Class two, Division two (Lower second)’ and ‘Third class’. There does not appear to be any defined standard but the QAA (2009) published a paper by Mantz Yorke looking at classifications and used the terminology ‘First’, ‘2:1’, ‘2:2’ and ‘Third’ which appears to be one of the more common formats used. To reduce misunderstanding, Northumbria University (2012) use a combination of them all in their Assessment Regulations for Northumbria Awards (ARNA); ‘First’, ‘Second Class Honours Upper Division (2.1)’, ‘Second Class Honours Lower Division (2.2)’ or ‘Third’. The author would recommend that whatever method is used there should be some consistency in the language used.

The English language level that is asked for entry onto the identified specialist Master’s programmes is consistent with Northumbria University policy and the same as what is asked for on the general English language web page (Northumbria University, 2013d). These English language levels were proposed by a subcommittee of University Learning and Teaching (ULT) committee, with experience of working with international students and endorsed by ULT. This also complies with the minimum requirements laid down by the UKBA (2012).

5.1.1.1 Comments on extra requirements at Northumbria University

As these are specialist programmes, apart from the level of the pre-entry award, there is an extra requirement for each of the programmes, which narrows down the number of individuals that can apply for any of the programmes. In the author's view, the only programme which provides sufficient information in detail for an applicant to apply is the MSc in Computer Science, which is very specific about the underpinning knowledge that will be required to study the programme. However when prospective students do apply, each application is looked at on an individual basis to determine if they have studied the appropriate underpinning programme which includes the extra requirements listed below. This is specific to each programme and was provided by the programme leader based on their experience of previous students. In the author's view this should also be included in the requirements on the appropriate web page. The extra requirements are as listed in Table 5.1.

Programme	Extra requirements.
MSc Mechanical Engineering	Students should have a sound knowledge of a 3D solid modelling package such as Solidworks, or Pro Engineer and have experience of producing assemblies, Finite Element Analysis and Computational Fluid Dynamics.
MSc Electrical Power Engineering	Students are required to have studied heavy current modules in the final year such as DC Machines and Power Distribution or Electronics.
MSc Microelectronics and Communications Engineering	Students are required to have studied Digital Signal Processing and Communications in their final year of study.
MSc Computer Network Technology	Students are required to have studied Networking modules in their final year of study or hold professional qualifications such as Cisco Certified Network Associate or Microsoft Network.
MSc Computer Science	Students are expected to have studied Programming in an Object Orientated Language (ideally Java), System Analysis and Design, Databases (ideally Oracle or similar) and Computer Operating Systems and Networks

Table 5.1 Extra requirements for applications at Northumbria University

5.1.2 Entry requirements at competitor set of Universities

The Universities that were identified within the competitor set were chosen because they all had some similarity with Northumbria in terms of student numbers, turnover, student mix etc.. They are listed in Table 5.2.

Competitor University	Type of University
City University	Pre 1992
Greenwich University	Post 1992
Hull University	Pre 1992
Salford University	Pre 1992
Brighton University	Post 1992
Hertfordshire University	Post 1992
Kingston University	Post 1992
Liverpool John Moores University	Post 1992
London Metropolitan University	Post 1992
Manchester Metropolitan University	Post 1992
Middlesex University	Post 1992
Nottingham Trent University	Post 1992
Oxford Brookes University	Post 1992
Plymouth University	Post 1992
Sheffield Hallam University	Post 1992
University of Central Lancashire	Post 1992
University of the West of England	Post 1992
Westminster University	Post 1992

Table 5.2 Table showing types of institution in competitor set

Altogether there are eighteen institutions and three (16.7%) of them are Pre 92, whilst the remaining fifteen (83.3%) are Post 92. The individual web pages of each institution, for the similar courses identified, were checked for academic and English requirements and any other extra information that was relevant to gaining entry to the programme. This was carried out during the period of March to May 2010.

5.1.2.1 Academic requirements at competitor universities on similar programmes

When checking the academic requirements it was noticed that different terminology was used as described in 5.1.1.1 above but several institutions also used the term "Good Honours" representing a First or 2:1 as defined by the QAA (2013).

University	Entry qualification	University type
Northumbria	**2:2**	**Post 92**
Brighton	Good Honours	Post 92
City	2:2	Pre 92
Greenwich	2:2	Post 92
Hertfordshire	2:2 / Good Honours	Post 92
Hull	2:1	Pre 92
Kingston	Good Honours	Post 92
LJMU	Honours degree	Post 92
London Metropolitan	Good Honours	Post 92
Manchester Metropolitan	2:2	Post 92
Middlesex	2:2	Post 92
Nottingham Trent	Honours degree	Post 92
Oxford Brookes	2:2	Post 92
Plymouth	2:2	Post 92
Salford	2:2	Pre 92
Sheffield Hallam	2:2 /2:1	Post 92
UCLAN	Good Honours	Post 92
UWE	Good Honours	Post 92
Westminster	2:2 / Good Honours	Post 92

KEY:

(blue)	11% (2)	Lower than Northumbria
(red)	50% (9)	Higher than Northumbria
(green)	39% (7)	Same as Northumbria

Table 5.3 Summary of academic entry requirements for competitor universities offering similar programmes

As can be seen from Table 5.3 only 39% (7) of the competitor universities have the same academic entry requirements in terms of classification, whilst 50% (9) ask for a higher classification and 11% (2) ask for a lower classification[1]. Of the three Pre 92 institutions in the competitor set, Salford and City ask for the same as Northumbria and Hull ask for a higher classification.

Table 5.4 includes all the programmes that were investigated and are grouped together by similar programme.

[1] Where an institution has asked for different levels on different programmes the higher level has been used.

University	Programme	Entry Qualification	Comments
Northumbria	**MSc Computer Network Technology**	**2:2**	
Sheffield Hallam	MSc Computer and Network Engineering	2:2	
Manchester Metropolitan	MSc Computer Network Technology	2:2	
Greenwich	MSc Computer Networking	2:2	
London Metropolitan	MSc Computer Networking	2:2	
Hertfordshire	MSc Computer Networking Principles and Practice	Good Honours	
Middlesex	MSc Computer Networks	2:2	
Plymouth	MSc Network Systems Engineering	2:2	
UCLAN	MSc Networking	Good Honours	
Kingston	MSc Networking and data communications	Good Honours	
Sheffield Hallam	MSc Networking Professional	Good Honours	
Westminster	MSc Computer Networks and Distributed Systems	Good Honours	

Northumbria	**MSc Computer Science**	**2:2**	
Brighton	MSc Computer Science	Good Honours	
Hertfordshire	MSc Computer Science	Good Honours	
Hull	MSc Computer Science	Good Honours	
London Metropolitan	MSc Computer Science	2:1	
Middlesex	MSc Computer Science	2:2	
Nottingham Trent	MSc Computer Science	Honours Degree	
Oxford Brookes	MSc Computer Science	2:2	
Plymouth	MSc Computer Science	2:2	
Salford	MSc Computer Science	2:2	
Westminster	MSc Advanced Computer Science	Good Honours	
Brighton	MSc Computing	Good Honours	
Greenwich	MSc Computing	Good Honours	
London Metropolitan	MSc Computing	Good Honours	
Oxford Brookes	MSc Computing	2:2	
UCLAN	MSc Computing	Good Honours	
Greenwich	MSc Computing and Information Systems	Good Honours	
LJMU	MSc Computing and Information Systems	Degree	
Nottingham Trent	MSc Computing Systems	Honours Degree	
Manchester Metropolitan	MSc Computing	2:2	
Sheffield Hallam	MSc Information Technology	2:1	
UWE	MSc Information Technology	Good Honours	
Westminster	MSc Software Engineering	2:2	

Northumbria	**MSc Microelectronics and Comm's Engineering**	**2:2**	
Greenwich	MSc Electrical and Communications Engineering	2:2	
Manchester Metropolitan	MSc Electrical and Electronic Engineering	2:2	
Hull	MSc Electronic Engineering	2:1	
Hertfordshire	MSc Advanced Digital Systems	2:2	

Plymouth	MSc Communications Eng. and Signal Processing	2:2	
Salford	MSc Data Telecommunications and Networks	2:2	
Brighton	MSc Digital Electronics and Communications	Good Honours	
LJMU	MSc Microelectronic System Design	Honours Degree	
Oxford Brookes	MSc Mobile and HS Telecommunication Networks	2:2	

Northumbria	**MSc Electrical Power Engineering**	**2:2**	
Greenwich	MSc Electrical Power Engineering	2:2	
LJMU	MSc Power and Control Engineering	Honours Degree	

Northumbria	**MSc Mechanical Engineering**	2:2	
Greenwich	MSc Mechanical and Manufacturing Engineering	2:2	
City	MSc Mechanical Engineering	2:2	
Kingston	MSc Mechanical Engineering	Good Honours	
Manchester Metropolitan	MSc Mechanical Engineering	2:2	
UWE	MSc Mechanical Engineering	Degree in Mech. Eng.	
Sheffield Hallam	MSc Advanced Mechanical Engineering	2:2	India 1st Class; China 4yr 80%+

KEY:

(blue)	12% (6)	Lower than Northumbria
(red)	40% (20)	Higher than Northumbria
(green)	48% (24)	Same as Northumbria

Table 5.4 Academic level entry requirements sorted by similar programme

Altogether fifty different programmes were identified across the eighteen institutions but not all institutions offered all of the programmes. Some programmes were offered with slightly different titles at the same institution where there appeared to be little difference in the programme content. Also depending on the programme, some institutions asked for different entry classifications such as at London Metropolitan where a 2:2 was asked for in Computer Networking and Good Honours (1^{st} or 2:1) for Computer Science. Conversely Westminster asked for Good Honours (1^{st} or 2:1) for Computer Networks and Distributed Systems and asked for a 2:2 in Software Engineering. There does not appear to be any reason for this and there is insufficient information available on the website to draw any conclusions. This could be down to individual departments making their own judgements or even the information on the web not being up to date. It is also interesting to note that Sheffield Hallam differentiate the requirements for Indian and Chinese students and ask for much higher than the perceived equivalent of a UK 2:2 degree. The University of West of England also lower their requirements to a 'Degree in Mechanical Engineering' to study their MSc Mechanical Engineering programme, rather than a 'Good Honours' but they are very specific about the subject that the degree has to be in. The results by programme are shown below in Table 5.5.

		Academic Entry Qualification		
University	Programme	Lower	Same	Higher
Northumbria	MSc Computer Network Technology	0%	55%	45%
Northumbria	MSc Computer Science	13%	32%	55%
Northumbria	MSc Microelectronics and Communications Engineering	11%	67%	22%
Northumbria	MSc Electrical Power Engineering	50%	50%	0%
Northumbria	MSc Mechanical Engineering	17%	66%	17%
	Average	12%	48%	40%

Table 5.5 Summary of competitor set academic entry qualifications by programme

In terms of academic entry requirements Northumbria do not appear to be doing anything different in terms of process to the competitor institutions although the classifications asked for do vary. For the similar programmes offered, 12% ask for a lower classification and 40% ask for a higher classification. In general none of them ask for any more specific information in the subject area than Northumbria.

5.1.2.2 English requirements at competitor universities on similar programmes

When checking the English level requirements it was noted that without exception the level was given initially in IELTS and then offered in equivalents such as TOEFL, Pearson etc.. The summary by institution is shown in Table 5.6.

University	English requirements	University type
Northumbria	**6.5**	**Post 92**
Brighton	6.0 / 6.5	Post 92
City	6.5	Pre 92
Greenwich	6.0	Post 92
Hertsfordshire	6.0	Post 92
Hull	6.0	Pre 92
Kingston	6.5	Post 92
LJMU	6.0	Post 92
London Metropolitan	6.0	Post 92
Manchester Metropolitan	6.5	Post 92
Middlesex	6.5	Post 92
Nottingham Trent	6.5	Post 92
Oxford Brookes	6.0	Post 92
Plymouth	6.5	Post 92
Salford	6.5	Pre 92
Sheffield Hallam	6.0 / 6.5	Post 92
UCLAN	6.5	Post 92
UWE	6.5	Post 92
Westminster	6.5	Post 92

KEY:

(blue)	44% (8)	Lower than Northumbria
(red)	0%	Higher than Northumbria
(green)	56% (10)	Same as Northumbria

Table 5.6 Summary of English entry requirements for competitor universities offering similar programmes

From the table it can be seen that 56% (10) of the competitor universities ask for the same English level as Northumbria whilst 44% (8) ask for lower levels. It is interesting to note that both Brighton and Sheffield Hallam ask for a different level depending on the particular programme. The English level by programme is shown in Table 5.7.

University	Programme	English	Comments
Northumbria	**MSc Computer Network Technology**	**6.5**	
Sheffield Hallam	MSc Computer and Network Engineering	6.0	
Manchester Metropolitan	MSc Computer Network Technology	6.5	
Greenwich	MSc Computer Networking	6.0	
London Metropolitan	MSc Computer Networking	6.0	5.5 or above in all components

Hertfordshire	MSc Computer Networking Principles and Practice	6.0	
Middlesex	MSc Computer Networks	6.5	6.0 minimum in all components
Plymouth	MSc Network Systems Engineering	6.5	Min 5.5 in writing
UCLAN	MSc Networking	6.5	6.0 minimum in all components
Kingston	MSc Networking and data communications	6.5	
Sheffield Hallam	MSc Networking Professional	6.0	
Westminster	MSc Computer Networks and Distributed Systems	6.5	

Northumbria	**MSc Computer Science**	**6.5**	
Brighton	MSc Computer Science	6.5	6.0 in writing
Hertfordshire	MSc Computer Science	6.0	
Hull	MSc Computer Science	6.0	
London Metropolitan	MSc Computer Science	6.0	5.5 or above in all components
Middlesex	MSc Computer Science	6.5	6.0 minimum in all components
Nottingham Trent	MSc Computer Science	6.5	
Oxford Brookes	MSc Computer Science	6.0	
Plymouth	MSc Computer Science	6.5	Min 5.5 in writing
Salford	MSc Computer Science	6.5	Min 5.5 in any band
Westminster	MSc Advanced Computer Science	6.5	
Brighton	MSc Computing	6.5	6.0 in writing
Greenwich	MSc Computing	6.0	
London Metropolitan	MSc Computing	6.0	5.5 or above in all components
Oxford Brookes	MSc Computing	6.0	
UCLAN	MSc Computing	6.5	6.0 minimum in all components
Greenwich	MSc Computing and Information Systems	6.0	
LJMU	MSc Computing and Information Systems	6.0	
Nottingham Trent	MSc Computing Systems	6.5	
Manchester Metropolitan	MSc Computing	6.5	
Sheffield Hallam	MSc Information Technology	6.5	
UWE	MSc Information Technology	6.5	
Westminster	MSc Software Engineering	6.5	

Northumbria	**MSc Microelectronics and Comm's Engineering**	**6.5**	
Greenwich	MSc Electrical and Communications Engineering	6.0	
Manchester Metropolitan	MSc Electrical and Electronic Engineering	6.5	
Hull	MSc Electronic Engineering	6.0	
Hertfordshire	MSc Advanced Digital Systems	6.0	
Plymouth	MSc Communications Eng. and Signal Processing	6.5	Min 5.5 in writing
Salford	MSc Data Telecommunications and Networks	6.5	Min 5.5 in any band
Brighton	MSc Digital Electronics and Communications	6.0	5.0 in writing
LJMU	MSc Microelectronic System Design	6.0	
Oxford Brookes	MSc Mobile and HS Telecommunication Networks	6.0	

Northumbria	**MSc Electrical Power Engineering**	**6.5**	

Greenwich	MSc Electrical Power Engineering	6.0	
LJMU	MSc Power and Control Engineering	6.0	

Northumbria	**MSc Mechanical Engineering**	**6.5**	
Greenwich	MSc Mechanical and Manufacturing Engineering	6.0	
City	MSc Mechanical Engineering	6.5	
Kingston	MSc Mechanical Engineering	6.5	
Manchester Metropolitan	MSc Mechanical Engineering	6.5	
UWE	MSc Mechanical Engineering	6.5	
Sheffield Hallam	MSc Advanced Mechanical Engineering	6.0	

KEY:

	48% (24)	Lower than Northumbria
	0%	Higher than Northumbria
	52% (26)	Same as Northumbria

Table 5.7 English level entry requirements sorted by similar programme

From Table 5.7 above it can be seen that 52% (26) of the programmes ask for the same IELTS level as Northumbria and 48% (24) ask for a lower level. It is worth noting the comments against some programmes asking for extra criteria in the IELTS score. The overall score is made up of an average given for four components; Reading, Writing, Speaking and Listening. Some institutions such as UCLAN ask for a minimum of 6.0 in all components and an average of 6.5, placing the same importance on all components. However some institutions such as Brighton and Plymouth ask for a minimum in the writing component only. This would imply that they see the writing component as more important than the other three. Since most PG programmes require a dissertation counting for one third of the programme, then the writing skills are particularly important. The results of English level by programme are shown in Table 5.8. From Table 5.8 it can be seen that the English entry qualifications vary by programme. It can be said that just under half of the similar programmes that are offered by the competitor set of universities ask for a lower IELTS score. The MSc Electrical Power Engineering is offered at a lower level of English by the competitor set of universities that offer the programme.

		English Entry Qualification		
University	Programme	Lower	Same	Higher
Northumbria	MSc Computer Network Technology	45% (5)	55% (6)	0%
Northumbria	MSc Computer Science	41% (9)	59% (13)	0%
Northumbria	MSc Microelectronics and Comm's Engineering	67% (6)	33% (3)	0%
Northumbria	MSc Electrical Power Engineering	100% (2)	0%	0%
Northumbria	MSc Mechanical Engineering	33% (2)	67% (4)	0%
	Average	**48%**	**52%**	**0%**

Table 5.8 Summary of competitor set English entry qualifications by programme

Twice as many of the institutions that offer the equivalent of the MSc Microelectronic and Communications Engineering programme do so at a lower level of IELTS. Where a single institution asks for different levels of English there does not appear to be any obvious rationale why this is done.

5.1.2.3 Summary of analysis of academic and English requirements at competitor universities

In general it appears that Northumbria is not doing anything different to any other institution when it comes to specifying the academic and English requirements of students for specialist programmes. Some institutions ask for one classification higher and some institutions look for two classifications lower. None of them ask for anything more than a degree in a cognate area and none of them ask for anything like the detail that Northumbria do for their Computer Science programme which is very specific. There are perceived benefits in asking for a higher classification since if the student has achieved more at UG level then they should be able to do better at PG level (Alias & Zain, 2006). In terms of marketing, when students are difficult to recruit, it does preclude all of the market that has the lower classification. It is interesting to note that Hull ask for a higher classification of degree than Northumbria for the computer science Master’s but a lower level of English. These are the advertised levels, but as the market becomes more competitive it is not known what actually happens in practice.

The English levels at Northumbria are laid down by University Learning and Teaching committee and are adhered to by all departments. There has been some discontent within individual departments regarding the English levels defined, as they make recruitment difficult when some of their major competitors have lower levels. General consensus within some of the departments is that the academic ability of the student on entry has a greater impact on the success of the student journey and this has also been confirmed in previous research (Cownie & Addison, 1996; Hooley & Horspool, 2006). Seelen (2002) also had similar reservations and asked for a study to be carried out to slowly reduce the English language level for entry and monitor academic results, whilst Light et al. (1987) found in their study that, in general, students that had 50 TOEFL (approximately 1.0 IELTS) points less than the entry level actually performed better than those meeting the exact entry standard. Cownie & Addison (1996) concluded "*that only 17% of institutions which lay down a particular standard of language proficiency for their international students are thought by our respondents to stick rigidly to that standard".* Another problem that can cause confusion is that many institutions use 'equivalents' to IELTS such as TOEFL, Test of English in Communication (TOEIC) and two years of previous study in the English Language. The TOEIC test taken at a College in London was recently exposed in a BBC Panorama programme as part of the systematic fraud of the student visa system, where the test was taken by a 'fake sitter' (Watson, 2014). These types of activities do not help the credibility of the English tests or the value of them when using them for access to a University. With the introduction of the tier 4 visa (UKBA, 2011a) and a minimum requirement for IELTS 5.5 across all components, then there will be greater controls in the future. Since there are mixed views to support the use of IELTS as a predictor of academic performance, can Northumbria be satisfied that they have made the correct decision when using the values they have specified, when other institutions use a lower value? There is already a precedent set with a variation order at Northumbria for recruitment to some UG programmes that are more analytical and require less discursive type assessment. This decision can have a huge impact on the size of the market that is available for recruitment and it is suggested that the entry levels for English be reviewed in light of these findings.

5.2 Results from investigating what knowledge students are expected to have in order for them to succeed on specialist Master's programmes

As discussed in section 4.7.2 the Programme Leaders and Module Tutors were asked to provide twenty questions that in their expert opinion UG students should be able to answer and would test underpinning knowledge that was required to enter the programme. The author spent some time with the Programme Leaders and Module Tutors facilitating the process but did not offer any technical expertise. Twenty questions for each of the four following programmes were provided:

1. MSc Mechanical Engineering
2. MSc Electrical Power Engineering
3. MSc Microelectronics and Communications Engineering
4. MSc Computer Network Technology

The details of the process for MSc Mechanical Engineering is shown below and the final information for the other programmes are shown in Appendix 4.

5.2.1 Questions for MSc Mechanical Engineering

The MSc Mechanical Engineering programme is made up of 180 credits as shown in Table5.9.

<table>
<tr><th>SEMESTER 1</th><th>SEMESTER 2</th><th>SEMESTER 3</th></tr>
<tr><td>EN0506
Advanced Dynamics and Vibration
10 credits</td><td rowspan="2">EN0718
Computer Aided Methods for Engineers
20 Credits</td><td rowspan="6">EN0542
Dissertation
60 Credits</td></tr>
<tr><td>EN0507
Computational Fluid Dynamics
10 credits</td></tr>
<tr><td>EN0510
Solid Modelling and Prototyping
10 credits</td><td rowspan="2">EN0721
Engineering Design
20 credits</td></tr>
<tr><td>EN0535
Engineering Data Analysis
10 credits</td></tr>
<tr><td>EN0536
Materials Process Modelling
10 credits</td><td>ME0088
Advanced Stress Analysis
10 credits</td></tr>
<tr><td colspan="2">IS0749
Research Methods and Project management
20 Credits</td></tr>
</table>

Table 5.9 Structure of MSc Mechanical Engineering programme

The structure shown above was for students with Semester 1 starting in September 2011. Since some of the modules in the programme are classed as ‘broadening’ modules (IS0749, EN0718, EN0721, EN0535) the Programme Leader provided some fundamental knowledge questions and then the Module Tutors provided questions based on the knowledge expected to study the modules that were classed as ‘deepening’ modules (EN0506, EN0507, EN0510, EN0536, ME0088). The dissertation would then give the student the opportunity to carry out research and deepen their learning further in one of the technical areas. According to the Institution of Mechanical Engineers (IMechE) broadening modules “*will typically develop a graduate’s knowledge such that he/she has a comprehensive* *understanding of techniques and/or methodologies applicable to their own work*"

whereas a deepening module

> "*will typically develop a graduate's knowledge such that he/she has a systematic and conceptual understanding of knowledge in specialised/applied areas and across areas and can work with theoretical/research-based knowledge at the forefront of their academic discipline*" (IMechE, 2012).

The breakdown of questions was submitted as shown in Table 5.10.

Module	Module type	Number of questions
EN0506	Deepening	2 (13,14)
EN0507	Deepening	2 (19,20)
EN0510	Deepening	2 (17,18)
EN0535	Broadening	2 (6,8)
EN0536	Deepening	2 (15,16)
EN0718	Broadening	0
EN0721	Broadening	1 (7)
ME0088	Deepening	2 (9,10)
IS0749	Broadening	0
Fundamental		7 (1-5,11,12)

Table 5.10 Breakdown of questions provided for MSc Mechanical Engineering programme

There were no questions provided for EN0718 or IS0749. EN0718 is a module that allows students to critically analyse a choice of engineering problems using different software packages and is very diverse depending on the problem and software package chosen. IS0718 is a research methods and project management module providing the skills to carry out the dissertation. The finalised test paper that was issued to the students can be found in Appendix 5. The test papers for the remaining programmes can be found in Appendices 6-8.

5.2.2 Summary of results when investigating what knowledge students are expected to have in order for them to succeed on specialist Master's programmes

Although guidance had been given to the Programme Leaders and Module Tutors regarding the structure of the test paper and the questions, they all came back with slightly different formats, but in their expert opinion they supplied questions that were a mix of fundamental questions and specific questions which they thought the students should be able to answer. In general they all provided questions for the deepening modules within each of the programmes where prior propositional knowledge was deemed the most important. The broadening modules were not seen as so important, as much of the material would be new knowledge with a recap at the beginning of the module. This would appear to be a reasonable conclusion since 40 credits of broadening material was common between three programmes of different disciplines, indicating that no specific prior knowledge was expected.

5.3 Confirmation of lecturing staff expectations of students graduating from UG programmes that act as feeders for the specialist PG programmes

As discussed in 4.7.2.1 the finalised papers were given to the graduating UG students to complete. Once the test papers had been marked the final percentages, by programme, were analysed using SPSS (version 21). Since the data provided were of the "*interval/ratio or continuous type*" (Bryman & Bell, 2003, p357) then the most useful features to investigate were the "*location, spread and symmetry*" (Easterby-Smith et al., 2008, p251). The results are shown in Table 5.11. The Computer and Network Technology and Electrical and Electronic Engineering Light

Current programmes both have small N (10, 11) so care must be taken when reading the statistical analysis.

		Mechanical Engineering	EEE Heavy Current	EEE Low Current	Computer and Network Technology
N	Valid	38	29	11	10
	Missing	0	0	0	0
Mean		55.00	64.31	60.91	73.50
Median		57.50	65.00	60.00	72.50
Mode		50[a]	70	40[a]	65[a]
Std. Deviation		12.945	12.728	13.751	9.443
Variance		167.568	162.007	189.091	89.167
Skewness		-.661	-.365	-.302	.416
Std. Error of Skewness		.383	.434	.661	.687
Kurtosis		-.087	-.691	-1.006	-.569
Std. Error of Kurtosis		.750	.845	1.279	1.334
Range		50	45	40	30
Minimum		25	40	40	60
Maximum		75	85	80	90
Percentiles	25	50.00	57.50	50.00	65.00
	50	57.50	65.00	60.00	72.50
	75	65.00	72.50	75.00	81.25

a. Multiple modes exist. The smallest value is shown

Table 5.11 Descriptive statistics from the UG test results

The descriptive statistics show that the data are generally Normally distributed since the skewness is between plus one and minus one (Robson, Pemberton, & McGrane, 2008) showing a reasonable level of symmetry and the kurtosis is small but negative giving a slightly platykurtic (less peaked than the Normal distribution) effect (NIST/SEMATECH, 2012). The median and mean in all cases are very similar which is also an indicator that the distribution is generally symmetrical and Normally distributed (Collis & Hussey, 2003).

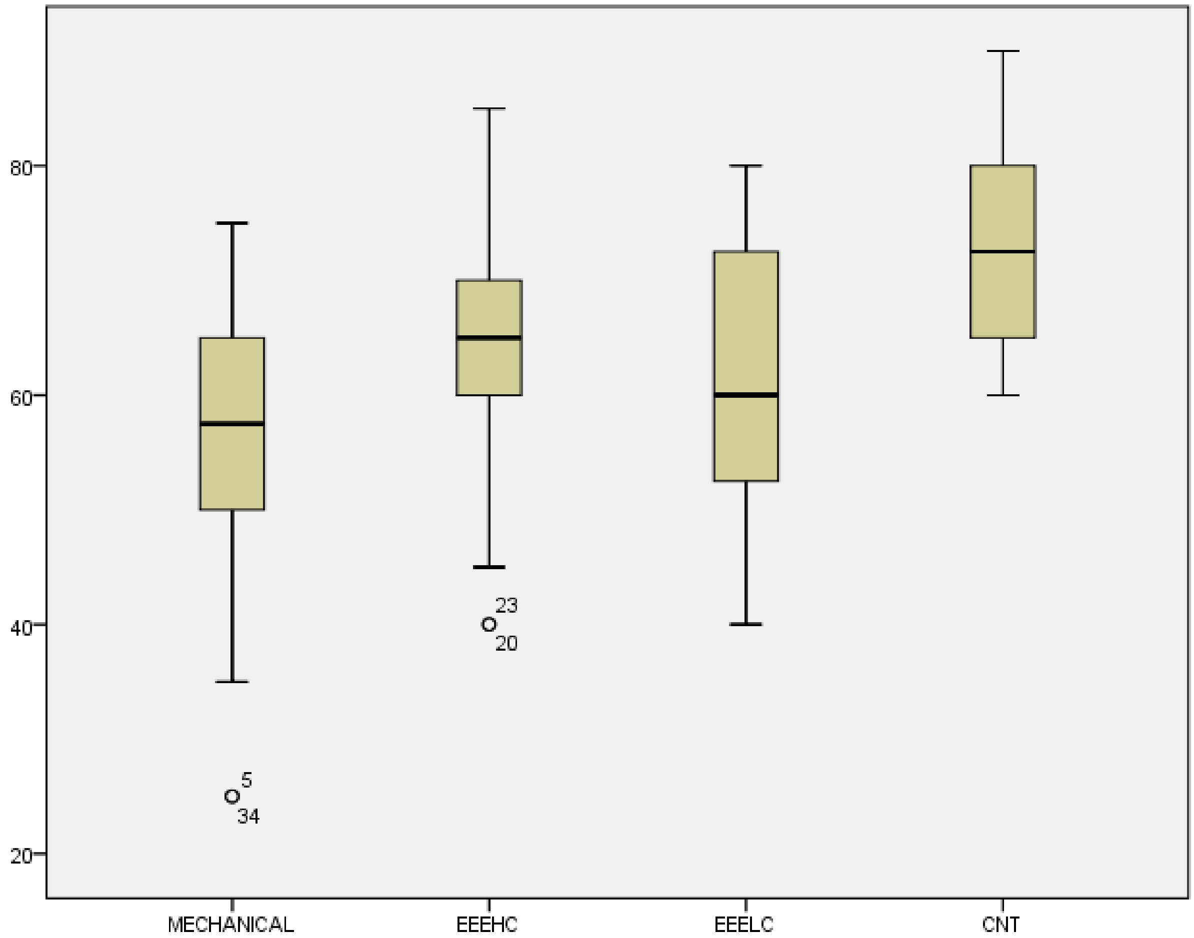


Figure 5.0 Boxplot of UG programme test results

The box plot shown in Figure 5.0 also gives a good indication that the data is generally symmetrical with a slight negative skew on the Mechanical, EEELC and EEEHC whilst the CNT has a slight positive skew. On inspecting the Q-Q plots below in Figure 5.1 it can also be seen that the distributions are approaching Normal as the points do not deviate far from the line. The distributions are being compared with a Normal distribution in this instance and if the points were to deviate away from the Normal line this would suggest that the distribution was not Normal.

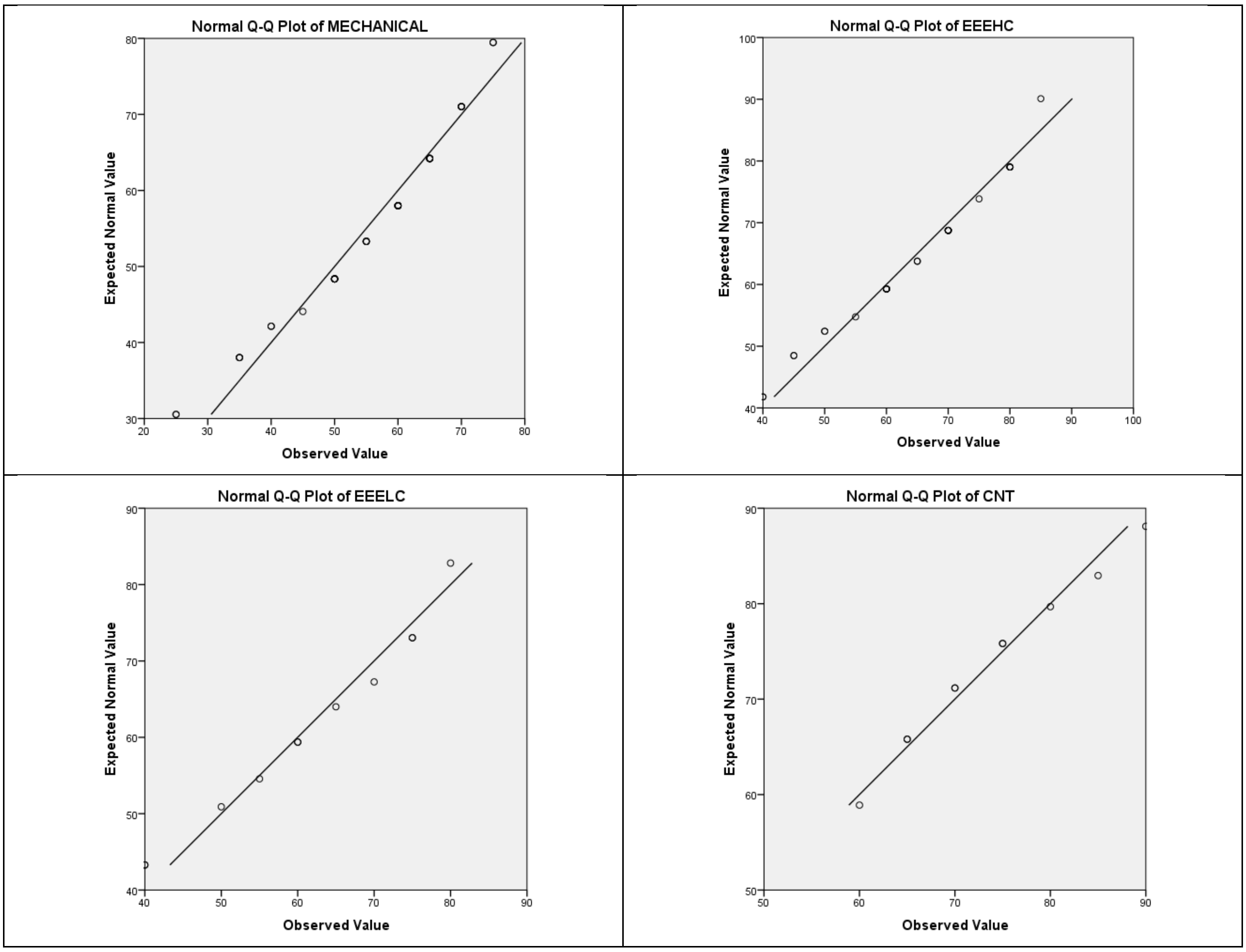


Figure 5.1 Normal Q-Q plots of all four tests

The pass rate for each of the tests was variable with 78.9% for Mechanical, 81.8% for EEELC, 86.2% for EEEHC and 100% for the CNT. As part of the CNT programme, the students also work towards achieving the Cisco Certified Network Associate (CCNA) qualification and the majority of this assessment is through the use of external MCQ tests. Therefore, the CNT students are familiar with this type of knowledge testing, which could have given them an advantage over the other three groups.

5.3.1 Descriptive statistics by question

In order to confirm the expectations of the Programme Leaders and Module Tutors it was necessary to analyse the results to look for variability in the scores for each question. The Programme Leaders had suggested that they would expect students to get at least 50% in the test and this is also the pass mark at MSc level. The pass mark of fifty percent was also used by Robinson and Croft (2003) when carrying out diagnostic testing in mathematics. The mean in all the tests was above this mark although each cohort differed with the Mechanical students the lowest at 55.0% and CNT students the highest at 73.5%. Any individual questions that scored less than 50% were reported back to the Programme Leaders since the majority of students had got the answer wrong.

5.3.1.1 Descriptive statistics by question for UG Mechanical Engineering students taking the MSc Mechanical Engineering test

The outcome for each question is shown in Table 5.12 and graphically in Figure 5.2.

Module	Module type	Question numbers	Percentage correct
EN0506	Deepening	(13,14)	(10.5, 76.3)
EN0507	Deepening	(19,20)	(65.8, 89.5)
EN0510	Deepening	(17,18)	(60.5, 60.5)
EN0535	Broadening	(6,8)	(5.3, 5.3)
EN0536	Deepening	(15,16)	(89.5, 21.1)
EN0721	Broadening	(7)	(65.8)
ME0088	Deepening	(9,10)	(84.2, 86.8)
Fundamental		(1-5,11,12)	(44.7, 50.0, 23.7, 73.7, 78.9, 34.2, 73.7)

Table 5.12 Results from individual questions for UG Mechanical Engineering students taking the MSc Mechanical Engineering test

Overall the students failed to score more than fifty percent on seven of the twenty questions. Three of the questions were classed as fundamental and two in the deepening modules. The statistic providing the most concern is the knowledge expected for the Engineering Data Analysis module (EN0535) where knowledge expectations are very different with a score of 5.3% which represents only 2 students from the cohort of 38 providing the correct answer.

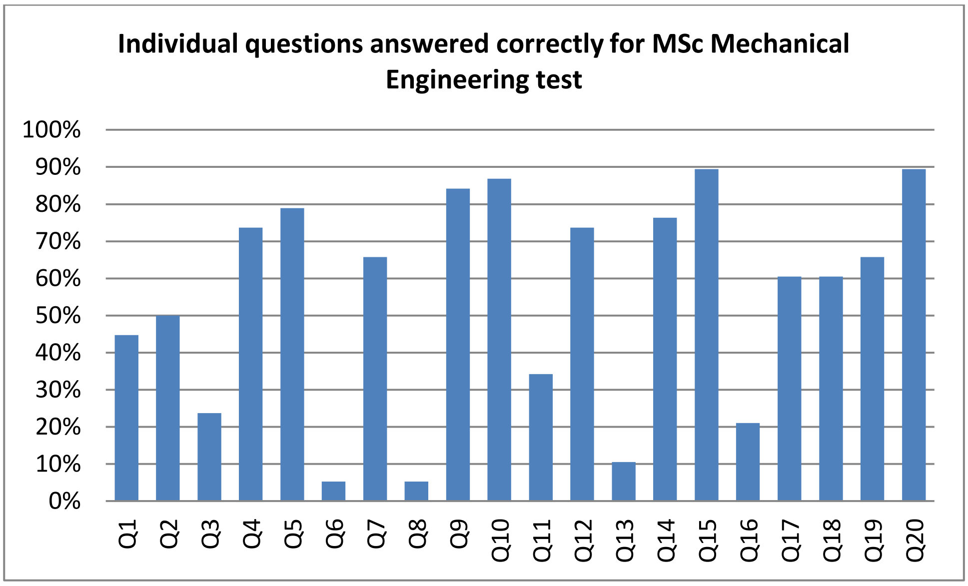


Figure 5.2 Results from individual questions for UG Mechanical Engineering students taking the MSc Mechanical Engineering test

5.3.1.2 Descriptive statistics by question for EEE Heavy Current students taking the Electrical Power Engineering test

The outcome for each question is shown in Table 5.13 and graphically in Figure 5.3.

Module	Module type	Question numbers	Percentage correct
EN0711	Deepening	(9,11,17,18)	(65.5, 27.6, 82.8, 82.8)
EN0712	Deepening	(10,12,19,20)	(65.5, 27.6, 79.3, 69.0)
EN0550	Deepening	(13-16)	(13.8, 51.7, 72.4, 75.9)
Fundamental		(1-8)	(86.2, 93.1, 41.4, 93.1, 55.2, 37.9, 100, 65.5)

Table 5.13 Results from individual questions for EEE Heavy Current students taking the MSc Electrical Power Engineering test

Overall the students scored less than fifty percent on three of the deepening questions with one per module and two of the fundamental questions.

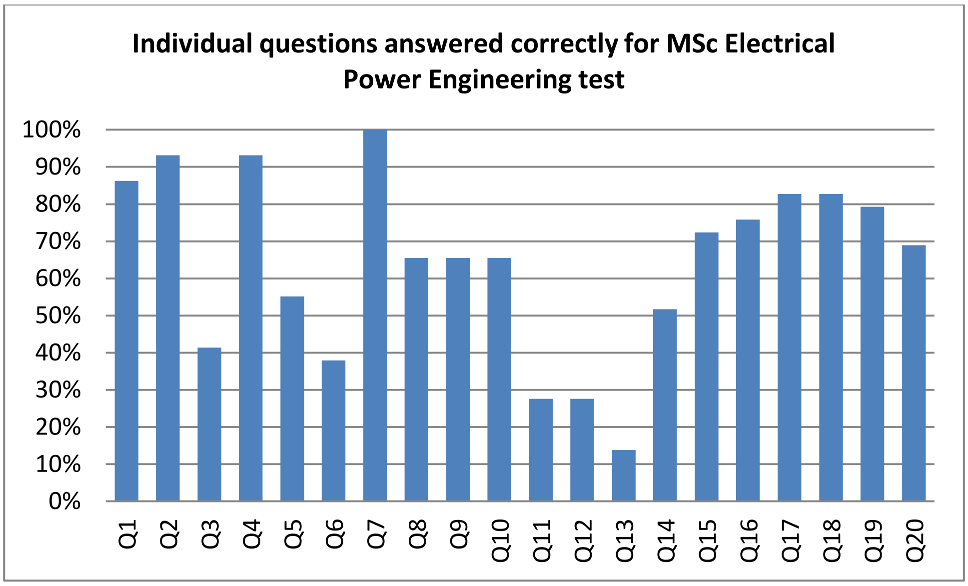


Figure 5.3 Results from individual questions for EEE Heavy Current students taking the MSc Electrical Power Engineering test

5.3.1.3 Descriptive statistics by question for UG EEE Light Current students taking the MSc Microelectronics and Communication Engineering test

The outcome for each question is shown in Table 5.14 and graphically in Figure 5.4.

Module	Module type	Question numbers	Percentage correct
EN0719	Deepening	(15-19)	(45.5, 27.3, 54.5, 27.3, 72.7)
EN0722	Deepening	(6-9)	(100, 27.3, 81.8, 54.5)
EP0191	Deepening	(1-4)	(100, 18.2, 100, 81.8)
Fundamental		(5, 10-14, 20)	(54.5, 63.6, 9.1, 81.8, 100, 90.9, 27.3)

Table 5.14 Results from individual questions for UG EEE Light Current students taking the MSc Microelectronics and Communication Engineering test

Overall the students scored less than 50% on five of the deepening questions and two fundamental questions. Three of the five questions for module EN0719 were less than 50% which suggested that the students had a different level of knowledge compared to that which was expected by the Module Tutor and Programme Leader.

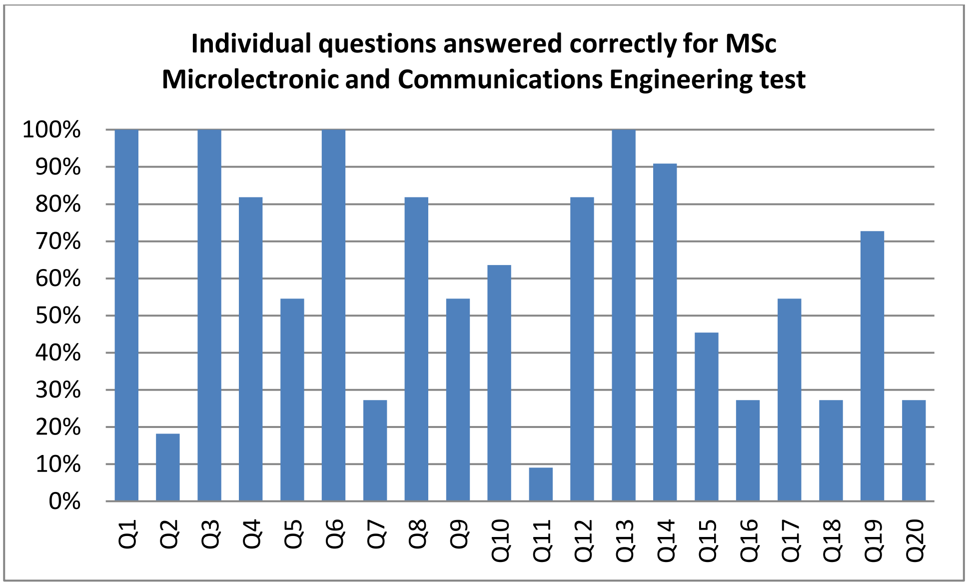


Figure 5.4 Results from individual questions for UG EEE Light Current students taking the MSc Microelectronics and Communication Engineering test

5.3.1.4 Descriptive statistics by question for UG CNT students taking the MSc CNT test

The outcome for each question is shown in Table 5.15 and graphically in Figure 5.5.

Module	Module type	Question numbers	Percentage correct
EN0714	Deepening	(8, 9, 17, 18)	(80,90,90,90)
EN0715	Deepening	(10,11,12, 20)	(100, 90, 40, 50)
EN0716	Deepening	(3-6)	(90, 40, 80, 100)
EN0717	Deepening	(13-16)	(100, 10, 40, 70)
Fundamental		(1, 2, 7, 19)	(90, 30, 90, 100)

Table 5.15 Results from individual questions for UG CNT students taking the MSc Computer Network Technology test

Overall the students scored less than fifty percent on four of the deepening questions and one fundamental question. Question fourteen which was related to the module Building Cisco Multilayer Switched Networks (EN0717) was particularly low with only one student getting the correct answer.

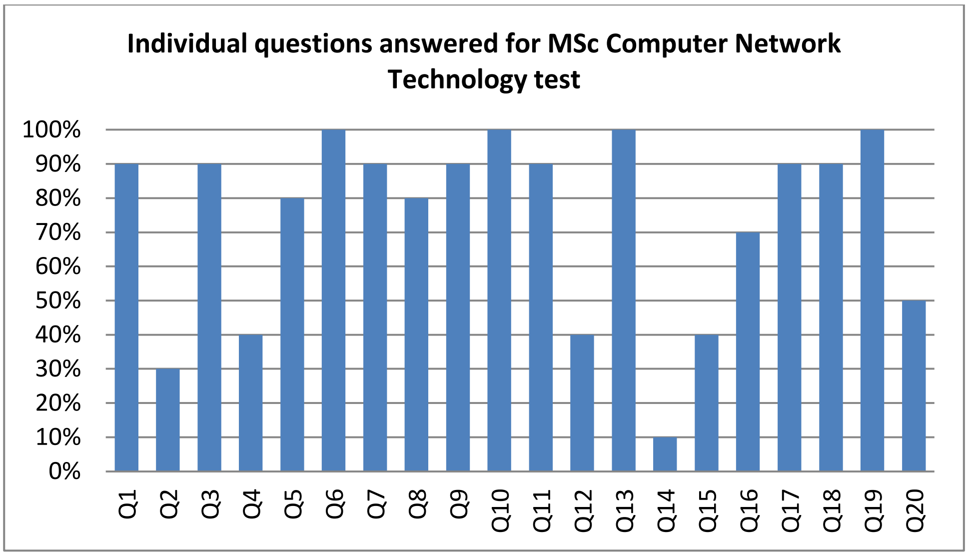


Figure 5.5 Results from individual questions for UG CNT students taking the MSc Computer Network Technology test

5.3.1.5 Summary of individual question statistics

Since the tests, students and programmes were all different it is not possible to compare the results directly, but it is fair to say that in general the CNT students were better prepared to answer the questions set in the test. They achieved a mean score of 73.5% with a 100% pass rate, compared to the Mechanical students who scored a mean of 55.0% and a pass rate of 78.9%. As mentioned previously the CNT students could have been better prepared due to their parallel studies related to the Cisco professional examinations of which the majority are MCQ type, testing the students' propositional knowledge. The results were fed back to the PG Module Tutors and Programme Leaders who discussed the results with the UG Programme Leaders.

Since the normal entry requirements to Master's programmes at Northumbria University are based purely on the classification of the degree it was appropriate to investigate if there was any relationship between the results from the test and the final percentage awarded to the students on their respective UG degrees.

5.3.1.6 Correlation between test scores and final UG degree result

Correlation is concerned with measuring if there is any association between two variables and how strong it is (Hussey & Hussey, 1997). Before carrying out any analysis it is advisable to create a scatter diagram which can give an initial visual indication if there is any association (Sarantakos, 2013). If the dots are gathered around a line from the left hand bottom corner to the right hand top corner, then the relationship would be positive and if they gathered around a line from the bottom right hand corner to the top left corner, the relationship would be negative (Sarantakos, 2007). The scatter diagrams are shown in Figure 5.6.

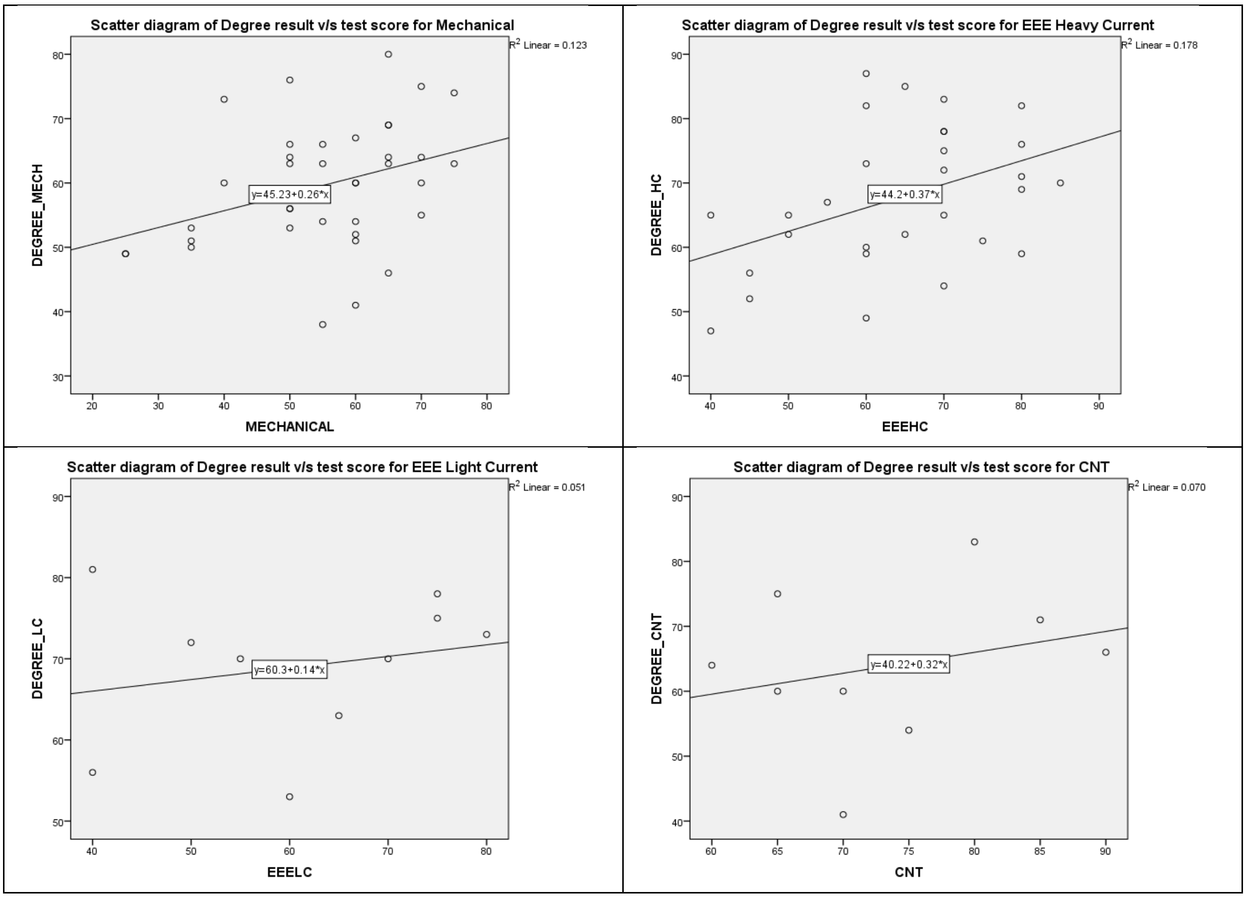


Figure 5.6 Scatter diagrams for test against UG degree for all programmes

On inspection it would appear that there is a positive relationship between the test and degree result for the students on the Mechanical and EEE Heavy Current programmes. There is no apparent correlation for the CNT and EEE Light Current programmes, but this could be due to the low sample numbers of ten and eleven respectively. This relationship can vary from weak to very strong depending on the position of the dots and how close they are to the line of best fit (Muijs, 2011). Statistical analysis was then carried out using SPSS. The Pearson's '*r*' correlation coefficient takes the value between ±1 with perfection at these extremes and no relationship when equal to zero (Bryman & Bell, 2003). To determine if the relationship is statistically significant an indication is provided by carrying out the '*F-test*' and obtaining a *'P-value'* which gives the statistical significance of the relationship (Muijs, 2011, p126). The results are shown below in Table 5.16.

		(ME_UG)	(ME_test)
Mechanical Engineering UG degree results (ME_UG)	**Pearson's *r* *p* (sig 2-tailed) N**	1 38	0.350* 0.031 38
MSc Mechanical Engineering test result (ME_test)	**Pearson's *r* *p* (sig 2-tailed) N**	0.350* 0.031 38	1 38
		(EEELC_UG)	**(MCE_test)**
EEE Light Current UG degree results (EEELC_UG)	**Pearson's *r* *p* (sig 2-tailed) N**	1 11	0.227 0.503 11
MSc Microelectronics and Communication Engineering test results (MCE_test)	**Pearson's *r* *p* (sig 2-tailed) N**	0.227 0.503 11	1 11
		(EEEHC_UG)	**(EPE_test)**
EEE Heavy Current UG degree results(EEEHC_UG)	**Pearson's *r* *p* (sig 2-tailed) N**	1 29	0.422* 0.023 29
MSc Electrical Power Engineering test results (EPE_test)	**Pearson's *r* *p* (sig 2-tailed) N**	0.422* 0.023 29	1 29
		(CNT_UG)	**(CNT_test)**
Computer & Network Technology UG results (CNT_UG)	**Pearson's *r* *p* (sig 2-tailed) N**	1 10	0.264 0.462 10
MSc Computer Network Technology test results (CNT_test)	**Pearson's *r* *p* (sig 2-tailed) N**	0.264 0.462 10	1 10
* Correlation is significant at the 0.05 level (2-tailed)			

Table 5.16 Correlation coefficients for MSc tests against degree results for all UG programmes

The analysis confirmed that there is a statistically significant positive relationship between the degree result and the test for students on the Mechanical ($r = 0.350, p < 0.05$) and EEE Heavy Current ($r = 0.422, p < 0.05$) programmes and this relationship is statistically significant at the 5% significance level. The values of *p* are both below the 0.05 level which suggests that there is a less than 5% chance of finding a relationship in the samples used if there was none in the population. These relationships could be best described between "*modest to moderate*" (Muijs, 2011, p126) or "*fairly weak*" (Saunders et al., 2009, p459) albeit statistically significant. The pass mark for the test was suggested as 50% which is the same for the Master's degrees. For a given pass mark for the test, the percentage of degree can be determined from the equation of best fit provided by the data. On the Mechanical and EEE Heavy Current programmes a test score of 50% equates to 58.2% and 62.7% respectively. The current UG requirement for entry to the programmes is an 'upper class, second division' or '2:2' which equates to 50% or more. If the test was used to recruit the students that took the test, then in general, they would have needed an 'upper class, first division' or '2:1' degree which is one classification higher than is currently asked to gain entry on to the MSc programmes.

5.3.1.7 Summary of confirmation of lecturing staff expectations of students graduating from UG programmes that act as feeders for the specialist PG programmes.

On average 84% of the students passed the tests with the Mechanical students the lowest at 78.9% and the CNT students with 100%. In terms of confirming the staff expectations it was important to identify those individual questions that scored less than 50% and these were identified as seven out of twenty for the Mechanical and EEE Light Current programmes and five out of twenty for the EEE Heavy Current and CNT programmes. The individual values for these questions varied from 5.3% to 45.5%. Although there was not a great deal of difference in the number of questions each group got wrong, the results did show that the CNT students had a greater grasp of knowledge required due to the high overall mean and the Mechanical students were the weakest with the lowest mean. All programmes had one or two questions that were answered incorrectly with very low numbers and these are the areas that the Programme Leaders were asked to investigate with the appropriate Module Tutors. No changes were made to the questions. However the UG Module Tutors agreed to review their teaching material to ensure that the appropriate knowledge was covered at the UG level if it was expected as underpinning knowledge at PG level.

When the results for the test were analysed along with the final degree percentage there was modest correlation for the Mechanical and EEE Heavy Current programmes that was statistically significant at the 5% significance level. More importantly the students that scored fifty percent or more on the test in general had obtained a 2:1 degree or higher which is one classification higher than that currently asked for entry to the MSc programmes. If this test provides the required level of knowledge at a pass mark of 50% then the academic entry requirement should be reviewed in light of these results as it is currently one classification lower than what the test suggests.

5.4 Summary of the chapter

This chapter has identified the entry criteria for the specialist programmes in computing and engineering at Northumbria and compared them to the competitor set for any major differences in terms of English language and academic level requirements. They were found to be very similar to what other institutions ask for in terms of stipulating minimum English and academic requirement and no apparent reference to specific knowledge requirements. The rationale for the compilation of the tests was presented, breaking down the questions by module and fundamental knowledge and the finalised test papers were then produced and completed by the UG students that would act as feeder programmes to the specialist Master's programmes. The results from the tests were all found to be Normally distributed with the Computer Network Technology students scoring a 100% pass rate and the Mechanical Engineering students scoring the lowest pass rate with 78.9%. When the individual questions were analysed, some scored exceptionally low which suggested that the expectations of knowledge of the Module Tutor and that acquired by the student differed. Any results of significance were fed back to Programme Leaders and Module Tutors for discussion and action where appropriate. When correlation analysis was carried out between test scores and final UG degree results a statistically significant positive correlation was found for the Mechanical Engineering and EEE Heavy Current programmes. This relationship, although not particularly strong but nevertheless statistically significant, suggested that the entry qualification for entry to a Master's degree should be a classification higher than currently asked for if the pass mark for the test was gauged at the correct level.

Chapter 6 Investigation of level of knowledge of incoming PG students

6.1 Introduction

The main aim of this chapter is to:-

> "Investigate the level of knowledge that students have when starting specialist Master's programmes and determine the relationship with academic success".

The tests that were developed and given to the graduating UG students in the previous chapter were given to incoming students on three specialist Master's programmes. The overall results and results by individual question are reviewed using descriptive statistics. The overall UG results obtained in the previous chapter are then compared to the PG results using the '*t-test*' to determine any statistical difference between the means. The same test is then carried out at an individual question level to determine any statistically significant differences in knowledge between the outgoing UG and incoming PG students. The relationship between how successful the PG students were on the test and how well they performed academically on their PG programme is then investigated by determining the correlation coefficient between the test and the marks achieved in semester 1 and semester 2. Further investigation is then carried out to determine the relationship between the questions associated with particular modules and the academic results achieved on those modules. Analysis is then completed to determine the relationship between the level of UG degree on entry, the test and their academic performance whilst on the PG programme. Multiple linear regression is then carried out using other available independent variables to determine if the results can be improved. Finally a model is proposed that can be used to predict academic success.

6.2 Results of the test given to the students entering specialist Master's programmes

The tests were given to students in October 2011, on the three MSc programmes; MSc Mechanical Engineering ($n = 15$), MSc Electrical Power Engineering ($n = 21$) and MSc Microelectronic and Communication Engineering ($n = 16$). As discussed previously in 4.7.2.2 the MSc Computer Network Technology students were no longer included in the research due to a small sample size ($n = 5$). The descriptive statistics for all three tests are shown in Table 6.0.

		Mechanical Engineering test	Electrical Power Engineering test	Microelectronic and Communication Engineering test
N	Valid	15	21	16
Mean		59.33	60.24	56.25
Median		60.00	60.00	55.00
Std. Deviation		12.373	18.740	10.408
Variance		153.095	351.190	108.333
Skewness		-0.281	0.469	-0.127
Kurtosis		2.001	-0.276	-0.161
Range		55	70	40
Minimum		30	30	35
Maximum		85	100	75
Percentiles	25	55.00	50.00	45.00
	50	60.00	55.00	60.00
	75	70.00	65.00	75.00

Table 6.0 Descriptive statistics for MSc student tests

The distributions can be described as Normal but all three have slightly different characteristics. The Mechanical Engineering and Electrical Power Engineering programmes have their mean and median very close together but the Microelectronic and Communication Engineering programme median is slightly lower than the mean. The Microelectronic and Communication Engineering and Mechanical Engineering programmes are slightly skewed to the left but the Electrical Power Engineering is more positively skewed to the right. Kurtosis for the Microelectronic and Communication Engineering and Electrical Power Engineering is marginally negative but the Mechanical Engineering is positive giving a slightly leptokurtic (more peaked at the mean) effect. The spread for the Mechanical Engineering and Microelectronic and Communication Engineering is reasonable, but larger for the Electrical Power Engineering due to the extreme of marks scored at 30 and 100% and could contribute to the distribution being more skewed. The box plots in Figure 6.0 clearly show the skewing effect on all three programmes due to their non-symmetrical shape although the Mechanical Engineering programme boxplot looks the opposite due to the outlier.

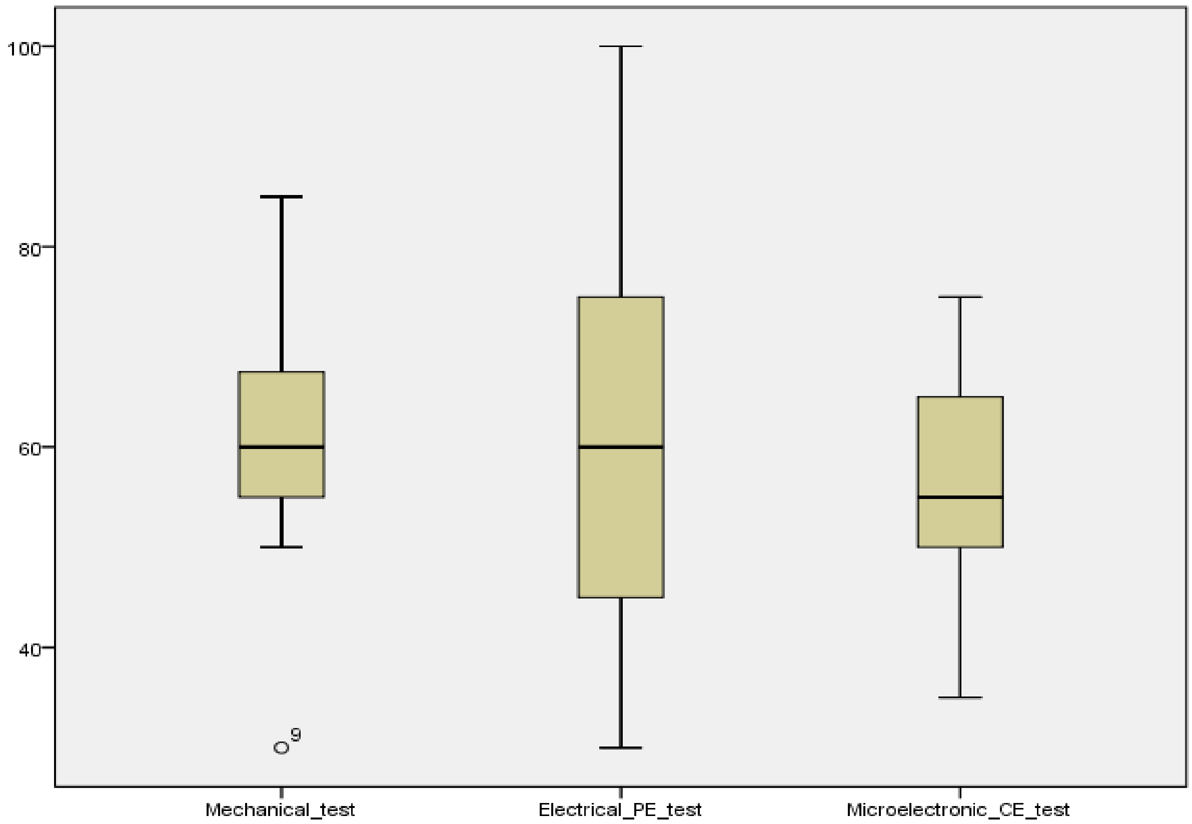


Figure 6.0 Box plot for MSc student tests

The Q-Q plots shown below in Figure 6.1 also show that the distributions are tending towards Normal with most of the points adjacent or very close to the line of normality.

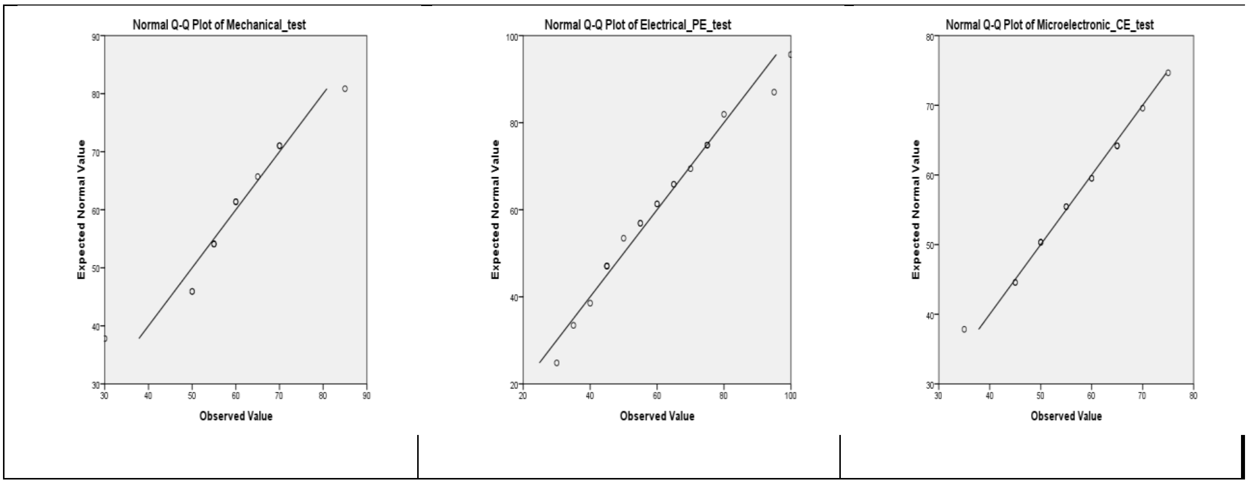


Figure 6.1 Q-Q plots for MSc student tests

Using the same pass mark as previously at 50%, the Electrical Power Engineering programme had the highest failure rate with seven of the twenty one (33.3%) students failing, followed by Microelectronic and Communication Engineering with three out of sixteen (18.75%) failing and the Mechanical Engineering (6.7%) with only one out of fifteen failing.

6.2.1 Descriptive statistics for individual questions

In order to analyse the results further it was necessary to investigate the variability in results for individual questions by programme. This would allow any questions that gave low or high results for a particular module to be identified.

6.2.1.1 Descriptive statistics by question for MSc students on Mechanical Engineering programme

The results can be seen in Figure 6.2. Overall the students failed to score more than 50% on eight of the twenty questions. Three of the questions were classed as fundamental, three in the deepening modules and both questions for the broadening module. The statistic providing some concern is the knowledge expected for the broadening module, Engineering Data Analysis (EN0535) where expectations between the Module Tutor and the students' knowledge were very different with a score of 20.0% and 46.7% for question six and eight. This represents only three and seven students from the cohort of fifteen providing the correct answer. Two of the deepening questions (13, 16) also scored particularly low scores (13.3%, 6.7%) which showed a lack of fundamental knowledge in the area of dynamics and thermodynamics.

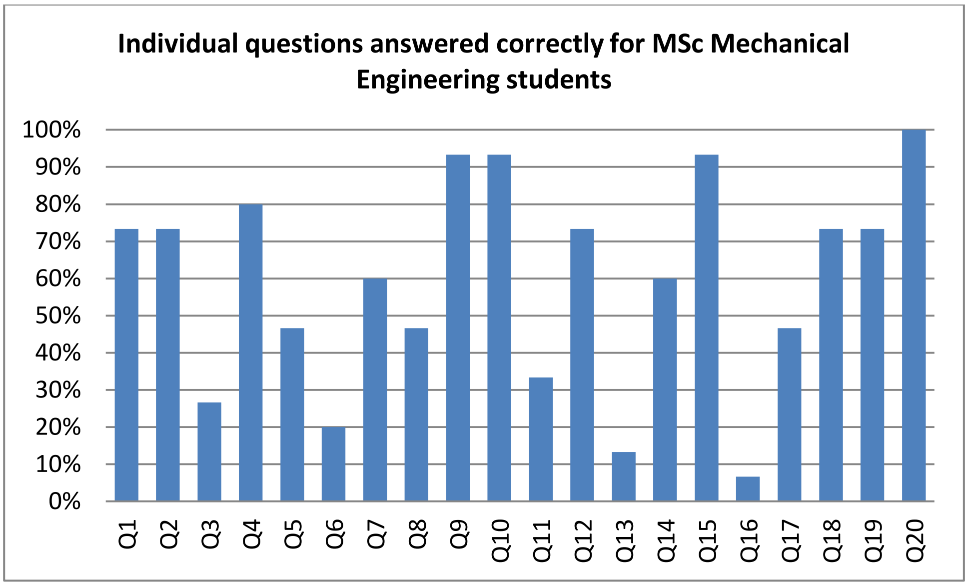


Figure 6.2 Results from individual questions for MSc Mechanical Engineering students

6.2.1.2 Descriptive statistics by question for MSc students on Electrical Power Engineering programme

The results can be seen in Figure 6.3. Overall the students failed to score more than 50% on six of the twenty questions. Four of the questions were classed as fundamental and two in the deepening modules. Question two had the lowest score of 28.6% which was classified as a fundamental question. The next lowest score at 33% (11, 12) were both deepening questions. The information was fed back to the Module Tutors and Programme Leader. Overall the students answered the other questions reasonably well with some high scores including one at 100%.

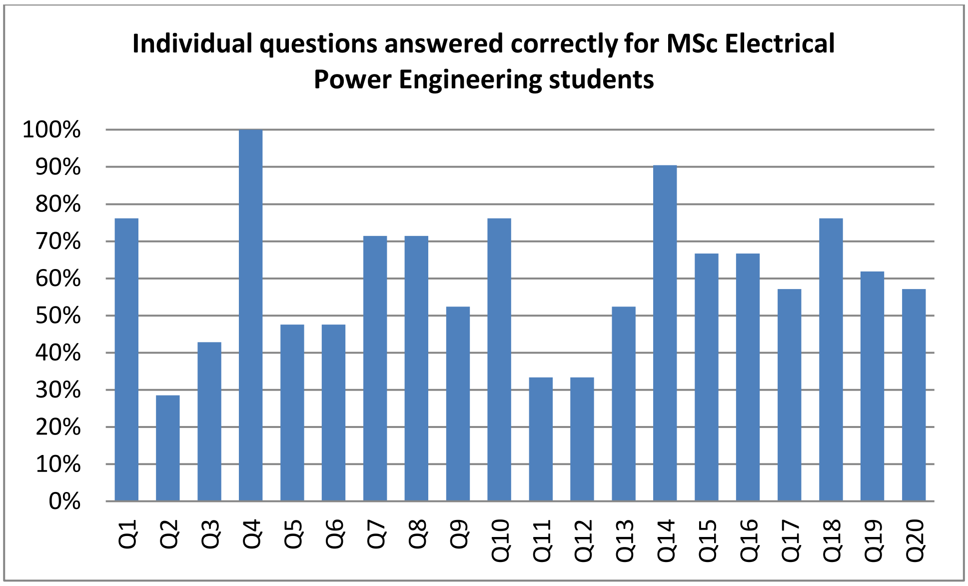


Figure 6.3 Results from individual questions for MSc Electrical Power Engineering students

6.2.1.3 Descriptive statistics by question for MSc students on Microelectronic and Communication Engineering programme

The results can be seen in Figure 6.4. Overall just under half of the questions scored less than fifty percent. Four of them were fundamental questions (5, 10, 11, 20) with low scores (37.5%, 37.5%, 37.5%, 25.0%) and five were deepening questions (6, 7, 9, 15, 18) with low scores (18.8%, 37.5%, 37.5%, 31.3%, 18.8%). The main area of concern is that three of the deepening questions that provided low scores (6, 7, 9) were all based on the Radio Frequency Communication Systems module. This would suggest that the majority of students do not have the underpinning knowledge for this module that was expected by the Module Tutor.

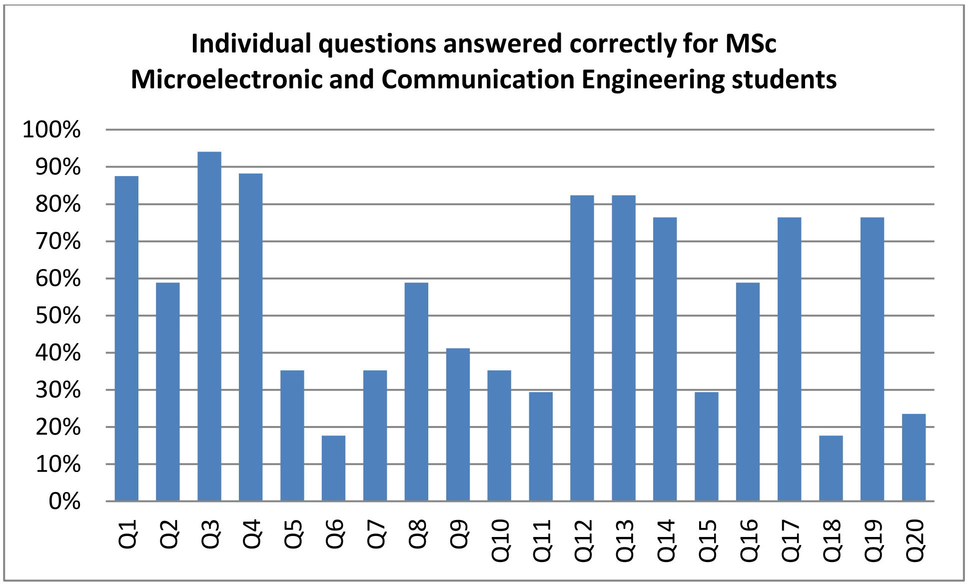


Figure 6.4 Results from individual questions for MSc Microelectronic and Communications Engineering students

6.2.1.4 Summary of descriptive statistics for PG students taking tests

The mean scores were all within four percent of each other varying from 56.25% for the Microelectronic and Communication Engineering programme and 60.24% for the Electrical Power Engineering programme, but the number of students passing the test varied dramatically with 93% for the Mechanical Engineering students and only 67% for the Electrical Power Engineering students. Even though the Mechanical Engineering students were the most successful in passing the test they had the second greatest number of individual questions with less than 50% at eight out of twenty. The Microelectronic and Communication Engineering students had the most individual questions scoring less than 50% with a total of nine out of twenty. The Electrical Power Engineering students had the highest mean score, the lowest number of individual questions less than 50%, but the highest failure rate. This could be due to the highest range of marks and a mode of forty five.

6.2.2 Comparison of results from tests carried out by Northumbria UG students and incoming international PG students

Since the tests had been taken by graduating UG students from the Northumbria programmes and the incoming PG students on to the specialist Master's programmes it was possible to compare the results scored by both groups and analyse for any major differences or similarities in the outcome. None of the students at UG level were the same students to take the test at PG level. The most appropriate test to determine if there is any statistically significant difference in the means is to use the '*t-test'* (Easterby-Smith et al., 2008, p267). The output from the *t-test* using independent samples is shown in Table 6.1.

Independent Samples Test for UG and PG student tests

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Interval of the Lower	Upper
Mech_test	Equal variances assumed	.413	.524	1.111	51	.272	4.333	3.900	-3.497	12.163
	Equal variances not assumed			1.133	26.817	.267	4.333	3.823	-3.514	12.180
EPE_test	Equal variances assumed	3.400	.071	-.916	48	.364	-4.072	4.447	-13.013	4.868
	Equal variances not assumed			-.862	32.966	.395	-4.072	4.723	-13.682	5.538
MCE_test	Equal variances assumed	1.099	.305	-1.003	25	.325	-4.659	4.645	-14.225	4.907
	Equal variances not assumed			-.952	17.608	.354	-4.659	4.895	-14.960	5.641

Table 6.1 Independent samples test for UG and PG tests

Since the *p-value* (Sig.) on Levene's test is not significant in any of the three cases, the 'equal variances assumed' are considered in the *t-test* and none of these are significant either. Therefore it can be concluded that none of the means are significantly different between the UG and PG students taking the three tests (Sarantakos, 2007). Based on these results it is fair to say that the UG students performed similarly to the PG students when taking the tests across the three programmes. Since there was no statistically significant differences between the test scores further investigation was carried out to determine if there was any major differences at the individual question level.

6.2.2.1 Comparison of results from tests carried out by Northumbria UG students and incoming international PG students at individual question level

In order to determine if there was any significant statistical difference between the means of the individual questions a *t-test* was carried out on the pairs of means calculated for each individual question for each of the three tests. The results are shown in Appendices 9 - 11.

6.2.2.1.1 Mechanical Engineering *t-test* results

The results showed that there was three statistically significant different means on the results of the answers given by the UG and PG groups of students. The questions identified were numbers five, eight and twenty. Question five and question eight can be clearly seen by observation when looking at the bar chart of results in Figure 6.5. However question twenty did not appear to look different with only eleven percent difference but it was identified as having a statistically significant different mean. Questions one and two also appeared to look significantly different on inspection but these were not identified by the *t-test.*

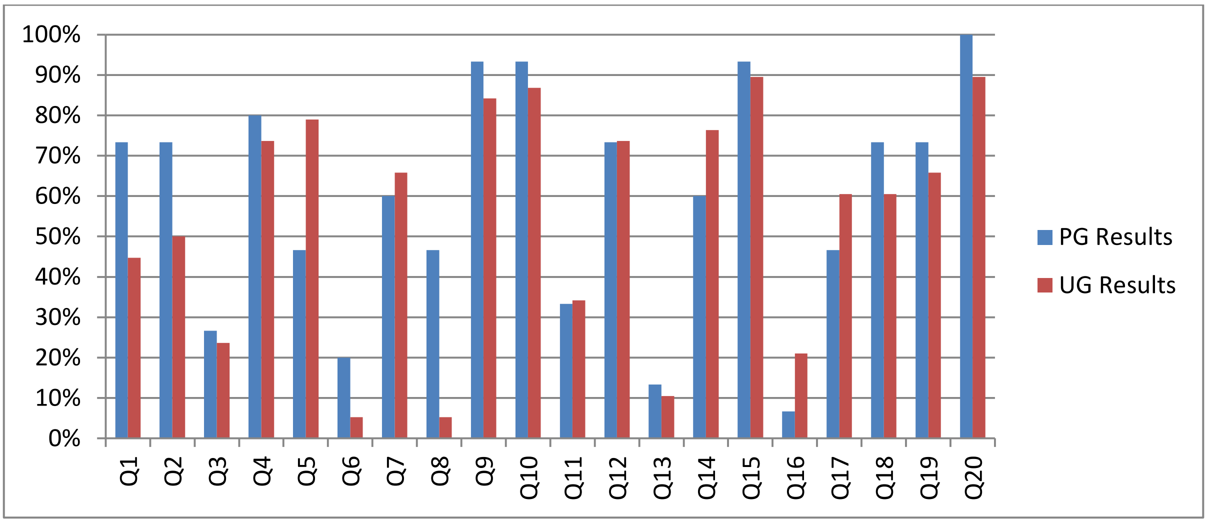


Figure 6.5 Bar chart showing answers to individual questions for the UG and PG students on the Mechanical Engineering test.

A summary of the questions with results that were worthy of further consideration is shown in Table 6.2.

Question number	Type	Comments
3	Fundamental	Both UG and PG scored very low <30%
5*	Fundamental	UG scored much higher than PG >30% difference
6	Broadening	Both UG and PG scored extremely low <20%
8*	Broadening	Both UG and PG <50% but PG 41% higher with 46.7%
11	Fundamental	Both UG and PG scored low <35%
13	Deepening	Both UG and PG scored extremely low <15%
16	Deepening	Both UG and PG scored very low <25%
20*	Deepening	PG scored 100% and UG scored 89.5%

*Identified by *t-test* with statistically significant different means

Table 6.2 Summary of questions of interest for the UG and PG students on the Mechanical Engineering test

Question twenty could have been identified as having statistically different means since the standard deviation for the PG students was zero, due to everyone getting the question correct, while it was 0.311 for the UG students and the number of UG students is more than 1.5 times the number of PG students (Saunders et al., 2009). Ignoring question twenty it can be said that in general the UG and PG students had similar levels of knowledge when answering the questions apart from questions five and eight. Both sets of students scored less than 50% on questions six and eight which were both aligned to a broadening module called Engineering Data Analysis (EN0535). This would suggest that the students do not have the underpinning knowledge to support this module even though it is classed as a broadening module and the questions were identified as broadening rather than deepening or fundamental knowledge questions.

6.2.2.1.2 Electrical Power Engineering *t-test* results

The results showed that there were four questions with statistically significant different means on the answers given by the UG and PG groups of students. The questions identified were number two, seven, thirteen and fourteen. This can be seen quite clearly by observation when looking at the bar chart of results below in Figure 6.6.

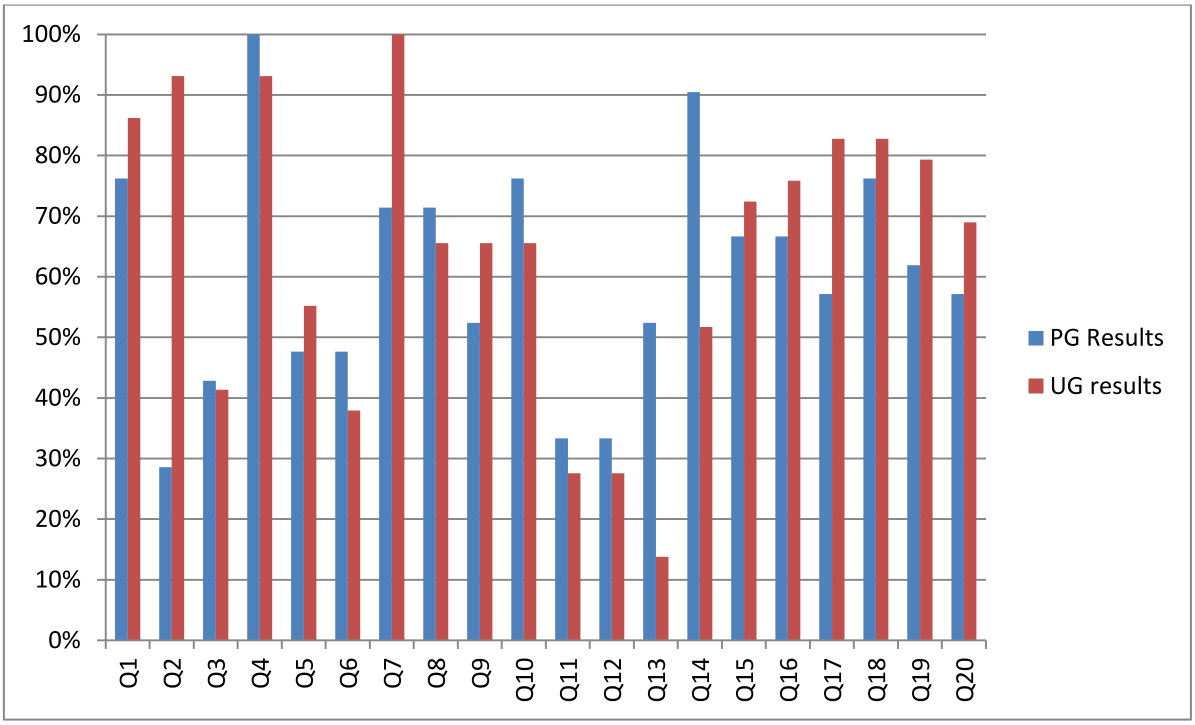


Figure 6.6 Bar chart showing answers to individual questions for the UG and PG students on the Electrical Power Engineering test

A summary of the questions with results that were worthy of further consideration is shown in Table 6.3. Of the four questions that were identified by the *t-test* as having statistically significant different means the UG students did better in two and the PG students better in the other two. Apart from those questions identified as having statistically significant different means by the *t-test* the UG and PG students appear to have similar levels of knowledge in the remaining questions.

Question number	Type	Comments
2*	Fundamental	UG scored much higher than PG >60% difference
3	Fundamental	Both UG and PG scored low <45%
6	Fundamental	Both UG and PG scored low <50%
7*	Fundamental	UG scored 100% and PG scored 71%
11	Deepening	Both UG and PG scored low <35%
12	Deepening	Both UG and PG scored low <35%
13*	Deepening	UG scored 14% and PG scored 52%
14*	Deepening	UG scored 52% and PG scored 90%

*Identified by *t-test* with statistically significant different means

Table 6.3 Summary of questions of interest for the UG and PG students on the Electrical Power Engineering test

6.2.2.1.3 Microelectronics and Communication Engineering *t-test* results

The results showed that there were two statistically significantly different means on the answers given by the UG and PG groups of students. The questions identified were number two and six. This can be seen quite clearly by observation when looking at the bar chart of results below in Figure 6.5.

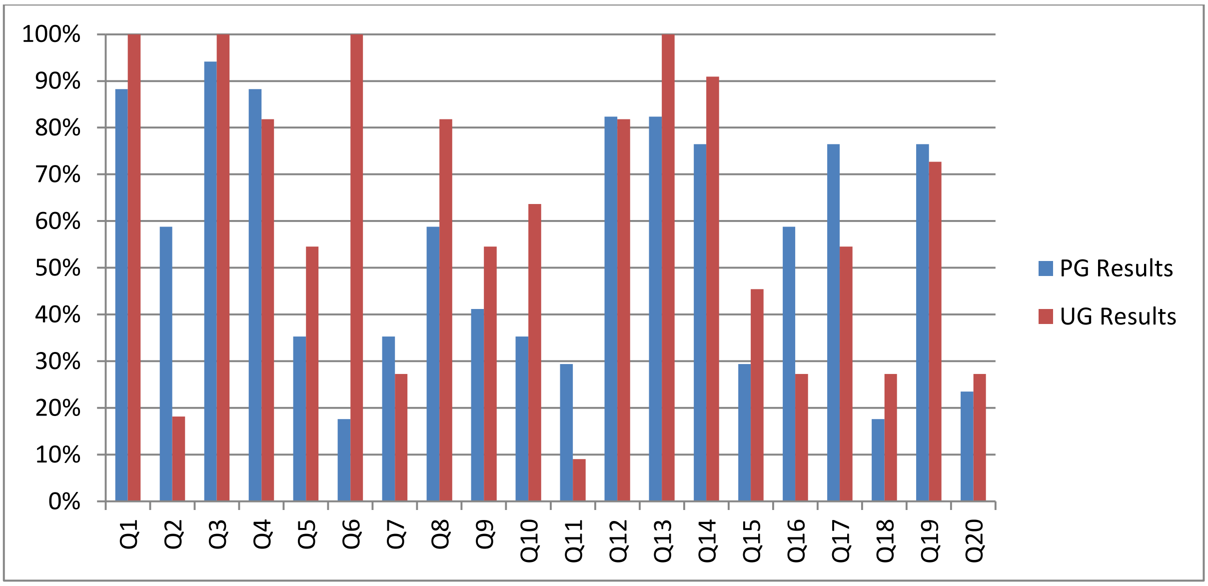


Figure 6.5 Bar chart showing answers to individual questions for the UG and PG students on the Microelectronic and Communication Engineering test

A summary of the questions with results that were worthy of further consideration is shown below in Table 6.4.

Question number	Type	Comments
2*	Deepening	PG scored much higher than UG >40% difference
6*	Deepening	UG scored much higher than PG >80% difference
7	Deepening	Both UG and PG scored low <35%
11	Fundamental	Both UG and PG scored very low <30%
15	Deepening	Both UG and PG scored low <45%
18	Deepening	Both UG and PG scored very low <30%
20	Fundamental	Both UG and PG scored very low <30%

*Identified by *t-test* with statistically significant different means

Table 6.4 Summary of questions of interest for the UG and PG students on the Microelectronic and Communications Engineering test

Of the two questions identified as having statistically significant different means the UG group scored higher in one and the PG group scored higher in the other. Ignoring these two questions the students from the UG and PG groups appeared to have performed similarly, displaying the same lack of knowledge and conversely the same strengths when answering the questions in the test.

6.2.2.1.4 Summary of comparison between UG and PG student tests

Across all three tests the number of questions that were identified as having statistically significant different means varied from two to four. After discounting question twenty for the Mechanical Engineering test the UG and PG students had 90% similar knowledge and of the two questions that differed the UG students were stronger in one and the PG stronger in the other. The students taking the Electrical Power Engineering test at UG and PG level had 80% similar knowledge and of the questions that differed, the UG students were stronger in two and the PG students stronger in the other two. The students taking the Microelectronic and

Communications Engineering test at UG and PG level had 90% similar knowledge with the UG students stronger in one question whilst the PG students were stronger in the other. Although the UG and PG students had similar levels of knowledge, both groups had different levels of knowledge to that which was expected by the Module Tutors and Programme Leaders.

In all three cases the questions that were identified as having statistically different means were shared equally between the UG and PG students so no group was identified as being stronger than the other. In summary it can be said that on average the students appeared to have similar levels of knowledge when answering between 80-90% of the questions. The UG and PG students had similar areas of strength and weakness evidenced by having similar high and very low scores. From these results it would appear that the incoming international PG students had a similar level of underpinning knowledge to the graduating Northumbria students across all three programmes. The smallest variation in knowledge was the Microelectronic and Communication Engineering students, followed by the Mechanical Engineering students and then the Electrical Power Engineering students. Although the UG and PG students had similar levels of knowledge, where the average mark for a question was less than 50% this information was fed back to the Module tutors and Programme Leaders for comment.

6.3 Investigation into the relationship between underpinning knowledge and academic success.

All the MSc students had completed their first semester by January 2012 and their results were available by module. Since one of the modules was yearlong rather than semester based they only had fifty credits worth of results in the first semester, with a further seventy credits worth of results available in June 2012. After the examination board had taken place it was possible to obtain the finalised marks for each semester by using the student identification number. In the analysis carried out it is not possible to identify any students on an individual basis.

As well as determining if there was any relationship between the test and the student marks achieved on the MSc, analysis was also carried out to identify if there was any relationship between specific module marks and those questions associated with them from the test. The sum of the test questions that were associated with each module were averaged to give a test mark for that particular module. Since the number of test questions per module or classed as fundamental varied from one to seven, the average marks per student only had a possibility of a number of fixed values. Table 6.5 below shows the possible average values per student depending on the number of questions that related to the module. This restricted range of values would have an impact on the correlation calculation and those with the higher number of questions would be expected to give a more meaningful result.

Number of Questions	**Possible averages**							
1	0	100						
2	0	50	100					
3	0	33.3	66.7	100				
4	0	25	50	75	100			
5	0	20	40	60	80	100		
6	0	16.7	33.3	50	66.7	83.3	100	
7	0	14.3	28.6	42.9	57.1	71.4	85.7	100

Table 6.5 Relationship between the number of questions testing a module and the possible average results per student

6.3.1 Analysis of marks between the test and the percentage achieved on Mechanical Engineering programme

A test for the correlation coefficient was carried out on the results of the test given to the students when they started on the programme and their results by semester and is shown in Table 6.6. For the Mechanical Engineering programme there does not appear to be any correlation between the students' test score and how they performed on the programme. The only correlation was between the average of their two semesters and performance in Semester 1 (*$r = 0.904$, $p < 0.01$*) and semester 2 (*$r = 0.698$, $p = < 0.01$*). This relationship as defined by "Pearson's r" is "*very strong*" (Muijs, 2011, p126) and highly statistically significant. This could be expected since the marks from both semesters are duplicated in the average, but it is also worthy of noting that there is no correlation between semester 1 and semester 2. One student did not complete the Mechanical Engineering programme and dropped out before the first semester was completed so they were not included in this analysis. Interestingly the same student scored 30% in the test.

Mechanical Engineering Correlations

		TEST	SEM_1	SEM_2	AVERAGE
TEST	**Pearson's r**	1	-.469	-.353	-.426
	Sig. (2-tailed)		.090	.215	.129
	N	14	14	14	14
SEM_1	**Pearson's r**	-.469	1	.412	.904**
	Sig. (2-tailed)	.090		.143	.000
	N	14	14	14	14
SEM_2	**Pearson's r**	-.353	.412	1	.698**
	Sig. (2-tailed)	.215	.143		.005
	N	14	14	14	14
AVERAGE	**Pearson's r**	-.426	.904**	.698**	1
	Sig. (2-tailed)	.129	.000	.005	
	N	14	14	14	14

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6.6 Correlation coefficients for test against Semester 1, Semester 2 and Semester average for MSc Mechanical Engineering students

When the correlation analysis was carried out for the groups of test questions for each module there was a mixture of results as shown below in Table 6.7.

Correlations between Module marks and Module test questions MSc Mechanical Engineering

		Module EN0506	Module EN0507	Module EN0510	Module EN0535	Module EN0536	Module EN0721	Module ME088	Test Questions EN0506	Test Questions EN0507	Test Questions EN0510	Test Questions EN0535	Test Questions EN0536	Test Questions EN0721	Test Questions ME0088	Fundamental TEST Questions	All TEST Questions
Module EN0506	Pearson's r	1	.466	.165	.348	.232	.097	.209	.220	-.199	.259	-.145	-.346	.071	-.011	-.088	-.038
	Sig. (2-tailed)		.093	.572	.222	.424	.742	.473	.451	.496	.371	.621	.225	.810	.971	.765	.896
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Module EN0507	Pearson's r	.466	1	.201	.281	.420	.225	.098	.088	-.183	.039	-.613*	-.383	.110	.222	-.072	-0.260
	Sig. (2-tailed)	.093		.491	.331	.135	.440	.739	.764	.531	.896	.020	.176	.709	.445	.806	.370
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Module EN0510	Pearson's r	.165	.201	1	.544*	.913**	.612*	.153	-.253	.234	-.159	.393	-.087	-.241	.135	-.571*	-.366
	Sig. (2-tailed)	.572	.491		.044	.000	.020	.601	.382	.420	.587	.165	.769	.406	.647	.033	.198
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Module EN0535	Pearson's r	.348	0.281	.544*	1	.531	.290	-.186	.176	.207	.134	-.032	-.372	.029	.164	.078	0.145
	Sig. (2-tailed)	.222	.331	.044		.051	.315	.525	.546	.477	.648	.914	.190	.921	.576	.792	.620
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Module EN0536	Pearson's r	.232	.420	.913**	.531	1	.621*	.244	-.151	.233	-.120	.071	-.037	-.161	.163	-.490	-.338
	Sig. (2-tailed)	.424	.135	.000	.051		.018	.400	.607	.423	.682	.808	.900	.582	.577	.075	.237
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Module EN0721	Pearson's r	.097	.225	.612*	.290	.621*	1	.403	-.053	.098	.034	-.040	-.320	-.389	-.107	-.134	-.254
	Sig. (2-tailed)	.742	.440	.020	.315	.018		.153	.857	.739	.909	.892	.265	.169	.715	.647	.381
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Module ME088	Pearson's r	.209	0.098	.153	-.186	.244	.403	1	-.215	-.242	-.172	.074	.101	-.046	.042	-.262	-.310
	Sig. (2-tailed)	.473	.739	.601	.525	.400	.153		.460	.405	.557	.801	.731	.877	.886	.365	.281
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Test Questions EN0506	Pearson's r	.220	.088	-.253	.176	-.151	-.053	-.215	1	.040	.340	-.404	-.339	.248	.391	.519	.676**
	Sig. (2-tailed)	.451	.764	.382	.546	.607	.857	.460		.891	.235	.152	.236	.392	.167	.057	.008
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Test Questions EN0507	Pearson's r	-.199	-.183	.234	.207	.233	.098	-.242	.040	1	.258	.230	.418	-.141	-.175	-.158	.351
	Sig. (2-tailed)	.496	.531	.420	.477	.423	.739	.405	.891		.373	.429	.137	.630	.549	.590	.219
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Test Questions EN0510	Pearson's r	.259	.039	-.159	.134	-.120	.034	-.172	.340	.258	1	.025	0.000	-.548*	-.283	.458	.648*
	Sig. (2-tailed)	.371	.896	.587	.648	.682	.909	.557	.235	.373		.933	1.000	.043	.327	.099	.012
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Test Questions EN0535	Pearson's r	-.145	-.613*	.393	-.032	.071	-.040	.074	-.404	.230	.025	1	.321	-.362	-.135	-.439	-.056
	Sig. (2-tailed)	.621	.020	.165	.914	.808	.892	.801	.152	.429	.933		.263	.204	.647	.117	.850
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Test Questions EN0536	Pearson's r	-.346	-.383	-.087	-.372	-.037	-.320	.101	-.339	.418	0.000	.321	1	0.000	0.000	-.330	.101
	Sig. (2-tailed)	.225	.176	.769	.190	.900	.265	.731	.236	.137	1.000	.263		1.000	1.000	.249	.731
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Test Questions EN0721	Pearson's r	.071	.110	-.241	.029	-.161	-.389	-.046	.248	-.141	-.548*	-.362	0.000	1	.372	.009	.034
	Sig. (2-tailed)	.810	.709	.406	.921	.582	.169	.877	.392	.630	.043	.204	1.000		.190	.975	.908
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Test Questions ME0088	Pearson's r	-.011	.222	.135	0.164	.163	-.107	.042	.391	-.175	-.283	-.135	0.000	.372	1	.052	0.191
	Sig. (2-tailed)	.971	.445	.647	.576	.577	.715	.886	.167	.549	.327	.647	1.000	.190		.860	.513
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Fundamental TEST Questions	Pearson's r	-.088	-.072	-.571*	.078	-.490	-.134	-.262	.519	-.158	0.458	-.439	-.330	.009	.052	1	.706**
	Sig. (2-tailed)	.765	.806	.033	.792	.075	.647	.365	.057	.590	.099	.117	.249	.975	.860		.005
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
All TEST Questions	Pearson's r	-.038	-.260	-.366	.145	-.338	-.254	-.310	.676**	.351	.648*	-.056	.101	.034	.191	.706**	1
	Sig. (2-tailed)	.896	.370	.198	.620	.237	.381	.281	.008	.219	.012	.850	.731	.908	.513	.005	
	N	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6.7 Correlations between Module marks and Module test questions for MSc Mechanical Engineering students

Since there was only a maximum number of two questions identified per module it was very difficult to compare this result with the module marks when only three variables of 0, 50 or 100% were available. Due to this restricted range of values the correlations between modules and module test questions were of little use. There were seven responses included in the fundamental question average and because of this it was possible to provide a meaningful value for the correlation between these values and the module marks. There was moderate negative correlation (*r = -0.571,*

$p < 0.05$) between the fundamental group of questions and the marks for the Solid Modelling and Prototyping module (EN0510). This suggests that the students who scored high marks in answering the fundamental questions scored low marks in EN0510 and vice versa implying that the students that had a good grasp of propositional knowledge did not have the procedural knowledge to successfully use the software. This module is very practical and dependent on the procedural knowledge of using the Solidworks software package rather than having fundamental propositional knowledge of Mechanical Engineering. The Solid Modelling and Prototyping module (EN0510) and Materials Process Modelling (EN0536) module are both dependent on the procedural knowledge of using the Solidworks software package. There is very strong, statistically significant positive correlation between the marks achieved on both these modules ($r = 0.913$, $p < 0.01$). There also appears to be moderate to strong, positive correlation between the Solid Modelling and Prototyping module (EN0510) and Engineering Data Analysis (EN0535) ($r = 0.544$, $p < 0.05$) and Engineering Design (EN0721) ($r = 0.621$, $p <0.05$) modules. These two modules are classed as Broadening Modules and are also very practically orientated, based around procedural knowledge and use of particular software packages. There is no apparent relationship between these modules and the remaining Deepening Modules such as Advanced Dynamics and Vibrations (EN0506), Computational Fluid Dynamics (EN0507) and Advanced Stress Analysis (ME0888) which require a good grasp of the appropriate propositional knowledge and are academically challenging. This would suggest that the students, who have good procedural knowledge of the software being used, tend to do well on both the practical modules in Solid Modelling and Prototyping and Materials Process Modelling.

The proposed test for admission to the MSc Mechanical Engineering programme would not appear to be a predictor of academic success.

6.3.2 Analysis of marks between the test and the percentage achieved on Electrical Power Engineering programme

The marks achieved in the test were analysed for a relationship with the student marks for semester 1, semester 2 and their overall average marks, by testing for any correlation and these can be seen below in Table 6.8.

Electrical Power Engineering Correlations

		Test	SEM_1	SEM_2	Average
Test	Pearson's r	1	.685**	.787**	.762**
	Sig. (2-tailed)		.001	.000	.000
	N	21	21	21	21
SEM_1	Pearson's r	.685**	1	.883**	.965**
	Sig. (2-tailed)	.001		.000	.000
	N	21	21	21	21
SEM_2	Pearson's r	.787**	.883**	1	.975**
	Sig. (2-tailed)	.000	.000		.000
	N	21	21	21	21
Average	Pearson's r	.762**	.965**	.975**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	21	21	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6.8 Correlation coefficients for test against Semester 1, Semester 2 and Semester average for MSc EPE students

The results show that there is statistically significant positive correlation between the test and the results achieved in semester 1 and semester 2. The relationship for semester 2 *($r = 0.787$, $p < 0.01$)* was stronger than semester 1 *($r = 0.685$, $p < 0.01$)* due to the higher value of Pearson's *r* and was more statistically significant due to the smaller value of *p*.

To investigate this relationship further, analysis of the correlation coefficient was carried out between the groups of test questions and the module mark that they were associated with. The results are shown in Table 6.9.

Correlations between Module marks and Module test questions MSc Electrical Power Engineering									
		Module EN0711	Module EN0712	Module EN0550	TEST Questions EN0711	TEST Questions EN0712	TEST Questions EN0550	Fundamental TEST Questions	All TEST Questions
Module EN0711	Pearson's r	1	.620**	.613**	.640**	.442*	.170	.607**	.667**
	Sig. (2-tailed)		.003	.003	.002	.045	.461	.003	.001
	N	21	21	21	21	21	21	21	21
Module EN0712	Pearson's r	.620**	1	.452*	.453*	.574**	.495*	.378	.613**
	Sig. (2-tailed)	.003		.040	.039	.006	.023	.091	.003
	N	21	21	21	21	21	21	21	21
Module EN0550	Pearson's r	.613**	.452*	1	.585**	.534*	.495*	.399	.643**
	Sig. (2-tailed)	.003	.040		.005	.013	.022	.073	.002
	N	21	21	21	21	21	21	21	21
TEST Questions EN0711	Pearson's r	.640**	.453*	.585**	1	.381	.342	.630**	.790**
	Sig. (2-tailed)	.002	.039	.005		.088	.129	.002	.000
	N	21	21	21	21	21	21	21	21
TEST Questions EN0712	Pearson's r	.442*	.574**	.534*	.381	1	.245	.290	.568**
	Sig. (2-tailed)	.045	.006	.013	.088		.284	.202	.007
	N	21	21	21	21	21	21	21	21
TEST Questions EN0550	Pearson's r	.170	.495*	.495*	.342	.245	1	.360	.625**
	Sig. (2-tailed)	.461	.023	.022	.129	.284		.109	.002
	N	21	21	21	21	21	21	21	21
Fundamental TEST Questions	Pearson's r	.607**	.378	.399	.630**	.290	.360	1	.880**
	Sig. (2-tailed)	.003	.091	.073	.002	.202	.109		.000
	N	21	21	21	21	21	21	21	21
All TEST Questions	Pearson's r	.667**	.613**	.643**	.790**	.568**	.625**	.880**	1
	Sig. (2-tailed)	.001	.003	.002	.000	.007	.002	.000	
	N	21	21	21	21	21	21	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6.9 Correlations between Module marks and Module test questions for MSc Electrical Power Engineering students

In every case the questions associated with each module were found to have moderate to strong positive correlation that was statistically significant and a predictor of the results achieved on that module. There was statistically significant positive correlation between the test questions for the Wind Energy Conversion Systems (EN0711) and Modern Power Engineering (EN0712) modules with the actual marks achieved in all three of the Deepening Modules (EN0550, EN0711, EN0712). However, in both modules the relationship between the appropriate test questions and the module they were aligned with had a stronger correlation coefficient and were the most statistically significant. There was also statistically significant strong positive correlation between the results achieved on all three Deepening Modules. The relationship between all the test questions and module EN0711 was statistically more significant and more positively correlated than the result for the specific test questions associated with that module.

The proposed test for admission to the MSc Electrical Power Engineering programme would appear to be a good predictor of academic success.

6.3.3 Analysis of marks between the test and the percentage achieved on Microelectronics and Communication Engineering programme

The marks achieved in the test were analysed for a relationship with the student marks for semester 1, semester 2 and their overall average marks, by testing for any correlation and these can be seen below in Table 6.10.

Microelectronic and Communication Engineering Correlations

		TEST	SEM_1	SEM_2	AVERAGE
TEST	Pearson's r	1	.255	.278	.215
	Sig. (2-tailed)		.341	.298	.425
	N	16	16	16	16
SEM_1	Pearson's r	.255	1	.723**	.953**
	Sig. (2-tailed)	.341		.002	.000
	N	16	16	16	16
SEM_2	Pearson's r	.278	.723**	1	.811**
	Sig. (2-tailed)	.298	.002		.000
	N	16	16	16	16
AVERAGE	Pearson's r	.215	.953**	.811**	1
	Sig. (2-tailed)	.425	.000	.000	
	N	16	16	16	16

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6.10 Correlation coefficients for test against Semester 1, Semester 2 and Semester average for MSc Microelectronic and Communication Engineering students

For the Microelectronic and Communication Engineering programme there does not appear to be any correlation between the students' test score and how they performed on the programme. There is statistically significant positive correlation between their performance in Semester 1 and Semester 2 *($r = 0.723$, $p < 0.01$)*, Semester 1 and their average of the two semesters *($r = 0.953$, $p < 0.01$)* and Semester 2 and their average of the two semesters *($r = 0.811$, $p < 0.01$)*. This relationship is "*very strong" (Muijs, 2011, p126)* and very statistically significant. The relationship between each semester and the average of their semesters could be expected, as the marks for each semester are duplicated in the average marks.

When the correlation analysis was carried out for the groups of test questions for each module there was very little correlation at all as shown below in Table 6.11.

Correlations between Module marks and Module test questions MSc Microelectronic and Communication Engineering

		Module EN0719	Module EN0722	Module EP0191	Test Questions EN0719	Test Questions EN0722	Test Questions EP0191	Fundamental TEST Questions	All TEST Questions
Module EN0719	Pearson's r	1	.495	.409	.120	-.006	.589*	.265	.440
	Sig. (2-tailed)		.051	.116	.658	.983	.016	.322	.088
	N	16	16	16	16	16	16	16	16
Module EN0722	Pearson's r	.495	1	.230	.205	-.058	.303	.306	.391
	Sig. (2-tailed)	.051		.392	.445	.832	.253	.248	.134
	N	16	16	16	16	16	16	16	16
Module EP0191	Pearson's r	.409	.230	1	.182	-.063	.341	-.090	.121
	Sig. (2-tailed)	.116	.392		.500	.816	.195	.741	.655
	N	16	16	16	16	16	16	16	16
TEST Questions EN0719	Pearson's r	.120	.205	.182	1	-.385	-.203	-.065	.232
	Sig. (2-tailed)	.658	.445	.500		.141	.451	.810	.387
	N	16	16	16	16	16	16	16	16
TEST Questions EN0722	Pearson's r	-.006	-.058	-.063	-.385	1	.103	.035	.373
	Sig. (2-tailed)	.983	.832	.816	.141		.705	.897	.154
	N	16	16	16	16	16	16	16	16
TEST Questions EP0191	Pearson's r	.589*	.303	.341	-.203	.103	1	.308	.489
	Sig. (2-tailed)	.016	.253	.195	.451	.705		.245	.055
	N	16	16	16	16	16	16	16	16
Fundamental TEST Questions	Pearson's r	.265	.306	-.090	-.065	.035	.308	1	.760**
	Sig. (2-tailed)	.322	.248	.741	.810	.897	.245		.001
	N	16	16	16	16	16	16	16	16
All TEST Questions	Pearson's r	.440	.391	.121	.232	.373	.489	.760**	1
	Sig. (2-tailed)	.088	.134	.655	.387	.154	.055	.001	
	N	16	16	16	16	16	16	16	16

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6.11 Correlations between Module marks and Module test questions for MSc Microelectronic and Communication Engineering students

There was statistically significant positive correlation between the fundamental test questions and all test questions *($r = 0.760$, $p < 0.01$)* but since the fundamental test questions made up seven of the twenty questions asked, this could reasonably be expected to happen. There was statistically significant positive correlation *($r = 0.589$, $p < 0.05$)* between the questions for the Optical Fibre Communications module (EP0191) and the module result for the Embedded System Technologies and Design (EN0719) module. There does not appear to be any logical reason for this as the EP0191 questions are based on fundamental physics knowledge and EN0719 studies the area of embedded systems and the programming of them.

The proposed test for admission to the MSc Microelectronics and Communications Engineering programme would not appear to be a predictor of academic success.

6.3.4 Summary of relationship between underpinning knowledge and academic success

Across the three programmes that were evaluated for the relationship between underpinning knowledge and academic success there were mixed results. The Mechanical Engineering and Microelectronic and Communications Engineering programmes appear to show no relationship between the test and the subsequent academic success of the students and, because of this, the Mechanical Engineering and Microelectronic and Communication Engineering programmes were no longer investigated in this study. However, the Electrical Power Engineering test did show a statistically significant strong positive correlation with the student results in Semester 1, Semester 2 and their overall average during their studies. Due to this strong relationship with the Electrical Power Engineering test and academic performance, further analysis was carried out at the module level to see if it was possible to predict the module results from the associated module test questions.

6.4 Correlation between module results and questions associated with the module

In the Electrical Power Engineering test, four questions were identified for each of the three deepening modules so it was possible to carry out simple linear regression between the average marks for the associated questions and the module results. The analysis that was carried out can be found in Appendix 12, but a summary and evaluation for each module is shown below.

6.4.1 Correlation between test questions for EN0711 and module results

Simple linear regression was carried out and the following model was extracted from the output. Where y is the predicted result for EN0711 and x is the mark achieved on the test.

$$y = 56.344 + 0.283x$$

Since there are only four questions the only possible outcome for the test is 0, 25, 50, 75 or 100%. Using the model which is statistically significant according to the *p-value* of 0.002 in the ANOVA table, the predicted results would be as shown in Table 6.12.

Test mark	Module mark
0	56
25	63
50	70
75	78
100	85

Table 6.12 Predicted results for Module EN0711 based on test results of questions associated with EN0711

This would suggest that even if a student scored zero on the test they would go on to pass the module. The mean of this module was particularly high at 71.86% whereas the mean for the test was 54.76%. The actual results were compared with the predicted results at a student level and are shown below in Table 6.13.

Test mark	Module mark	Predicted mark	Difference	% Difference
25	81	63	-18	-22%
25	67	63	-4	-5%
25	72	63	-9	-12%
75	77	78	1	1%
25	67	63	-4	-5%
75	75	78	3	3%
50	63	70	7	12%
75	63	78	15	23%
50	80	70	-10	-12%
75	80	78	-2	-3%
75	70	78	8	11%
75	83	78	-5	-7%
50	61	70	9	16%
100	96	85	-11	-12%
50	54	70	16	31%
50	77	70	-7	-8%
50	76	70	-6	-7%
25	65	63	-2	-2%
100	88	85	-3	-4%
0	42	56	14	34%
75	72	78	6	8%

Table 6.13 Test results for Module EN0711, showing Module mark, predicted mark and difference

One student scored zero in the test and failed the module but the model predicted that they would pass. The rest of the students passed the module. In terms of academic success the model predicted the correct result for 95% of the students. According to the R^2 value the model only represents 40.9% of the outcome of the module mark so there is 59.1% unexplained. The maximum difference varies from 34% to -22%. Since there are restricted values for the test mark, the model is not as refined as it could be.

6.4.2 Correlation between test questions for EN0712 and module results

Simple linear regression was carried out and the following model was extracted from the output, where y is the predicted result for EN0712 and x is the mark achieved on the test.

$$y = 37.708 + 0.306x$$

Since there are only four questions the only possible outcome for the test is 0, 25, 50, 75 or 100%. Using the model, which is statistically significant according to the *p-value* of 0.006 in the ANOVA table, the predicted results would be as shown in Table 6.14.

Test mark	Module mark
0	38
25	45
50	53
75	61
100	68

Table 6.14 Predicted results for Module EN0712 based on test results of questions associated with EN0712

This would suggest that if a student scored zero or twenty five on the test they would go on to fail the module. The mean of the module was 55.19% and the mean for the test was 57.14% so were quite similar. The actual module marks were compared with the predicted results at a student level and are shown in Table 6.15.

Two students scored twenty five in the test and failed the module but two students scored twenty five in the test and passed whereas the model predicted failure. One student scored fifty and one student scored seventy five but they both failed the module, whereas the model predicted a pass. The rest of the students passed the module. In terms of academic success the model predicted the correct result for 81% of the students.

Test mark	Module mark	Predicted mark	Difference	% Difference
50	60	53	-7	-12%
25	30	45	15	51%
50	63	53	-10	-16%
50	50	53	3	6%
50	35	53	18	51%
50	63	53	-10	-16%
25	35	45	10	30%
75	42	61	19	44%
50	54	53	-1	-2%
75	60	61	1	1%
50	60	53	-7	-12%
25	68	45	-23	-33%
25	53	45	-8	-14%
100	81	68	-13	-16%
50	50	53	3	6%
100	73	68	-5	-6%
75	61	61	0	-1%
75	52	61	9	17%
100	67	68	1	2%
50	52	53	1	2%
50	50	53	3	6%

Table 6.15 Test results for Module EN0712, showing Module mark, predicted mark and difference

According to the R^2 value the model only represents 33.0% of the outcome of the module mark so there is 67.0% unexplained. The maximum difference varies from 51% to -33%. Since there are restricted values for the test mark, the model is not as refined as it could be.

6.4.3 Correlation between test questions for EN0550 and module results

Simple linear regression was carried out and the following model was extracted from the output. Where y is the predicted result for EN0550 and x is the mark achieved on the test. $$y = 36.016 + 0.291x$$

Since there are only four questions the only possible outcome for the test is 0, 25, 50, 75 or 100%. According to the *p-value* of 0.022 in the ANOVA table, the model is statistically significant and the predicted results would be as shown in Table 6.16.

Test mark	Module mark
0	36
25	43
50	51
75	58
100	65

Table 6.16 Predicted results for Module EN0550 based on test results of questions associated with EN550

This would suggest that even if a student scored zero or twenty five on the test they would go on to fail the module. The mean of the module was 56.1% and the mean for the test was 69.04%, a difference of nearly 13%. The actual module marks were compared with the predicted results at a student level and are shown in Table 6.17.

Test mark	Module mark	Predicted mark	Difference	% Difference
25	50	43	-7	-13%
75	67	58	-9	-14%
75	45	58	13	29%
75	70	58	-12	-17%
50	43	51	8	18%
100	61	65	4	7%
50	46	51	5	10%
25	50	43	-7	-13%
50	40	51	11	26%
75	50	58	8	16%
75	61	58	-3	-5%
75	50	58	8	16%
75	57	58	1	1%
100	81	65	-16	-20%
100	50	65	15	30%
100	80	65	-15	-19%
50	66	51	-15	-23%
50	54	51	-3	-6%
100	78	65	-13	-17%
75	27	58	31	114%
50	52	51	-1	-3%

Table 6.17 Test results for Module EN0550, showing Module mark, predicted mark and difference

Two students scored twenty five in the test and passed whereas the model predicted failure. Three students scored fifty and failed the module, whereas the model predicted a pass. Two students scored seventy five in the test and failed, whereas the model predicted a pass. The rest of the students passed the module. In terms of academic success the model predicted the correct result for 67% of the students. According to the R^2 value the model only represents 24.5% of the outcome of the module mark so there is 75.5% unexplained. The maximum difference varies from 114% to -23%. Since there are restricted values for the test mark, the model is not as refined as it could be.

6.4.4 Summary of predicted module marks using simple linear regression

The main purpose of carrying out this analysis was to try and identify any particular shortcomings in knowledge for a particular module based on their ability to answer certain questions. Due to the number of questions associated with each module being low, the restricted values do not give an appropriate level of detail for further analysis. It does not appear to be possible to identify particular areas of knowledge at the module level that could be used to predict academic success. The best option would appear to be to feedback the results of the test to the students, showing which questions they had answered incorrectly and at least make them aware of their shortcomings in particular areas of subject knowledge. However based on the analysis of these particular modules, in the majority of cases, even when the students have not answered questions correctly they have gone on to achieve academic success, in that they pass the module.

In light of these results it was decided to investigate the relationship between the test, level of degree on entry and the student academic performance on the Electrical

Power Engineering programme to determine if the test or their UG degree result on entry was the best predictor of their academic performance.

6.5 Correlation between Entry Degree, test, Semester 1 and Semester 2 for MSc Electrical Power Engineering

It was possible to gather the data required to identify the actual percentage of the students' entry degree and investigate if there was a relationship between this value and how the students succeeded academically on the programme. This was compared to the relationship between the score achieved on the test and their academic success. The results can be seen in Table 6.18.

Correlations between Entry degree, Semester 1, Semester 2, Average and TEST for Electrical Power Engineering students

		Test	Degree	SEM_1	SEM_2	Average
Test	Pearson's r	1	.537*	.685**	.787**	.762**
	Sig. (2-tailed)		.012	.001	.000	.000
	N	21	21	21	21	21
Degree	Pearson's r	.537*	1	.171	.346	.273
	Sig. (2-tailed)	.012		.459	.124	.232
	N	21	21	21	21	21
SEM_1	Pearson's r	.685**	.171	1	.883**	.965**
	Sig. (2-tailed)	.001	.459		.000	.000
	N	21	21	21	21	21
SEM_2	Pearson's r	.787**	.346	.883**	1	.975**
	Sig. (2-tailed)	.000	.124	.000		.000
	N	21	21	21	21	21
Average	Pearson's r	.762**	.273	.965**	.975**	1
	Sig. (2-tailed)	.000	.232	.000	.000	
	N	21	21	21	21	21

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6.18 Correlations between Entry degree, Semester 1, Semester 2 and test for Electrical Power Engineering students

From the results it can be seen that there is no statistically significant relationship between the actual percentage of the students' degree on entry and how they performed academically in semester 1, semester 2 or the average of the two semesters. However there is a statistically significant strong positive correlation between the test and the students' academic performance in semester 1, semester 2 and the average of the two semesters. There is also statistically significant moderate positive correlation between the test and the percentage of the students' degree on entry. In light of the results above it was possible to carry out linear regression analysis between the test scores and academic performance and test for statistical significance and validity.

6.5.1 Linear Regression analysis of the test scores and academic performance

Using SPSS, simple linear regression was carried out using the test scores as the independent variable (*x*), with the academic scores for Semester 1, Semester 2 and the average of the two semesters, in turn, as the dependent variable (*y*) to determine the strongest relationship. The full results can be found in Appendices 13 – 15 and a summary is shown in Table 6.19.

	R	R^2	R^2 adjusted	Constant	Test	Sig
Sem_1	0.685	0.470	0.442	38.968	0.380	0.001
Sem_2	0.787	0.619	0.599	41.791	0.364	0.000
Average	0.762	0.581	0.559	40.646	0.370	0.000

Table 6.19 Summary of linear regression analysis between Test, Semester 1, Semester 2 and average for Electrical Power Engineering students

In all three cases the test is a highly significant predictor of academic performance at the 1% level since the 'Sig' or *p-value* is less than 0.001. When the *p-value* is 0.000

"*this indicates a very high level of significance, the highest one can obtain*" (Sarantakos, 2013, p385) meaning that the association between the test and the students semester 2 and average marks are "*extremely significant*" (Sarantakos, 2007, p110). The correlation coefficient "*Pearson's r*" varies from 0.685 for semester 1 to 0.787 for semester 2 which can both be described as having *"high positive correlation"* (Hussey & Hussey, 1997, p229). The coefficient of determination R^2 varies from 0.470 for semester 1 to 0.619 for semester 2. For semester 1, this would suggest that 47% of the variation in the semester 1 marks can be expressed in terms of the variation of the test. For semester 2, the relationship is stronger and 61.9% of the variation in semester 2 marks can be expressed in terms of the variation of the test. The adjusted value of R^2 would normally be used in multiple regression models as it *"accounts for the number of independent variables required to describe the variation in the dependent or y variable data"* (Robson et al., 2008, p210).

Since semester 2 gives the strongest relationship between the test and academic marks the regression model for this relationship is shown below. However, the model for semester 1 and the average marks would be very similar. The model is made up from the output table of coefficients found in Appendix 15. The equation of the model for semester 2 is shown below where y is the predicted semester 2 result taking into account the value achieved in the test and substituted for x:-

$$y = 41.791 + 0.364x$$

A table of predicted results is shown below in Table 6.20 using the equation of the model. Since the test only accounts for 61.9% of the second semester marks, the differences for each predicted value are made up of the unexplained variables.

Test mark	Predicted semester 2 mark	Test mark	Predicted semester 2 mark	Test mark	Predicted semester 2 mark
0	42	35	55	70	67
5	44	40	56	75	69
10	45	45	58	80	71
15	47	50	60	85	73
20	49	55	62	90	75
25	51	60	64	95	76
30	53	65	65	100	78

Table 6.20 Predicted marks for semester 2 based on test marks for Electrical Power Engineering students

Using this model to predict the outcome of the academic results in semester 2 would suggest that the pass mark for the test should be 25% predicting a result of 51%. The test results along with the actual marks for semester 2, the difference between the predicted and actual mark, and the percentage difference is shown in Table 6.21.

Test mark	Semester 2 mark	Predicted mark	Difference	% Difference
45	66	58	-8	-12%
45	59	58	-1	-2%
50	61	60	-1	-1%
65	66	65	0	0%
35	55	55	0	0%
75	67	69	2	3%
55	59	62	3	4%
45	55	58	3	5%
70	62	67	5	8%
80	62	71	9	14%
65	65	65	0	0%
55	67	62	-5	-7%
45	62	58	-4	-7%
95	82	76	-6	-7%
75	59	69	10	17%
75	80	69	-11	-13%
60	68	64	-4	-6%
40	57	56	-1	-1%
100	81	78	-3	-3%
30	48	53	4	9%
60	56	64	8	14%

Table 6.21 Actual marks for semester 2 with predicted marks for semester 2 for Electrical Power Engineering students

One student scored 30% on the test and failed academically even though the test predicted success. Everyone above 30% on the test succeeded academically and therefore the pass mark of 50% needs reviewing to take these results into account. Since the model only accounts for 61.9% of the value in the semester 2 marks it was decided to investigate any further independent variables that were available and carry out multiple regression analysis.

6.5.2 Multiple regression analysis for MSc Electrical Power Engineering students

For the cohort of MSc Electrical Power Engineering student it was possible to extract some further data from their application forms that could be used in the multiple regression analysis. The other data which were available were the students' age, UG degree mark and whether English was their first language. Some students did have an IELTS score, but many of them had studied and been assessed in the English language for more than two years, so this was used to show they had met the English criterion for entry to the programme.

The age of the student and their degree mark were continuous variables but since the question of whether English was their first language gave the answer of either 'yes' or 'no' this had to be treated as a dummy variable and assigned the value '0' for 'no' and '1' for 'yes' (Robson et al., 2008).

Multiple linear regression was carried out using SPSS defining semester 2 as the dependent variable and age, test score, degree percentage, and English as the independent variables. The model summary is shown in Table 6.22. The R^2 value increased from 0.619 to 0.631 by including the extra independent variables but the adjusted R^2 value decreased from 0.599 to 0.539 and this would be the value that would be used, due to carrying out multiple linear regression rather than simple linear regression (Robson et al., 2008).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.795[a]	.631	.539	5.8816

a. Predictors: (Constant), English, Age, Test, Degree_UG

b. Dependent Variable: Semester_2

Table 6.22 Model summary of multiple linear regression analysis for Electrical Power Engineering students using Enter method

The full output from the analysis can be found in Appendix 16. The *p-value* of 0.002 taken from the ANOVA table shows that the model is a significant predictor of the semester 2 results. When the coefficient table shown in Table 6.23 is analysed, there are points worthy of noting. The age *($t = 0.221$, $p = 0.828$)*, degree percentage *($t =-0.425$, $p = 0.677$)* and English as a first language *($t = 0.377$, $p = 0.711$)* are not significant in predicting the semester 2 results.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	43.655	12.935		3.375	.004
	Age	.051	.230	.035	.221	.828
	Test	.383	.088	.828	4.375	.000
	Degree_UG	-.082	.193	-.081	-.425	.677
	English	1.030	2.733	.061	.377	.711

a. Dependent Variable: Semester_2

Table 6.23 Coefficients of multiple linear regression analysis for Electrical Power Engineering students

Due to the fact that the test appeared to be the only independent variable that was statistically significant a "stepwise" analysis was carried out in SPSS and the model summary is shown below in Table 6.24, whilst the full analysis is in Appendix 17. This method removes any of the independent variables that are not statistically significant and the model summary gives the same results as the simple linear regression showing that the most appropriate predictor of the semester 2 results is simply the test score and the other variables are of no statistical significance.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.787[a]	.619	.599	5.4885

a. Predictors: (Constant), Test

b. Dependent Variable: Semester_2

Table 6.24 Model summary of multiple linear regression analysis for Electrical Power Engineering students using Stepwise method

For this particular cohort of students it would appear that the test of underpinning knowledge is the best predictor of academic success from the information that is available regarding the student.

6.5.3 Summary of simple and multiple linear regression analysis of Electrical Power Engineering students

Simple linear regression was carried out between the test marks obtained by the students and their academic results for semester 1, semester 2 and the average of the results. Semester 2 gave the strongest positive correlation and was very statistically significant *($r = 0.787$, $p < 0.01$)* where the *p-value* was actually 0.000. The association between the test and the semester 2 marks is extremely significant and the model identified in the analysis is also statistically significant when observing the *p-value* of 0.000 in the ANOVA table. The model was then used to calculate the predicted semester 2 results and compared with the actual results obtained. The R^2 value suggest that 61.9% of the semester 2 result can be accounted for by the test and the maximum difference between actual and predicted marks was 17%. Since there were still 38.1% of the semester 2 marks unaccounted for, multiple linear regression was carried out using the other independent variables that were available for the students; UG degree percentage, age, English as first language. The multiple linear regression analysis showed that none of these extra independent variables had any statistical significance and highlighted the test as the most significant predictor of the semester 2 marks.

6.6 Summary of chapter

The descriptive statistics of the tests from the three Master's programmes were reviewed and found to be generally Normally distributed with small differences in mean, median, skewness and kurtosis. To confirm the knowledge of the incoming PG students, their test results were compared to the outgoing UG students and a *t-test* showed no statistically significant difference between the UG and PG students taking the three tests. This result suggested that the UG and PG students had similar levels of knowledge. When the *t-test* was carried out at the individual question level some questions were identified as having statistically significant different means. In general the students across the three programmes had between eighty and ninety percent similar knowledge. The UG and PG students also had similar weaknesses and strengths across the three programmes.

The students' test marks along with their academic results for semester 1, semester 2 and average results were analysed for any correlation. The only programme that showed any statistically significant results between the test and the academic performance was the Electrical Power Engineering programme. Analysis of the modules and their associated questions were not found to help identify a lack of underpinning knowledge at the module level. The percentage of the UG degree was included in the correlation analysis but found not to be a statistically significant predictor of academic performance despite this being one of the current criteria for entry to the programme.

Simple linear regression was carried out between the test score and the semester 1, semester 2 and average results in turn. Semester 2 gave the strongest results that were the most statistically significant and the model identified was used to calculate predicted semester 2 results from the possible test scores. The model accounted for 61.9% of the outcome in the semester 2 results. In order to try and account for the remaining variance, three other independent variables were introduced (UG degree percentage, Age and English as the first language) and multiple linear progression was carried out. None of these extra variables were found to be statistically significant in predicting the semester 2 results.

The best model for predicting the semester 2 results was found to be the test score and this accounts for 61.9% of the value in the academic results in semester 2.

Chapter 7 Conclusions

7.1 Introduction

This thesis has investigated the relationship between underpinning knowledge requirements and academic success of international students on specialist Master's programmes in order to inform a successful recruitment strategy that can help facilitate academic success. This chapter will review the research carried out and draw conclusions to answer the initial research question "*What is the relationship between underpinning knowledge and the academic success of international students enrolled on specialist Master's programmes.*" There will then follow a discussion of the contribution to both knowledge and practice and some reflections regarding the carrying out of this research. Finally the limitations to the research and suggested further work are discussed.

7.2 Review of the research objectives

The following objectives were identified to answer the research question:-

- To critically review the existing literature on international student education exploring the factors potentially associated with academic success and determine if these factors can be used to predict academic success;
- To critically review the existing literature on international student education as a supply chain and review this within the context of wider manufacturing and operations management literature with respect to viewing the student going through a manufacturing system;
- To develop an appropriate methodology and methods to determine the relationship between underpinning knowledge and achieving academic success for international students;

- Investigate the level of knowledge that students are expected to have when enrolling on specialist Master's programmes;
- Investigate the level of knowledge that students have when starting specialist Master's programmes with the Faculty of Engineering and Environment of Northumbria University and determine the relationship with academic success;
- To ensure that international students have the required underpinning knowledge to facilitate academic success when starting specialist Master's programmes with the Faculty of Engineering and Environment of Northumbria University and make a contribution to international student recruitment practice.

Each objective will be reviewed in light of the findings from the research carried out.

7.2.1 To critically review the existing literature on international student education exploring the factors potentially associated with academic success and determine if these factors can be used to predict academic success.

In order to gain an understanding of international student education it was important to evaluate the current market position within the UK and general trends across the market. It was found that UK Universities are under great pressure to diversify their income due to changes in Government funding and allocation of student numbers for home students. There are no caps on the number of international students that a UK institution can recruit but the Government have made the recruitment of international students more difficult by introducing new legislation around student visas and the criteria that have to be met to successfully award them. Since immigration is a key concern for the Government they have introduced strict control measures that have required institutions to create compliance teams at great cost but these measures were not taken seriously by some institutions, such as London Metropolitan University which led to their licence to enrol international students being revoked. This lapse created even more financial and political pressure on the institution when they were not allowed to recruit international students showing the importance of adhering to the control measures. Most of the legislation changes that caused the problems for recruitment were based around the students' English Language skill, their ability to financially support themselves and the removal of the Post Study Work visa that allowed graduates to stay and work in the UK. The academic requirements have been left at the discretion of the recruiting institutions. The above activity has identified that the market for recruitment of international students is very volatile and that having an appropriate strategy is important to recruit the students that have the required underpinning knowledge to facilitate academic success. Due to the financial pressures placed on institutions they must not see international students at any cost and must balance quantity with quality. The level of international student recruitment required to create financial stability has to be judged against the quality so that students can achieve academic success and help institutions improve their KPIs that contribute towards University league tables.

The international student lifecycle has been developed by the HEA to help academic and professional support staff meet the diverse needs of international students by identifying where problems or shortcomings can occur during the education process. The majority of shortcomings identified are based around five key themes but none of them look at ensuring that the student has the correct knowledge to succeed academically.

Within the literature reviewed there are many factors identified as affecting academic success such as preparation before arrival, language, social and cultural but the majority of interventions are carried out once a student arrives and the shortcomings can be identified. In general the literature reviewed assumes that the students have met the required academic criteria and English language level to enrol on the programme of their choice. This is identified as the current entry requirements by the institutions reviewed and what appears to be an accepted standard that should allow students to achieve academic success. The use of the term success was used quite frequently in the literature but many authors offered no definition of what the term meant. The use of the term success was found to have several meanings depending on the point of view the person or organisation using it. Employers, universities and students all see success differently and so the definition of success identified for this study was "successfully completing a programme of study" and obtaining the award registered for.

There have been many attempts over the last twenty years to predict academic success using English language, retention, entry tests and previous academic performance. The results from all areas are inconclusive with findings at both extremes. Several of the studies did however allude to the need for a test including subject knowledge to improve the outcomes (Light et al., 1987; Mathews, 2007b; Stacey & Whittaker, 2005), thus identifying the shortcomings in some of the tests in their current form.

This thesis has argued that, in order to recruit students that have the best possibility of achieving academic success they must meet the correct specification. However, the current specification of English and academic level are not sufficient. This method of recruitment can introduce significant variability in to the education system and as such it is very difficult to predict academic success. When viewed as a manufacturing system this variability can be identified and minimised through adopting different recruitment processes. For instance, the recruitment process may include articulations, where the presence of the required subject knowledge can be identified and delivered to the students due to the relationship between the institution providing the students and the institution recruiting them.

The significance of subject knowledge has been acknowledged as a possible predictor of academic success and as such was identified, in this thesis, as the factor to concentrate on to predict academic success.

7.2.2 To critically review the existing literature on international student education as a supply chain and review this within the context of wider manufacturing and operations management literature with respect to viewing the student going through a manufacturing system

Limited research has been conducted regarding students flowing through an educational supply chain, a theory which first appeared in 1996 through the work of O'Brien and Deans (1996). They identified the problem of variability and proposed that the suppliers (Colleges and Schools) of students were given feedback on the shortcomings of their students. They also suggested that universities work with employers so that the output from the educational supply chain met customer expectations. This work was then revived again in 2007 where it was recognised by Lau (2007) that every student was an individual and as such should have a customised supply chain so that any variability could be dealt with appropriately. Murali and Venkata (2012b) aligned the whole educational process to that of a basic Input – Process – Output model as used in manufacturing industry. Pathik and Habib (2012) took the whole process one stage further and identified an Integrated Tertiary Educational Supply Chain Model (ITESCM) but more importantly recognised the need for an entrance exam or admissions test to get into a university purely to confirm the ‘quality’ of the intake. This was viewed as an attempt to ensure that the students met the specification for entry and would therefore have the required prerequisites to facilitate academic success.

The incoming students can now be viewed as an input entering the educational process and leaving the system as an output. As long as the students meet the specification at the input level then the process can be defined with a suitable process capability to ensure that they leave the process as an output at the required quality level. The defined process capability has to be to be set up to cope with the agreed incoming variability. This process capability is however the responsibility of the Institution and it will vary significantly depending on the capability of the individual lecturers and the interventions made by the HEI to ensure that the staff are capable of dealing with the student variability. If the variability can be minimised then the process does not need as much flexibility and the students can flow through the educational supply chain with minimum interventions. If root cause analysis was used and identified deficiencies in underpinning knowledge, then it would eliminate the need for the interventions that would normally be carried out whilst continually treating the symptoms. The tests designed in this study acts as a form of root cause analysis to determine the deficiencies in underpinning knowledge and, therefore this test had the potential to offer a methodological contribution to the field of international student recruitment.

7.2.3 To develop an appropriate methodology and methods to determine the relationship between underpinning knowledge and achieving academic success

From the literature review carried out in Chapter’s Two and Three there was evidence of both quantitative and qualitative approaches adopted depending on the type of study and the methodology used to collect the data. A realist ontology and positivist epistemology was found to be the most appropriate for this research. It was made clear that both qualitative and quantitative data were going to be collected in the research but the data were processed using only quantitative methods. The use of a test was likened to a survey and this method was also used by Gray (2004) to give MCQ tests in a closed classroom situation.

The proposed methodology and methods were aligned with the objectives and the research questions that needed to be answered in order to provide an answer to the main research question:

"What is the relationship between underpinning knowledge and the academic success of international students enrolled on specialist Master's programmes?"

7.2.4 Investigate the level of knowledge that students are expected to have when enrolling on specialist Master's programmes

The first activity was to determine what Northumbria does in terms of defining entry criteria. It was evident, from published information on the Northumbria website, that there was a range of practices in place across the specialist programmes in terms of style of definition of entry requirements and the vocabulary used. It was found that Northumbria only specifies the level of academic award, normally in a cognate subject area and the level of English required. If a student met these criteria then it was deemed that they had met the specification for entry and should be capable of achieving academic success. When individual student applications were received and reviewed by Programme Leaders they were using extra requirements, over and above those on the website, which tried to ensure that the applicant's knowledge in the subject area was a good fit to the programme of study. This was in essence trying to minimise the variation of the incoming students.

The next priority was then to determine if Northumbria was doing anything different in terms of setting the entry criteria for entry to their specialist Master's programmes compared to other institutions. In order to do this, the 'Competitor set' of Universities that Northumbria used for benchmarking was identified for the purpose, rather than creating another group. In terms of academic requirements there was mixed practice with some institutions asking for higher grades and some lower. The more interesting findings were when different levels were used for different programmes at London Metropolitan and Westminster and when Sheffield Hallam specifies much higher awards from Chinese and Indian students compared to the equivalent UK level. None of the eighteen institutions identified any specific knowledge requirements.

From the programmes reviewed, approximately half asked for a lower level of English than Northumbria but did require specific IELTS bands for example in the 'Writing' component, recognising that one third of a Master's programme is the dissertation and good writing skills are required. The level of English identified at Hull is lower than Northumbria but they ask for a higher academic level, therefore putting more emphasis on academic studies rather than competence in English.

Previous research identified in the literature review confirmed that English level is not a good predictor of academic success (Cownie & Addison, 1996; Seelen, 2002) and perhaps the academic level on entry is more important (Hooley & Horspool, 2006; Light et al., 1987). From the competitor group of University programmes reviewed for the research, 40% (20) asked for a higher academic entry level and 48% (24) asked for a lower English level which agrees with the previous research findings that higher academic level and lower English level could be a better predictor of academic success.

The confirmation of knowledge expected by Programme leaders and Module Tutors was carried out through testing the students with twenty questions that in their "*expert opinion"* (Heffner Media Group, 2011) would test the underpinning knowledge that was required to enter their relevant programmes. The programme leader for Computer Science declined to provide any questions and this programme was no longer used in the research. Despite asking for the questions in a particular format based on the deepening modules in the programmes, the structure of each of the papers was different. The structure of the programmes was also different and this caused problems when for example in the Mechanical Engineering test there were only two questions per module which meant that analysis of the results of testing for the underpinning knowledge at the module level was limited. The results by programme were found to be all reasonably Normally distributed and when using a pass mark of fifty percent, the pass rate ranged from high eighties for the Mechanical Engineering students to one hundred percent for the CNT students. The tests did show some deficiencies in the knowledge expected by the Module Tutors compared to how the students performed, identified by some very low scores on individual questions. This information was provided to the appropriate tutors, which allowed them to review the content and delivery of their modules. Correlation between the test and the final UG degree percentage showed statistically significant results for the Mechanical and Heavy Current students but there was no relationship found for the Computer Network Technology or Light Current students. The relationship showed that based on a pass mark for the test of fifty percent the relevant degree percentage was found to be nearer sixty percent which is one classification higher than currently asked for on entry to the Master's programmes. If the pass mark for the test is correct then this would support the findings in 7.2.4 above that a higher academic level should be set for entry to the PG programme than the current ‘second class lower division’ or higher.

7.2.5 Investigate the level of knowledge that students have when studying specialist Master’s programmes and determine the relationship with academic success

The tests that had been produced for the research above in section 7.2.4 were given to incoming students on the MSc Mechanical Engineering (*n = 15)*, MSc Electrical Power Engineering (*n = 21)* and the MSc Microelectronic and Communication Engineering *(n = 16)* programmes. The number of students recruited on the CNT programme was too small *(n = 5)* to be worthy of further investigation and was no longer used in the research. The results were generally Normally distributed but each programme having slightly different characteristics. Using the same pass mark of fifty percent, the pass rate ranged from 66.3% for the Electrical Power Engineering to 93.3% for the Mechanical Engineering students. When the results for the questions were analysed on an individual level there was a difference in expectations of knowledge from the academic staff and the incoming students’ performance, similar to that of the UG students. Some of the low scores could be attributed to specific module questions and this information was provided to the Module Tutors and Programme Leaders.

A statistical analysis was carried out on the results between the UG and PG results using *t-tests* and it was found that there was no statistically significant difference between the overall results for UG and PG across each of the three programmes. This implied that both sets of students had similar levels of knowledge. To analyse this further, statistical analysis was carried out at the individual question level using *t-tests* which did identify some questions that had statistically significant different means. Based on the individual questions, the Mechanical Engineering and Microelectronic and Communication Engineering students had 90% similar levels of knowledge, whilst the Electrical Power Engineering students had an 80% similar level of knowledge. When comparing the UG and PG results, no group were found to be stronger than the other and both groups had similar strengths and weaknesses. In general, it can be concluded that the outgoing UG students had similar levels of knowledge to the incoming PG students.

The main purpose of determining if the students had sufficient underpinning knowledge was to determine the relationship between underpinning knowledge and academic success. For the three groups of students that had completed the test, it was possible to gain access to their academic results by semester and identify any relationship between the marks achieved in the test and their academic performance by semester. This was done at the semester average level and at the module level. Of the three programmes evaluated the only one to show any statistically significant relationship between the test and academic achievement was the MSc Electrical Power Engineering programme. The reason for this lack of relationship is not certain but the numbers on these two programmes were low and it is possible that the questions on the test papers were not asking the right questions or indeed in these subject areas, there is no relationship between underpinning knowledge and academic success. Since there was no statistically significant relationship between the test and the academic results for the Mechanical and Microelectronic and Communication Engineering students, these two programmes were no longer investigated. For the Electrical Power Engineering the correlation results for semester 2 were the most significant (*$r = 0.787$, $p = 0.000$)* showing a "*high"* (Sarantakos, 2005, p377) and "*dependable association*" (Sarantakos, 2005, p380) between the test and average marks for semester 2. Simple linear regression was carried out and a coefficient of determination of 0.619 was calculated suggesting that 61.9% of the semester 2 mark could be explained by the marks achieved in the test. Multiple linear regression was carried out by taking into account the entry degree percentage, age of the student and whether English was the first language, but none of these variables were found to be statistically significant. Therefore, the test remains the best predictor of the academic performance. The original pass mark of fifty percent was found to be too high and a suggested pass mark of twenty five percent was proposed.

For the Electrical Power Engineering students the level of knowledge when entering the programme has been found to be a statistically significant predictor of academic success.

7.2.6 To ensure that international students have the required underpinning knowledge to facilitate academic success when starting specialist Master's programmes with the Faculty of Engineering and Environment of Northumbria University and make a contribution to international student recruitment practice

The current recruitment policy used at Northumbria University for Engineering and Computing students simply asks for an English and academic level and, although English and academic levels differed this was found to be typical across a comparative set of institutions. Even though the results from the Mechanical and Microelectronic and Communications Engineering programmes were not found to have a statistically significant relationship with academic success, they did indicate where the students had a lack of knowledge which the Programme Leaders and Module Tutors thought that in their "expert opinion", they should have. For this reason alone, the tests will be used alongside the English and academic level as a diagnostic tool to inform the students that some extra work in a particular area is required, which will ultimately help with their studies and help reduce the variability between students. The best method identified for reducing this variability is to recruit students through collaboration with other institutions using the augmented articulation process where all the students are at least guaranteed to have studied the same material albeit at different levels of success. This will require Northumbria University to identify strategic partners to work with in a very competitive and volatile market, which will not be easy but will reduce the variability in inputs as shown in Figure 3.4. Recruitment through augmented articulation using the current admissions criteria is the preferred method but for individual students the test will be used along with the current admissions criteria to act as a diagnostic tool and allow remedial work be carried out before the student starts and/or during the programme of study.

7.2.7 Summary of review of research objectives

From the current literature the factors associated with academic success were identified and from these areas the subjects of English language, retention, entry tests and previous academic performance were identified as having been used to predict academic success with variable results. None of the factors accounted for all the variation in the outcome and underpinning knowledge was identified for further research.

Literature on an Educational Supply Chain was reviewed with its beginnings in 1996 and further development from 2004 where it was recognised that every student should have their own supply chain. This eventually led to a proposed Integrated Educational Supply Chain Management (IESCM) model in 2008 which was further developed in to a specific Integrated Tertiary Educational Supply Chain Model

(ITESCM) in 2012 where it was recognised that Universities should have an entrance exam or admissions test to justify the quality of the students. It was quite clearly demonstrated that when a student flows through an educational supply chain there is great scope for variation but this can be minimised when the supply chain is optimised.

A suitable methodology and methods were then developed to determine the relationship between underpinning knowledge and academic success.

The methodology was then applied to determine the level of knowledge that was expected for entry on to three specialist Master's programmes and tested on outgoing UG students. This was a new methodology and methods designed specifically for the study into underpinning knowledge.

Incoming PG students were then tested for their underpinning knowledge and when these results were compared against the UG results it was found that there was between eighty and ninety percent similar knowledge levels across the three programmes of study. There was a statistically significant positive strong relationship between the test of underpinning knowledge and the academic performance for MSc Electrical Power Engineering students.

The tests of underpinning knowledge will be used as part of the application process for students on the specialist Master's programmes for Computing and Engineering students at Northumbria. Augmented articulation agreements have been identified, through the use of educational supply chain theory, as the most suitable method of recruitment to minimise variation in underpinning knowledge.

7.3 Contribution to practice

During this research many things have come to light that have impacted on the author and informed his outlook on how his role is carried out but also many aspects that impact on the wider audience.

One of the first findings of this research identified the different practice that was being used across the University in terms of the language used for describing the level of the UG degree obtained (‘2:1’ or ‘second class honours, upper division’ or ‘class two division one’) but since there does not appear to be any agreed standard a decision has to be made by the University in what language should be adopted. The University website is due for renewal in 2014 and the author has provided feedback to the development team regarding this issue so it is hoped that during the rewriting of the material that at least a common standard can be adopted.

When reviewing entry qualifications, it was noted that the “extra requirements” that admissions tutors looked for on an application were not actually on the web pages and the information that was there was very generic. This is now in the process of being changed and hopefully will be completed with the launch of the new website. Although some tutors argued that it could actually put off students who may have applied without the extra information, this will allow the students to make a better judgement on the suitability of the programme. This also identifies the need for better communication between the designers of new programmes and those who have responsibility for recruitment to ensure that one meets the needs of the other. This link is very clear when setting up an augmented articulation agreement with clear communication between the two parties ensuring that when the students arrive at the University, the teaching staff know exactly what to expect, thus minimising the variation in underpinning knowledge. This is how a supply chain should work.

When reviewing the entry requirements at the competitor institutions it was noted that on the programmes included in the research, 40% asked for a higher academic award and 48% asked for a lower level of English. Based on this and the results of the research carried out by Cownie and Addison (1996) and Seelen (2002) and the success of the reduced English requirements on specific UG programmes at Northumbria, the author requested through University Student Learning and Experience committee to lower its English requirements for the MSc Mechanical Engineering, MSc Electrical Power Engineering, MSc Microelectronic and Communications Engineering and MSc Computer Network Technology to IELTS 6.0 from IELTS 6.5. This then allows the Faculty to compete directly with other Institutions including Newcastle University that specifies IELTS 6.0 on, for instance, its MSc Power programme. However, this will be monitored on annual basis to ensure that students continue to succeed academically.

Working with the Module Tutors and Programme Leaders to provide the questions for the test was an interesting exercise and they were quite intrigued when in certain areas, the student results did not meet their expectations. However, this has allowed Module Tutors to review their modules in terms of what they were delivering, the depth and the language used. The Electrical Power Engineering Programme Leader was very helpful and where one question was particularly high scoring for the UG students but poor for the incoming PG students, it was simply down to the terminology used in different countries for the same thing and was quite easily dealt with once identified. This has helped contribute towards ‘internationalising’ the curriculum even if, at this stage, in a small but important way. Since the academic staff provided the tests and received feedback from them, they now better understand the needs of the students. Shortcomings from both parties are now understood, which will hopefully lead to a better experience for both staff and students.

By viewing the recruitment and delivery of specialist Master's programmes as an educational supply chain it has become very obvious that there can be excessive variation in the levels of knowledge that a student has and that the current admissions criteria of an appropriate level of English language and academic qualification are not the best predictors of academic success. Even though it was the Electrical Power Engineering test that had statistically significant results identifying a positive relationship between underpinning knowledge and academic success, all of the tests are now routinely used when interviewing potential applicants for the MSc Electrical Power Engineering, MSc Microelectronic and Communication Engineering, MSc Mechanical Engineering and MSc Computer Network Technology. These tests are used by staff when they are on recruiting missions and are marked on the spot and feedback given to the student. If they score less than 50%, they are advised that perhaps they may not have the appropriate underpinning knowledge to study the programme and suggestions are made to make up the shortcomings and reapply. In reality they get offers from other institutions based solely on their academic and English levels. If they score more than 50% as long as their academic and English levels are satisfactory, they are made an offer. The students are also counselled on the questions they got wrong and strong suggestions made regarding some reading and extra study they may need to do before arriving at University. A pilot web based system was developed through a student project for providing the questions and automatic marking and it is intended to develop this further in the future. Anecdotally since using the test papers, the Programme Leaders have commented on the fact that they appear to be getting better students who are capable of completing the programme.

The results from this research were presented at the Three Rivers Conference 2014: ‘Broadening Horizons – The Global Graduate’ which is a consortium of Northumbria, Newcastle, Durham, Sunderland and Teesside Universities and focuses on Learning and Teaching research. The conference was on 27th March 2014 at Durham University and the presentation can be found in Appendix 18. The presentation was well received by the audience and several participants commented that the pre testing for knowledge was a good idea as international student qualifications became more diverse. The more contentious issue was the lowering of the English language level, where a member of academic staff came from a humanities background and thought that the English language level at IELTS 6.5 was not sufficient for their students in the first place. However, another academic from an engineering background thought the lowering of English to IELTS 6.0 was suitable as long as the students came from a strong academic background. What he was referring to was a ‘good honours’ degree which would confirm the academic ability of the student, but not necessarily the required underpinning knowledge.

The author has also become a member of the SIG for Internationalisation at the HEA and intends to become more involved and contribute to the work that they do in the future.

As a research supervisor at BEng, MSc and PhD level, the carrying out of this particular research has allowed a better understanding of the different research methodologies available and I now feel in a better position to advise students in this area along with a greater knowledge of statistical analysis and the tools available.

7.4 Contribution to knowledge

As seen in Chapter Two there is a wealth of literature around the subject area of international student education and much of this can be mapped to the International Student Lifecycle. In addition to this many authors have looked at trying to predict academic success using different variables associated with international students such as English Language (Abel, 2002; Cook et al., 2004; Graham, 1987; Light et al., 1987; Seelen, 2002; Van Nelson et al., 2004; Yen & Kuzma, 2009), retention (Brunsden, 2000; Mannan, 2007; Martin, 1988; Murtaugh et al., 1999), entry tests (Marks et al., 1981; Mathews, 2007b; Orlando, 2005) and previous academic qualifications (Alias & Zain, 2006; de Winter & Dodou, 2011; Robinson & Croft, 2003; Stacey & Whittaker, 2005). Several authors (Light et al., 1987; Mathews, 2007b; Stacey & Whittaker, 2005) have identified that the level of knowledge a student has should possibly be included in further research. Pathik and Habib (2012) also identified the need for an entrance exam or admissions test as part of their proposed Integrated Tertiary Education Supply Chain Model (ITESCM) to ensure the correct quality of students. None of these recommendations appear to have been followed up in further studies and none of the factors previously identified to predict academic success account for all the variation in the outcome of predicting academic success. This research has contributed to addressing the gap of using knowledge as a predictor of academic success in determining the relationship between underpinning knowledge and academic success for specialist Master's programmes when viewing the process as an educational supply chain. The degree of variability in the incoming supply chain was identified using supply chain theory and this variability was minimised through the testing of underpinning knowledge. The results from the underpinning knowledge test is related proportionally to the academic success of

Electrical Power Engineering students at the 1% significance level and accounts for 61.9% of their semester 2 average mark. There was no statistically significant relationship between the current entry criteria to the programme and subsequent academic success. The result from this research has provided evidence confirming that there is a relationship between underpinning knowledge and academic success, and adds to the previous factors of English language, entry tests and previous academic performance used to predict academic success identified in Chapter Two. A contribution to methodology and methods is also made due to the novelty of the approach adopted, which is described in Chapter Four. The method used to determine the knowledge requirements in the first instance and the confirmation of this through the use of current UG students was not evidenced in previous research and the actual testing of underpinning knowledge was limited to diagnostic testing of mathematics (Robinson & Croft, 2003). Researchers at other institutions that have identified academic success as a problem may employ a similar test and/or refine it to help identify the level of variation in incoming students and use this information to carry out interventions and predict academic success.

7.5 Reflections on research

Carrying out this research has provided a better understanding of international student education, beyond the relationship between underpinning knowledge and academic success. The International Student Lifecycle encompasses some excellent resources for all those involved in international student education including professional as well as academic staff. This knowledge has allowed informed debate with colleagues, both senior and junior, to ensure the student experience is continually recognised and improved.

Networking and presenting at the annual research conference organised by Newcastle Business School has provided the opportunity for encouragement and consoling when needed. Having the opportunity to discuss with other doctoral students has helped put in to context the problems encountered during this doctoral journey. As a member of academic staff, being a student in the same institution places extra pressure on the whole process, as the need to succeed becomes more important. Seeing the names of those students who started at the same time graduating gave the encouragement needed to continue.

Being a supervised researcher has also allowed me to see what it is like from the "other side" and the importance of the relationship with the supervisor and second supervisor and how all three need to work together harmoniously.

7.6 Limitations to research and suggested further work

Although the review of literature carried out was comprehensive and research related to this study was recognised there is no guarantee that all the work carried out in relation to predicting academic success or testing in the area of international student education has been identified. Using English language and previous academic performance of students as predictors of academic success will continue since these are the two variables that are used to recruit international students and as such new research should emerge continuously. As new research emerges, this can be reviewed in the context of this study and further complementary research carried out. Since it has been shown that there can be correlation between underpinning knowledge and academic success it is the intention to refine and improve the tests for Mechanical Engineering and Microelectronic and Communication Engineering programmes. None of the input variables fully explain the variation in output so this highlights the area for further investigation.

This study highlighted the variation in input variables (students) but also identified that the process capability is key to working with this variation. This capability is the responsibility of the University in ensuring that the academic staff have the required development and training to deal with the incoming variation. This is an area that requires further study as there is no easy way to measure if the process (lecturer) is capable, which is relatively simple to do in a manufacturing process, but not so in a service process with heterogeneous inputs (students) and processes (lecturers).

Through the literature review the research gap was identified but the nature of the research meant that the populations used in the study were always limited by the specific number of specialist programmes and the students enrolled on those programmes agreeing to take part in the research. The Electrical Power Engineering programme had the largest number of students *(n = 21)* and this gave the most promising results. If there had been more students on the other programmes then this could have had an impact on those results. A further group of Electrical Power Engineering students took the test and there was no statistically significant results, but since the group was small (*n = 8*) this could be expected. However everyone passed the test with a mark of 40% or more and went on to succeed academically. Very low student numbers on the other programmes meant that the tests could not be repeated on the Mechanical Engineering or Microelectronic and Communications Engineering programmes. Sadly, as seen in the literature review, the recruitment of international students is becoming more difficult and obtaining larger numbers in the future may not be possible. If and when this happens it would be appropriate to continue the research in all specialist subject areas.

The structure of the final three tests was very different, but this was down to the information provided by the Module Tutors and Programme Leaders and what was required in their ‘expert opinion’. In the authors view the Electrical Power Engineering was structured in the most appropriate manner and allowed a reasonable level of analysis to be carried out, whereas the others were not so. This gave the students the opportunity to confirm their propositional knowledge but also use procedural knowledge for the analysis. For further research to be carried out on the Mechanical Engineering and Microelectronic and Communication Engineering, it is suggested that the structure of the paper be aligned with the Electrical Power Engineering where the most success was achieved.

Although this research is limited to the programmes within the Faculty of Engineering and Environment at Northumbria University, the methodology and methods used could be adopted and applied at any institution delivering specialist Master’s programmes in technical subject areas.

7.7 Summary of chapter

This chapter has reviewed the initial research objectives in light of the findings associated with each one. The contributions to both knowledge and practice have been identified and how they have influenced the author’s understanding in the subject area of international student education. Reflections on the research carried out are presented and then limitations to the research and further work are suggested.

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Appendix 1 Research Organisation informed consent form

RESEARCH **ORGANISATION** INFORMED CONSENT FORM

Newcastle Business School
University of Northumbria

Completion of this form is required whenever research is being undertaken by NBS staff or students within any organisation. This applies to research that is carried out on the premises, or is about an organisation, or members of that organisation or its customers, as specifically targeted as subjects of research.

The researcher must supply an explanation to inform the organisation of the purpose of the study, who is carrying out the study, and who will eventually have access to the results. In particular issues of anonymity and avenues of dissemination and publications of the findings should be brought to the organisations' attention.

Researcher's Name: David Bell

Student ID No. (if applicable) 92605553

Researcher's Statement:

I am currently registered within Newcastle Business School to study for a DBA. The working title of my research is "Predicting and improving post graduate international student success; a model looking at entry characteristics."The main aim of the research is to improve the academic success of international students studying at post graduate level within the School of CEIS at Northumbria University. This will hopefully impact on the continuous growth of international students within the School and help to meet the aims of the corporate strategy.

The objectives to achieve these aims are as listed below:-

1. To analyse the entry requirements for post graduate programmes at a selection of UK universities, to compare with Northumbria
2. To analyse the knowledge expected of post graduate students enrolling on programmes delivered within the School of Computing, Engineering and Information Sciences (CEIS)
3. Create an MCQ test to evaluate the knowledge of prospective post graduate students and confirm the expectations of lecturing staff of students graduating from under graduate programmes within CEIS
4. To evaluate and analyse the entry characteristics of students entering the post graduate programmes within the School of CEIS and analyse them with regard to their exit qualifications
5. To analyse the data collected in 3 and 4 above to determine any characteristics that could indicate success or failure and create a model for future students
6. Evaluate the model using current students to see how reliable it is on predicting success or failure and then use this model on prospective students to accept/reject or identify possible remedial work to help prevent failure.

The intention is to use the post graduate student body to help with objectives 4, 5 and 6 and the final year of the current under graduate students to achieve objective 3. Any student who is involved will be issued with an "Informed Consent" form so that they are fully aware of the purpose of the research and what and how the information will be used. All individual records will be anonymised in any publications that may arise from the research. The intention is then to use the model on prospective students to improve the success of students recruited to specific post graduate programmes within the School of CEIS.

Any organisation manager or representative who is empowered to give consent may do so here:

Name: Professor Alistair Sambell

Position/Title: Dean of School of Computing, Engineering and Information Sciences.

Organisation Name: Northumbria University

Location: Pandon Building, Newcastle upon Tyne. NE2 1XE

Anonymity must be offered to the organisation if it does not wish to be identified in the research report. Confidentiality is more complex and cannot extend to the markers of student work or the reviewers of staff work, but can apply to the published outcomes. If confidentiality is required, what form applies?

[ ] No confidentiality required
[ ] Masking of organisation name in research report
[ ] No publication of the research results without specific organisational consent
[ ] Other by agreement as specified by addendum

Signature: ________________________________ Date: _____________

This form can be signed via email if the accompanying email is attached with the signer's personal email address included. The form cannot be completed by phone, rather should be handled via post

Appendix 2 Example student informed consent form

Newcastle Business School
Informed Consent Form for research participants

Title of Study	Predicting and improving post graduate international student success; a model looking at entry characteristics.
Person(s) conducting the research	David Bell
Programme of study	Doctor of Business Administration.
Address of the researcher for correspondence	School of Computing, Engineering and Information Sciences, Pandon Building, Camden Street, Newcastle upon Tyne. NE1 8ST.
Telephone	0191 227 4724
E-mail	david.bell@northumbria.ac.uk
Description of the broad nature of the research	Confirming the academic expectations to study a specific Masters level qualification. Investigating the possibility of using entry criterion and previous academic knowledge to predict the outcome of a student's achievement on a Masters level qualification.
Description of the involvement expected of participants including the broad nature of questions to be answered or events to be observed or activities to be undertaken, and the expected time commitment	This will involve participants providing basic information about their education prior to coming to study at Masters level and taking a short MCQ test specific to their area of study that will last approximately 15 minutes.

Information obtained in this study, including this consent form, will be kept strictly confidential (i.e. will not be passed to others) and anonymous (i.e. individuals and organisations will not be identified *unless this is expressly excluded in the details given above*).

Data obtained through this research may be reproduced and published in a variety of forms and for a variety of audiences related to the broad nature of the research detailed above. It will not be used for purposes other than those outlined above without your permission.

Participation is entirely voluntary and participants may withdraw at any time.

By signing this consent form, you are indicating that you fully understand the above information and agree to participate in this study on the basis of the above information.

Participant's signature **Date** **Student ID______________**

Researcher's signature **Date**

Please keep one copy of this form for your own records

Appendix 3 Ethics approval from NBS Ethics Committee.

From:	Sarah Boon [s.boon@northumbria.ac.uk]
Sent:	29 April 2010 15:39
To:	David Bell
Subject:	RE: Ethical Approval

Dear David,

I can now confirm that your project entitled 'Predicting and improving post graduate international student success; a model looking at entry characteristics' has now been approved by the Chair of the School Ethics Committee and will be presented at the next School Ethics Committee on the 26th May 2010.

If you have any queries please do not hesitate to contact me.

Kind regards,

Sarah Boon
Administrator

Academic Support Office
Newcastle Business School

☎ 0191 227 3896
@ s.boon@northumbria.ac.uk

Appendix 4 Structure of specialist Master's programmes

Questions for MSc Electrical Power Engineering

The MSc Electrical Power Engineering programme is made up of 180 credits as shown below.

<table>
<tr><th>SEMESTER 1</th><th>SEMESTER 2</th><th>SEMESTER 3</th></tr>
<tr><td>EN0712
Modern Power Engineering
20 Credits</td><td>EN0550
Photovoltaic System Technology
20 Credits</td><td rowspan="4">EN0542
Dissertation
60 Credits</td></tr>
<tr><td>EN0718
Computer Aided Methods for Engineers
20 Credits</td><td>EN0711
Wind Energy Conversion Systems
20 Credits</td></tr>
<tr><td>EN0713
New and Renewable Technology for Electricity Supplies
10 Credits</td><td>EN0549
Photovoltaics – Economics, Policy and Environment
10 Credits</td></tr>
<tr><td colspan="2">IS0749
Research Methods and Project management
20 Credits</td></tr>
</table>

Structure of MSc Electrical Power Engineering programme.

The structure shown above was for students with Semester 1 starting in September 2011.

The breakdown of questions was submitted as shown in the table below.

Module	Module type	Number of questions
EN0711	Deepening	4 (9,11,17,18)
EN0712	Deepening	4 (10,12,19,20)
EN0713	Broadening	0
EN0718	Broadening	0
EN0549	Broadening	0
EN0550	Deepening	4(13-16)
IS0749	Broadening	0
Fundamental		8 (1-8)

Breakdown of questions provided for MSc Electrical Power Engineering programme. .

The finalised test paper that was issued to the students can be found in Appendix xxx.

Questions for MSc Microelectronics and Communications Engineering

The MSc Microelectronics and Communication Engineering programme is made up of 180 credits as shown below.

<table>
<tr><th>SEMESTER 1</th><th>SEMESTER 2</th><th>SEMESTER 3</th></tr>
<tr><td>EN0719
Embedded System Technologies and Design
20 Credits</td><td>EN0720
Digital Design Automation
20 Credits</td><td rowspan="4">EN0542
Dissertation
60 Credits</td></tr>
<tr><td>EN0718
Computer Aided Methods for Engineers
20 Credits</td><td>EN0722
Radio Frequency Communication Systems
20 Credits</td></tr>
<tr><td>EN0519
Silicon Electronic Design
10 Credits</td><td>EP0191
Optical Fibre Communication Systems10 Credits</td></tr>
<tr><td colspan="2">IS0749
Research Methods and Project management
20 Credits</td></tr>
</table>

Structure of MSc Microelectronic and Communication Engineering programme.

The structure shown above was for students with Semester 1 starting in September 2011.

The breakdown of questions was submitted as shown below.

Module	Module type	Number of questions
EN0519	Broadening	0
EN0718	Broadening	0
EN0719	Deepening	5 (15-19)
EN0720	Broadening	0
EN0722	Deepening	4 (6-9)
EP0191	Deepening	4 (1-4)
IS0749	Broadening	0
Fundamental		7 (5, 10-14, 20)

Breakdown of questions provided for MSc Microelectronic and Communication Engineering programme.

The finalised test paper that was issued to the students can be found in Appendix xxx.

Questions for MSc Computer Network Technology

The MSc Computer Network Technology programme is made up of 180 credits as shown below.

<table>
<tr><th>SEMESTER 1</th><th>SEMESTER 2</th><th>SEMESTER 3</th></tr>
<tr><td>EN0715
Optimising Converged Cisco Networks
20 Credits</td><td>EN0716
Building Scalable Cisco Internetworks
20 Credits</td><td rowspan="4">EN0542
Dissertation
60 Credits</td></tr>
<tr><td>EN0714
Implementing Secure Converged Wide Area Networks
20 Credits</td><td>EN0717
Building Cisco Multilayer Switched Networks
20 Credits</td></tr>
<tr><td>EN0519
Silicon Electronic Design
10 Credits</td><td>EN0725
Wireless Computer Network Technology
10 Credits</td></tr>
<tr><td>EN0746
Computer Network Implementation
10 Credits</td><td>EN0726
Network Programming
10 Credits</td></tr>
</table>

Structure of MSc Computer Network Technology programme.

The structure shown above was for students with Semester 1 starting in September 2011.

The breakdown of questions was submitted as shown below.

Module	Module type	Number of questions
EN0566	Broadening	0
EN0714	Deepening	4 (8, 9, 17, 18)
EN0715	Deepening	4 (10,11,12, 20)
EN0716	Deepening	4 (3-6)
EN0717	Deepening	4 (13-16)
EN0725	Broadening	0
EN0726	Broadening	0
EN0746	Broadening	0
Fundamental		4 (1, 2, 7, 19)

Breakdown of questions provided for MSc Computer Network Technology programme.

The finalised test paper that was issued to the students can be found in Appendix xxx.

Appendix 5 Final test paper for Mechanical Engineering

Northumbria University

Students who graduate from the BEng(Hons)Mechanical Engineering programme are believed to have the appropriate knowledge and background to enter the MSc Mechanical Engineering programme.

I am carrying out some research to test this hypothesis so could you please complete the questions in this paper by circling the correct answer.

Please answer all 20 questions under examination conditions (no cheating!!!) and spend no more than 15 minutes answering the questions. If you want to know your results supply an e-mail address below.

Please also sign the attached informed consent form and keep one copy for yourself.

Instructions:

There are 20 questions.

For each of the questions, circle the answer you believe is correct on the paper.

Student name:__________________________ Student ID__________________

E-Mail address:____

Q1 Rearrange the equation below to make **"t"** the subject:

$V = 2t / (t - r)$

a. $t = (V-2)/r$
b. $t = Vr /(V-2)$
c. $t = (V-2)/Vr$
d. $t = r/(V-2)$

Q2 What is the value of '**x**' in the following equation?

$(x+4) / (x+6) = (2x+7) / (2x+10)$

a. 3
b. 2
c. -2
d. -3

Q3 What is the period of the oscillation given by the following?

$y = \text{Sin } 8\pi t$

a. 0.50
b. 0.25
c. 4
d. 8

Q4 Differentiate the following:

$2\text{Sin } 3x$

a. $2\text{Cos } 3x$
b. $-2\text{Cos } 3x$
c. $6\text{Sin}3x$
d. $6\text{Cos}3x$

Q5 The sigma of the "six sigma" quality control system refers to:

a. Standard variation
b. Variance
c. Kurtosis
d. Skewness

Q6 For a random variable with a mean of $\bar{x}$ that is Normally distributed, the 95% confidence interval of this variable is:

a. $\bar{x} \pm \sigma$
b. $\bar{x} \pm 2\sigma$
c. $\bar{x} \pm 2\sigma^2$
d. $\bar{x} \pm 1.96\sigma$

Q7 In engineering design, the aims of optimisation is to:

a. Produce the best design in every aspect
b. Achieve minimum cost
c. Achieve optimality of an objective function given a list of variables and constraints
d. Satisfy customers' needs

Q8 The skewness coefficient of a Normal distribution is:

a. 0 (zero)
b. +1 (plus one)
c. -1 (minus one)
d. +/- 0.5 (plus or minus 0.5)

Q9 A solid rectangular beam (100 mm x 150 mm cross section) is subjected to an axial force of 2.5 kN. The axial stress on the beam is:

a. 137 kN/m^2
b. 15700 N/m^2
c. 167 kN/m^2
d. 19700 N/m^2

Q10 The yield stress of a particular steel is 200 MN/m^2. This steel is used to make a beam with a 'T' cross section. If the factor of safety is 4, what is the maximum allowable bending stress?

a. 45 MN/m^2
b. 50 MN/m^2
c. 55 MN/m^2
d. 60 MN/m^2

Q11 A frame work structure, with pin joints at all connections, can be classified as:

a. a dynamically determined structure
b. a statically determined structure
c. a statically in-determined structure
d. a free structure

Q12 Which of the following materials has the highest yield strength?

a. Aluminium
b. Copper
c. Lead
d. Steel

Q13 A mass is attached to a spring. If the mass is doubled and the stiffness increased by 4 times, what is the new frequency compared to the original value ω_n ?

a. 0.8 ω_n
b. 1.4 ω_n
c. 2.0 ω_n
d. 4.0 ω_n

Q14 The speed of a car is increased from rest to 20 m/s in 8 seconds. What is the total distance travelled?

a. 32 m
b. 56 m
c. 80 m
d. 96 m

Q15 Which of the following materials has the highest value of thermal conductivity?

a. Stone
b. Rubber
c. Wood
d. Gold

Q16 An ideal gas expands from a volume of 1 m^3 to 2 m^3 at a constant pressure of 5 bar. What is the energy required for this process?

a. 10 kJ
b. 50 kJ
c. 100 kJ
d. 500 kJ

Digital Three Dimensional modelling software such as Pro-Engineer, Catia, Solidworks are traditionally either solid or surface modeller!

3D Modelling Creation Features

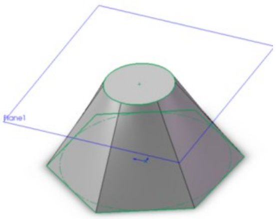


Figure 1

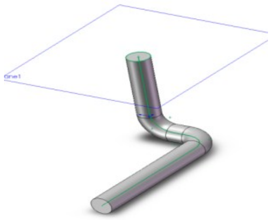


Figure 2

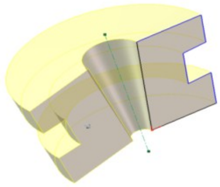


Figure 3

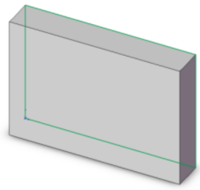


Figure 4

Q17 The feature in **Figure 1** would normally be created from a command called:

a. Sweep
b. Loft
c. Extrude
d. Revolve

Q18 The feature in **Figure 2** would normally be created from a:

a. Sweep
b. Loft
c. Extrude
d. Revolve

Q19 The feature in **Figure 3** would normally be created from a:

e. Sweep
f. Loft
g. Extrude
h. Revolve

Q20 The feature in **Figure 4** would normally be created from a:

a. Sweep
b. Loft
c. Extrude
d. Revolve

Appendix 6 Final test paper for Electrical Power Engineering

Students who graduate from the BEng(Hons)Electrical and Electronic Engineering programme (Heavy current option) are believed to have the appropriate knowledge and background to enter the MSc Electrical Power Engineering programme.

I am carrying out some research to test this hypothesis so could you please complete the questions in this paper by circling the correct answer.

Please answer all 20 questions under examination conditions (no cheating!!!) and spend no more than 15 minutes answering the questions. If you want to know your results supply an e-mail address below.

Please also sign the attached informed consent form and keep one copy for yourself.

Instructions:

There are 20 questions.

For each of the questions, circle the answer you believe is correct on the paper.

Student name:__________________________ Student ID______________________

E-Mail address:____

MSc Electrical Power Engineering

Q1 If an a,c, voltage has a peak value of 100 V, the r.m.s. value is:

a. 100 V
b. 141 V
c. 50 V
d. 71 V

Q2 In three-phase star connected systems, if the phase voltage is 230 V, the line voltage is:

a. 108 V
b. 230 V
c. 400 V
d. 0 V

Q3 In three-phase circuits with unbalanced linear phase currents:

a. No neutral return current conductor is required
b. Neutral return current conductor which has the same size as the other three conductors is recommended
c. Neutral return current conductor with twice the size of other conductors is recommended
d. Neutral current conductor with very small diameter is required

Q4 The average power consumed in a resistor is:

a. Current times resistance squared
b. Voltage squared times resistance
c. Current squared times resistance
d. Current divided by resistance

Q5 When a capacitor is connected to an a.c. supply:

a. The current drawn by the capacitor leads the voltage by 90°.
b. The current drawn lags the voltage by 90°.
c. The current is in phase with the voltage.
d. The current leads the voltage by an angle which depends on the frequency.

Q6 The power factor angle is the angle between:

a. The apparent power and active power
b. The voltage and current
c. Either a or b
d. Neither a nor b

Q7 A current of 10 A flows in an impedance of (20+j10) Ω, the active and reactive power are:

a. 4 kW and 1 kVAr
b. 1 kW and 2 kVAr
c. 2 kW and 1 kVAr
d. 1 kW and 4 kVAr

Q8 Customers with low power factor equipment may be charged extra by the utility because, for the same real load power:

a. They draw more current than equivalent unity power factor equipment
b. They consume more reactive power than unity power factor equipment
c. They cause increased power loss in the supply system
d. All of the above

Q9 A step-down transformer reduces the secondary (output) voltage as compared to the primary (supply) voltage. The current in the secondary winding is:

a. Less than the current in the primary winding
b. More than the current in the primary winding
c. Equal to the current in the primary winding
d. Independent of the current in the primary winding

Q10 Which of the following three-phase transformer connections is usually used to deal with the third harmonic currents in power distribution networks:

a. Delta $(\Delta) - Star\ (Y)$
b. $Delat\ (\Delta) - Delta(\Delta)$
c. $Star\ (Y) - Star(Y)$
d. $Star\ (Y) -\ Delta\ (\Delta)$

Q11 In a turbine generation system supplying its own load, the frequency of the output voltage can be controlled by:

a. Controlling the excitation voltage
b. Controlling the fuel fed to the turbine
c. Controlling the line impedance
d. Either a or b

Q12 In a grid connected turbine generation system, if the excitation voltage is increased:

a. Reactive power is supplied to the grid
b. Reactive power is absorbed from the grid
c. Active power is supplied to the grid
d. Active power is absorbed from the grid

Q13 A Silicon Controlled Rectifier (thyristor) is switched off by:

a) Switching off the gate voltage
b) Reducing the main (Anode-Cathode) current to zero
c) Applying a reverse voltage to the gate
d) Connecting the gate terminal to the Cathode terminal

Q14 A heat-sink is used with high-power electronic devices in order to:

a) Maintain a constant temperature
b) Remove heat produced by power losses within the device
c) Heat the device to make it more conductive
d) Increase the efficiency

Q15 Some of the main sources of greenhouses gases:

a) Burning of fossil fuels and deforestation leading to higher carbon dioxide concentrations
b) Use of chlorofluorocarbons (CFCs) in refrigeration systems
c) The use of fertilizers, that lead to higher nitrous oxide concentrations
d) All of the above

Q16 The output voltage waveform of a photovoltaic cell is:

a) Pure sinusoidal
b) PWM sinusoidal
c) D.C.
d) Square

Q17 The synchronous speed of an induction machine with 4 poles running at 50 Hz is:

a) 1200 rpm
b) 1500 rpm
c) 1800 rpm
d) 200 rpm

Q18 An induction machine based wind turbine can run at variable speed if a power converter is connected at the generator terminal in order to:

a. Vary the frequency of the generated voltage
b. Vary the generator output current
c. Vary the magnitude of the generated voltage
d. Both a and c

Q19 Transformers are used to step up the voltage for transmission of bulk power over long distances. High transmission voltages are required in order to:

a. Increase the current
b. Increase the frequency
c. Reduce the current and produce lower resistive losses
d. Reduce the reactive power loss in the line

Q20 The transmission system parameters that determine power flow are:

a. Voltages, impedance and phase angle
b. Voltages, currents and rated frequency
c. Rated frequency
d. Reactance and phase angle

Appendix 7 Final test paper for Computer Network Technology

Students who graduate from the BSc(Hons)Computer Network Technology programme are believed to have the appropriate knowledge and background to enter the MSc Computer Network Technology programme.

I am carrying out some research to test this hypothesis so could you please complete the questions in this paper by circling the correct answer.

Please answer all 20 questions under examination conditions (no cheating!!!) and spend no more than 15 minutes answering the questions. If you want to know your results supply an e-mail address below.

Please also sign the attached informed consent form and keep one copy for yourself.

Instructions:

There are 20 questions.

For each of the questions, circle the answer you believe is correct on the paper.

Student name:_________________________ Student ID________________

E-Mail address:____

Q1 Which function does a router **NOT** do?

e. Forward data based on layer 3 addresses
f. Calculate the best route to a destination
g. Forward data based in layer 2 addresses
h. Exchange routing tables with other routers

Q2 What is the minimum number of physical interfaces needed by a useful router?

e. 0
f. 1
g. 2
h. 3

Q3 What is a default route?

e. The route that is set when the router powers up
f. A route that is set by the administrator to deal with packets whose destination is not in the routing table
g. The route learned from external routers
h. A route that is used for all ICMP packets

Q4 Which is an advantage of static routing?

e. It has a low processor overhead
f. It is really simple to configure
g. The routes do not change
h. They need little administrator intervention once set

Q5 Which is an advantage of dynamic routing?

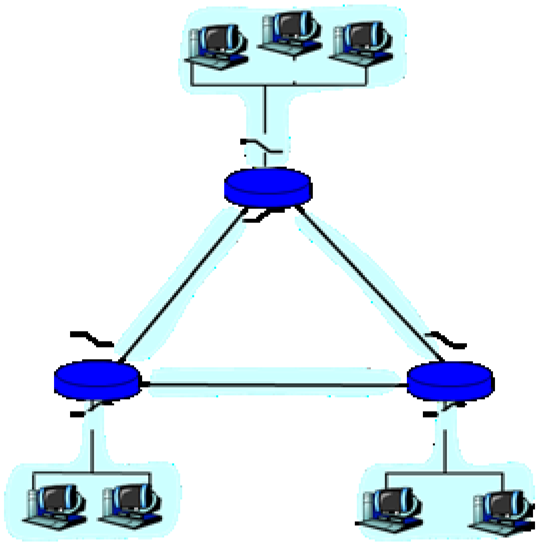
a. It is the fastest type of routing
b. Once set it needs little maintenance
c. It requires only a few CPU cycles to compute
d. It minimises the waste of data exchanged between routers

Q6 What is a directly connected route?

e. A network connected on a serial interface
f. A network connected on a Fast Ethernet Interface
g. A network connected on a Giga Ethernet Interface
h. Any network connected to a physical interface on a router

Q7 How many networks exist in the diagram below?

a. 3
b. 4
c. 5
d. 6



Q8 What is the binary equivalent of the IP address 192.168.0.1?

e. 11000000 11101000 00000000 00000001
f. 11000000 10101010 00000000 00000001
g. 11000000 10101000 00000000 00000001
h. 11100000 10101000 00000000 00000001

Q9 What is the binary equivalent of the subnet mask address 255.255.0.0?

e. 11111111 11111111 00000000 00000000
f. 11111111 11111111 00000000 11111111
g. 11111111 11111111 11111111 00000000
h. 11111111 01010101 00000000 00000000

Q10 What Class of address does 192.168.0.1 belong to?

e. A
f. B
g. C
h. D

Q11 What Class of address does 19.8.0.1 belong to?

e. A
f. B
g. C
h. E

Q12 What Class of address does 250.8.0.1 belong to?

e. A
f. B
g. C
h. E

Q13 What happens in a hub based network when two devices try to communicate simultaneously?

e. The data packets simply pass each other on the wire and carry on undamaged to the destination
f. A data collision occurs and both devices try to transmit again
g. Data packets are automatically interleaved with hub technology, so there is no problem
h. The hub stores the data packet from each sender and forwards the packets on a round robin basis

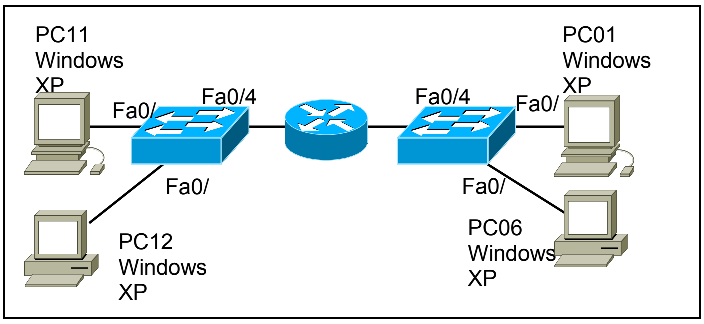
Q14 A device transmits a 10MByte file on a 10BaseT network. Approximately how many seconds would the file take to transmit with no other traffic present?

e. (10 * 1.02) /10
f. (10 * 8) /10
g. (10 * 8 * 1.02) /10
h. (10 *1.02) /(10 *8)

Q15 How does a CSMA/CD do the Collision Detect part?

e. It can detect ‘garbled’ data
f. It detects over-current because too much current is being injected on the line
g. It detects over-voltage when two signals superpose on each other
h. It can detect unique signatures from each sender and then knows if it is receiving two signals at once

Q16 In the figure below – how many broadcast domains and how many collision domains can you see?



e. 2 Broadcast, 6 Collision
f. 6 Broadcast, 6 Collision
g. 2 Broadcast, 2 Collision
h. 6 Broadcast, 2 Collision

Q17 Which of the following can be used to describe the subnet mask 255.255.255.0 ?

a. /32
b. /24
c. /16
d. /8

Q18 Which of the following can be used to describe the subnet mask 255.255.0.0 ?

a. /32
b. /24
c. /16
d. /8

Q19 Which of the following is **NOT** a routing protocol?

a. Rip
b. OSPF
c. EIGRP
d. PPP

Q20 Which of the following is a private network address?

a. 192.168.1.0
b. 192.168.1.1
c. 25.25.1.1
d. 200.1.1.1

Appendix 8 Final test paper for Microelectronic and Communication Engineering

Students who graduate from the BEng(Hons)Electrical and Electronic Engineering and BEng(Hons) Communication and Electronic Engineering programmes are believed to have the appropriate knowledge and background to enter the MSc Microelectronic and Communication Engineering programme.

I am carrying out some research to test this hypothesis so could you please complete the questions in this paper by circling the correct answer.

Please answer all 20 questions under examination conditions (no cheating!!!) and spend no more than 15 minutes answering the questions. If you want to know your results supply an e-mail address below.

Please also sign the attached informed consent form and keep one copy for yourself.

Instructions:

There are 20 questions.

For each of the questions, circle the answer you believe is correct on the paper.

Student name:__________________________ Student ID______________________

E-Mail address:____

Q1 When light travelling in air is incident on the smooth surface of a glass block the light is generally:

a. All reflected
b. All refracted
c. Partially reflected and partially refracted
d. All diffracted

Q2 When light is incident at a smooth interface between two optical materials the following is true:

a. The incident, reflected and refracted rays and the normal to the surface all point in the same direction
b. The incident, reflected and refracted rays and the normal to the surface all lie in the same plane
c. The incident, reflected and refracted rays and the normal to the surface are all perpendicular to one another
d. None of the above

Q3 The refractive index of a material is defined as:

a. The ratio of the speed of light in a vacuum to the speed of light in the material
b. The speed of light in the material
c. The speed of sound in the material
d. The ratio of the speed of sound in a vacuum to the speed of sound in the material

Q4 Essential components of any optical fibre communication system are:

a. Light source, fibre, receiver
b. Light source, coaxial cable, receiver
c. Light source, receiver
d. Fibre only

Q5 You digitize a 10 kHz optical signal by sampling it at twice this frequency and encode the intensity data in 7 bits. What is the resulting data rate?

a. 20 kbit/s
b. 56 kbit/s
c. 140 kbit/s
d. 1.28 Mbit/s

Q6 The minimum bandwidth of Multisymbol NRZ baseband signalling is:

a. The bit rate
b. The baud rate
c. Half the bit rate
d. Half the baud rate

Q7 For a fixed bit rate, using more symbols results in:

a. A bigger bandwidth
b. Smaller bandwidth
c. No bandwidth change
d. A carrier frequency

Q8 The spectrum of an envelope amplitude modulated transmission consists of:

a. 1 sideband
b. 2 sidebands
c. A carrier frequency and 2 sidebands
d. A carrier frequency only

Q9 Frequency modulation occupies:

a. More bandwidth than AM
b. Less bandwidth than AM
c. The same bandwidth as AM
d. Same bandwidth as baseband transmission

Q10 The ideal product of any 2 sinusoidal signals always produces:

a. Product of their frequencies
b. Sum and difference of their frequencies
c. Sum of their frequencies only
d. Frequency modulation

Q11 In an eight bit microprocessor system the following is **true**:

a. The address bus is 8 bits
b. The data bus is 8 bits
c. Both the address bus and data bus are 8 bits
d. The address bus and data bus together add up to 8 bits

Q12 ROM memory can be:

a. Both written to and read from
b. Only written to
c. Only read from
d. Cannot be read from or written to

Q13 RAM memory can be:

a. Both written to and read from
b. Only written to
c. Only read from
d. Cannot be read from or written to

Q14 Flash memory can be:

a. Both written to and read from
b. Only written to
c. Only read from
d. Cannot be read from or written to

Q15 Which type of memory is used to contain the program of a microcontroller?

a. RAM memory
b. Flash memory
c. Both RAM and Flash memory
d. Neither RAM or Flash memory as the program is hard wired into the microcontroller

Q16 Which type of memory is used to contain the data used by a microcontroller?

a. RAM memory
b. Flash memory
c. Both RAM and Flash memory
d. Data is contained in memory outside the microcontroller

Q17 What is the first type of program that must be written by the Embedded system designer?

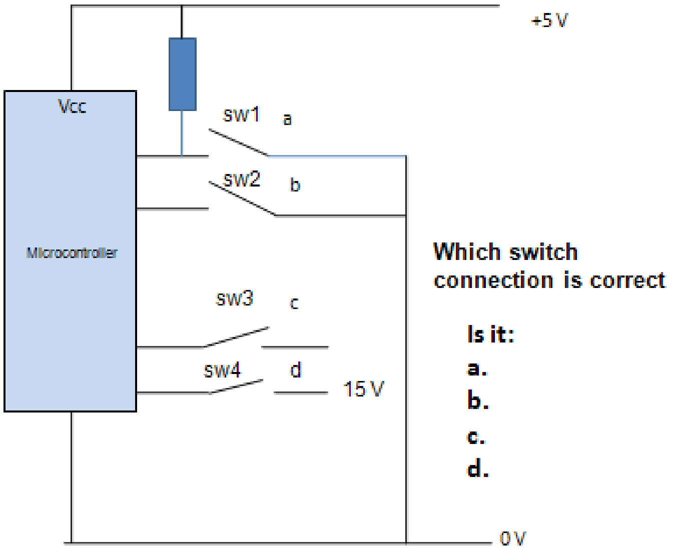
a. A machine code program
b. An assembly language program
c. An object program
d. A list file

Q18 A microcontroller register is:

a. A memory location that can be both written to and read from
b. A specially named memory location used to store data inside the microcontroller
c. A memory location used to perform special tasks
d. Any memory location inside the microcontroller

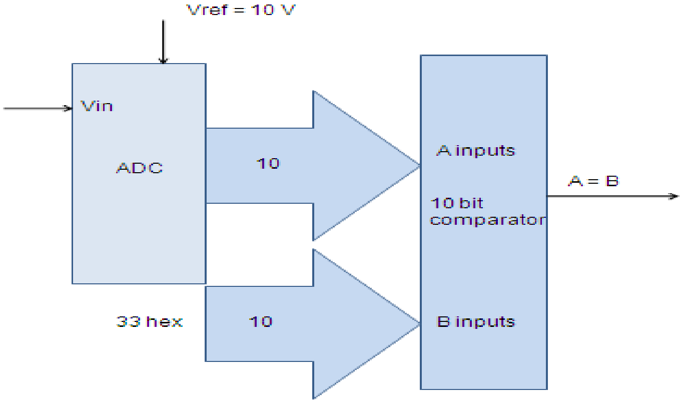
Q19 The following diagram shows a number of ways of connecting a switch to the input port of a microcontroller.

Choose the correct connection: (Assume inputs do not have internal pull-ups).



Q20 In the block diagram below, the inputs B of the ten bit comparator are 33 hex. What is the analogue input to the ADC in order to obtain an output of logic 1 from the comparator?

a. 0.05 Volt
b. 0.5 Volt
c. 5 Volt
d. 10 Volts



Appendix 9 Mechanical Engineering *t-test* results

Independent Samples Test for Mechanical Engineering test UG_PG

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									Interval of the	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Q1	Equal variances	7.886	.007	1.907	51	.062	.286	.150	-.015	.587
	Unequal variances			1.990	28.160	.056	.286	.144	-.008	.580
Q2	Equal variances	10.180	.002	1.550	51	.127	.233	.151	-.069	.536
	Unequal variances			1.621	28.313	.116	.233	.144	-.061	.528
Q3	Equal variances	.189	.665	.223	51	.824	.030	.134	-.239	.298
	Unequal variances			.217	24.377	.830	.030	.137	-.253	.313
Q4	Equal variances	1.002	.322	.473	51	.638	.063	.133	-.205	.331
	Unequal variances			.489	27.589	.629	.063	.129	-.201	.328
Q5	Equal variances	7.030	.011	-2.385	51	.021	-.323	.135	-.595	-.051
	Unequal variances			-2.163	21.451	.042	-.323	.149	-.633	-.013
Q6	Equal variances	11.178	.002	1.665	51	.102	.147	.088	-.030	.325
	Unequal variances			1.304	17.405	.209	.147	.113	-.091	.385
Q7	Equal variances	.491	.487	-.389	51	.699	-.058	.149	-.357	.241
	Unequal variances			-.380	24.530	.707	-.058	.152	-.372	.256
Q8	Equal variances	56.675	.000	4.087	51	.000	.414	.101	.211	.617
	Unequal variances			2.994	16.168	.009	.414	.138	.121	.707
Q9	Equal variances	3.581	.064	.873	51	.387	.091	.104	-.118	.301
	Unequal variances			1.018	36.711	.316	.091	.090	-.090	.273
Q10	Equal variances	1.943	.169	.662	51	.511	.065	.098	-.132	.262
	Unequal variances			.748	34.004	.460	.065	.087	-.111	.241
Q11	Equal variances	.015	.905	-.060	51	.953	-.009	.147	-.304	.287
	Unequal variances			-.059	25.376	.953	-.009	.148	-.314	.296
Q12	Equal variances	.003	.959	-.026	51	.980	-.004	.137	-.279	.272
	Unequal variances			-.025	25.137	.980	-.004	.139	-.289	.282
Q13	Equal variances	.317	.576	.285	51	.777	.028	.098	-.170	.226
	Unequal variances			.270	23.134	.789	.028	.104	-.187	.243
Q14	Equal variances	3.764	.058	-1.181	51	.243	-.163	.138	-.441	.114
	Unequal variances			-1.099	22.427	.283	-.163	.148	-.471	.144
Q15	Equal variances	.764	.386	.426	51	.672	.039	.091	-.143	.221
	Unequal variances			.462	30.805	.648	.039	.084	-.132	.209
Q16	Equal variances	8.418	.005	-1.251	51	.217	-.144	.115	-.375	.087
	Unequal variances			-1.522	40.822	.136	-.144	.095	-.335	.047
Q17	Equal variances	.520	.474	-.907	51	.369	-.139	.153	-.445	.168
	Unequal variances			-.890	24.780	.382	-.139	.156	-.459	.182
Q18	Equal variances	3.962	.052	.865	51	.391	.128	.148	-.169	.425
	Unequal variances			.896	27.696	.378	.128	.143	-.165	.421
Q19	Equal variances	1.281	.263	.521	51	.604	.075	.145	-.215	.366
	Unequal variances			.533	26.917	.599	.075	.142	-.215	.366
Q20	Equal variances	8.725	.005	1.303	51	.198	.105	.081	-.057	.267
	Unequal variances			2.086	37.000	.044	.105	.050	.003	.207

Appendix 10 Electrical Power Engineering *t-test* results

Independent Samples Test for EEE Heavy Current test UG_PG

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									Interval of the	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Q1	Equal variances	3.201	.080	-.899	48	.373	-.100	.111	-.324	.124
	Unequal variances			-.868	37.275	.391	-.100	.115	-.334	.134
Q2	Equal variances	21.074	.000	-6.293	48	.000	-.645	.103	-.852	-.439
	Unequal variances			-5.773	28.955	.000	-.645	.112	-.874	-.417
Q3	Equal variances	.040	.842	.102	48	.919	.015	.144	-.275	.305
	Unequal variances			.102	42.953	.919	.015	.145	-.277	.306
Q4	Equal variances	6.967	.011	1.222	48	.228	.069	.056	-.045	.182
	Unequal variances			1.440	28.000	.161	.069	.048	-.029	.167
Q5	Equal variances	.117	.733	-.518	48	.607	-.076	.146	-.368	.217
	Unequal variances			-.517	42.967	.607	-.076	.146	-.370	.219
Q6	Equal variances	1.119	.295	.674	48	.503	.097	.144	-.192	.386
	Unequal variances			.670	42.319	.506	.097	.144	-.195	.388
Q7	Equal variances	123.733	.000	-3.337	48	.002	-.286	.086	-.458	-.114
	Unequal variances			-2.828	20.000	.010	-.286	.101	-.496	-.075
Q8	Equal variances	.787	.380	.434	48	.666	.059	.136	-.215	.333
	Unequal variances			.437	44.334	.664	.059	.135	-.213	.331
Q9	Equal variances	2.011	.163	-.925	48	.360	-.131	.142	-.417	.154
	Unequal variances			-.917	41.763	.365	-.131	.143	-.421	.158
Q10	Equal variances	2.765	.103	.802	48	.427	.107	.133	-.161	.374
	Unequal variances			.815	45.622	.419	.107	.131	-.157	.370
Q11	Equal variances	.701	.407	.430	48	.669	.057	.134	-.211	.326
	Unequal variances			.425	41.661	.673	.057	.135	-.215	.330
Q12	Equal variances	.701	.407	.430	48	.669	.057	.134	-.211	.326
	Unequal variances			.425	41.661	.673	.057	.135	-.215	.330
Q13	Equal variances	21.891	.000	3.166	48	.003	.386	.122	.141	.631
	Unequal variances			2.984	33.190	.005	.386	.129	.123	.649
Q14	Equal variances	52.361	.000	3.115	48	.003	.388	.124	.137	.638
	Unequal variances			3.370	46.421	.002	.388	.115	.156	.619
Q15	Equal variances	.701	.407	-.430	48	.669	-.057	.134	-.326	.211
	Unequal variances			-.425	41.661	.673	-.057	.135	-.330	.215
Q16	Equal variances	1.844	.181	-.704	48	.485	-.092	.131	-.355	.171
	Unequal variances			-.692	40.460	.493	-.092	.133	-.360	.176
Q17	Equal variances	12.987	.001	-2.033	48	.048	-.256	.126	-.509	-.003
	Unequal variances			-1.945	35.695	.060	-.256	.132	-.523	.011
Q18	Equal variances	1.243	.271	-.563	48	.576	-.066	.117	-.300	.169
	Unequal variances			-.552	39.810	.584	-.066	.119	-.306	.175
Q19	Equal variances	6.281	.016	-1.351	48	.183	-.174	.129	-.433	.085
	Unequal variances			-1.310	38.098	.198	-.174	.133	-.443	.095
Q20	Equal variances	2.233	.142	-.849	48	.400	-.118	.139	-.398	.162
	Unequal variances			-.838	41.275	.407	-.118	.141	-.403	.167

Appendix 11 Microelectronic and Communication Engineering *t-test* results

Independent Samples Test for EEE Light Current test UG_PG

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									Interval of the	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Uq1	Equal variances	7.922	.009	-1.206	25	.239	-.125	.104	-.338	.088
	Unequal variances			-1.464	15.000	.164	-.125	.085	-.307	.057
uq2	Equal variances	5.326	.030	2.438	25	.022	.443	.182	.069	.818
	Unequal variances			2.538	24.223	.018	.443	.175	.083	.803
uq3	Equal variances	3.118	.090	-.824	25	.418	-.063	.076	-.219	.094
	Unequal variances			-1.000	15.000	.333	-.063	.063	-.196	.071
uq4	Equal variances	.614	.441	.394	25	.697	.057	.144	-.240	.354
	Unequal variances			.382	19.140	.707	.057	.149	-.255	.368
uq5	Equal variances	.466	.501	-.855	25	.401	-.170	.199	-.581	.240
	Unequal variances			-.848	21.012	.406	-.170	.201	-.589	.248
uq6	Equal variances	15.889	.001	-6.643	25	.000	-.813	.122	-1.064	-.561
	Unequal variances			-8.062	15.000	.000	-.813	.101	-1.027	-.598
uq7	Equal variances	1.235	.277	.536	25	.597	.102	.191	-.291	.495
	Unequal variances			.543	22.608	.592	.102	.188	-.288	.492
uq8	Equal variances	5.326	.030	-1.063	25	.298	-.193	.182	-.568	.181
	Unequal variances			-1.106	24.223	.280	-.193	.175	-.553	.167
uq9	Equal variances	.466	.501	-.855	25	.401	-.170	.199	-.581	.240
	Unequal variances			-.848	21.012	.406	-.170	.201	-.589	.248
uq10	Equal variances	.014	.908	-1.330	25	.196	-.261	.197	-.666	.143
	Unequal variances			-1.327	21.522	.198	-.261	.197	-.670	.147
uq11	Equal variances	10.433	.003	1.357	25	.187	.222	.163	-.115	.558
	Unequal variances			1.474	24.879	.153	.222	.150	-.088	.531
uq12	Equal variances	.005	.943	-.036	25	.972	-.006	.158	-.331	.320
	Unequal variances			-.036	21.603	.972	-.006	.158	-.334	.323
uq13	Equal variances	15.889	.001	-1.533	25	.138	-.188	.122	-.439	.064
	Unequal variances			-1.861	15.000	.083	-.188	.101	-.402	.027
uq14	Equal variances	5.275	.030	-1.027	25	.314	-.159	.155	-.478	.160
	Unequal variances			-1.104	25.000	.280	-.159	.144	-.456	.138
uq15	Equal variances	1.411	.246	-.730	25	.472	-.142	.194	-.543	.259
	Unequal variances			-.718	20.361	.481	-.142	.198	-.554	.270
uq16	Equal variances	1.235	.277	1.846	25	.077	.352	.191	-.041	.745
	Unequal variances			1.871	22.608	.074	.352	.188	-.038	.742
uq17	Equal variances	3.082	.091	1.091	25	.286	.205	.187	-.182	.591
	Unequal variances			1.059	19.347	.303	.205	.193	-.199	.608
uq18	Equal variances	.983	.331	-.506	25	.617	-.085	.168	-.432	.262
	Unequal variances			-.492	19.461	.628	-.085	.173	-.447	.277
uq19	Equal variances	.983	.331	.506	25	.617	.085	.168	-.262	.432
	Unequal variances			.492	19.461	.628	.085	.173	-.277	.447
uq20	Equal variances	.064	.803	-.127	25	.900	-.023	.178	-.390	.345
	Unequal variances			-.126	21.012	.901	-.023	.180	-.397	.351

Appendix 12

Simple linear regression of Modules EN0711, EN0712 and EN0550 and their associated test questions

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
MEN0712	21	30	81	55.19	12.734	162.162	-.192	.501	.007	.972
MEN0550	21	27	81	56.10	13.856	191.990	.211	.501	-.119	.972
MEN0711	21	42	96	71.86	11.930	142.329	-.444	.501	1.048	.972
EN0711	21	.00	100.00	54.7619	26.94792	726.190	-.151	.501	-.631	.972
EN0712	21	25.00	100.00	57.1429	23.90457	571.429	.495	.501	-.443	.972
EN0550	21	25.000	100.000	69.04762	23.591261	556.548	-.263	.501	-.692	.972
Valid N	21									

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	EN0712[b]	.	Enter

a. Dependent Variable: MEN0712

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.574[a]	.330	.295	10.696

a. Predictors: (Constant), EN0712

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1069.689	1	1069.689	9.351	.006[b]
	Residual	2173.549	19	114.397		
	Total	3243.238	20			

a. Dependent Variable: MEN0712

b. Predictors: (Constant), EN0712

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37.708	6.175		6.106	.000
	EN0712	.306	.100	.574	3.058	.006

a. Dependent Variable: MEN0712

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	EN0550[b]	.	Enter

a. Dependent Variable: MEN0550

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.495[a]	.245	.205	12.351

a. Predictors: (Constant), EN0550

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	941.299	1	941.299	6.170	.022[b]
	Residual	2898.511	19	152.553		
	Total	3839.810	20			

a. Dependent Variable: MEN0550

b. Predictors: (Constant), EN0550

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	36.016	8.521		4.227	.000
	EN0550	.291	.117	.495	2.484	.022

a. Dependent Variable: MEN0550

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	EN0711[b]	.	Enter

a. Dependent Variable: MEN0711

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.640[a]	.409	.378	9.406

a. Predictors: (Constant), EN0711

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1165.489	1	1165.489	13.173	.002[b]
	Residual	1681.082	19	88.478		
	Total	2846.571	20			

a. Dependent Variable: MEN0711

b. Predictors: (Constant), EN0711

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	56.344	4.742		11.883	.000
	EN0711	.283	.078	.640	3.629	.002

a. Dependent Variable: MEN0711

Appendix 13

Output data from SPSS for simple linear regression analysis of test and average of both semester marks for Electrical Power Engineering students.

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Test[b]	.	Enter

a. Dependent Variable: Average

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.762[a]	.581	.559	6.04222

a. Predictors: (Constant), Test

b. Dependent Variable: Average

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	961.930	1	961.930	26.348	.000[b]
	Residual	693.660	19	36.508		
	Total	1655.590	20			

a. Dependent Variable: Average

b. Predictors: (Constant), Test

Coefficients[a]

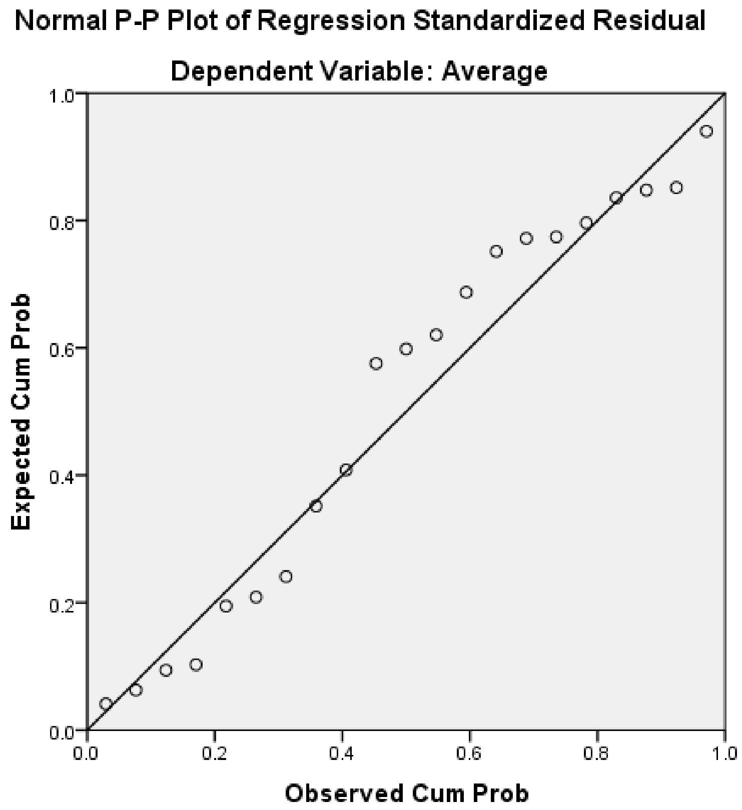
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	40.646	4.539		8.955	.000
	Test	.370	.072	.762	5.133	.000

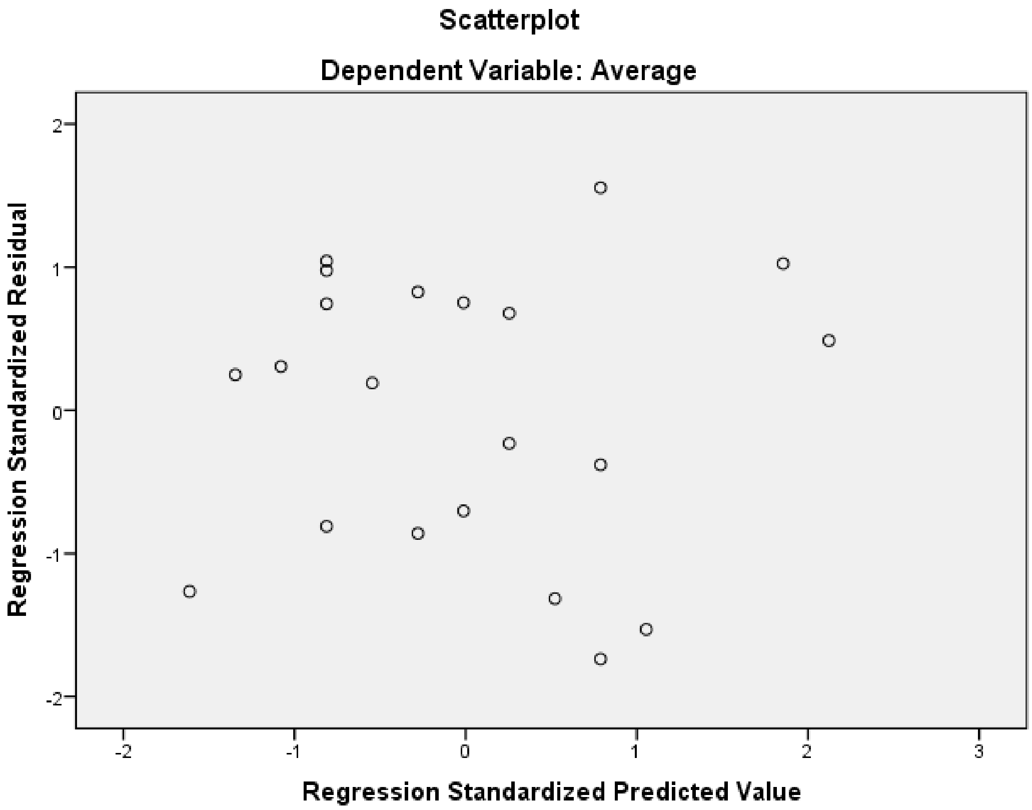
a. Dependent Variable: Average

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	51.7478	77.6528	62.9381	6.93516	21
Residual	-10.50105	9.39895	.00000	5.88923	21
Std. Predicted Value	-1.614	2.122	.000	1.000	21
Std. Residual	-1.738	1.556	.000	.975	21

a. Dependent Variable: Average


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Average
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: Average
Regression Standardized Residual
Regression Standardized Predicted Value
-2
-1
0
1
2
3

Appendix 14

Output data from SPSS for simple linear regression analysis of test and Semester 1 marks for Electrical Power Engineering students.

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Test[b]	.	Enter

a. Dependent Variable: Sem_1

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.685[a]	.470	.442	7.76229

a. Predictors: (Constant), Test

b. Dependent Variable: Sem_1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1013.261	1	1013.261	16.817	.001[b]
	Residual	1144.811	19	60.253		
	Total	2158.072	20			

a. Dependent Variable: Sem_1

b. Predictors: (Constant), Test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	38.968	5.831		6.683	.000
	Test	.380	.093	.685	4.101	.001

a. Dependent Variable: Sem_1

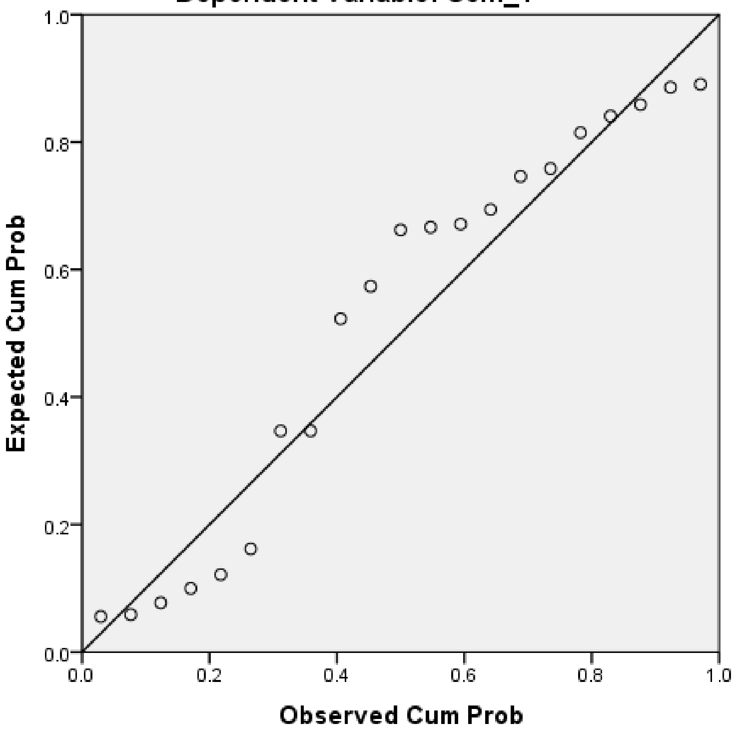
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	50.3627	76.9499	61.8476	7.11780	21
Residual	-12.36268	9.54007	.00000	7.56575	21
Std. Predicted Value	-1.614	2.122	.000	1.000	21
Std. Residual	-1.593	1.229	.000	.975	21

a. Dependent Variable: Sem_1

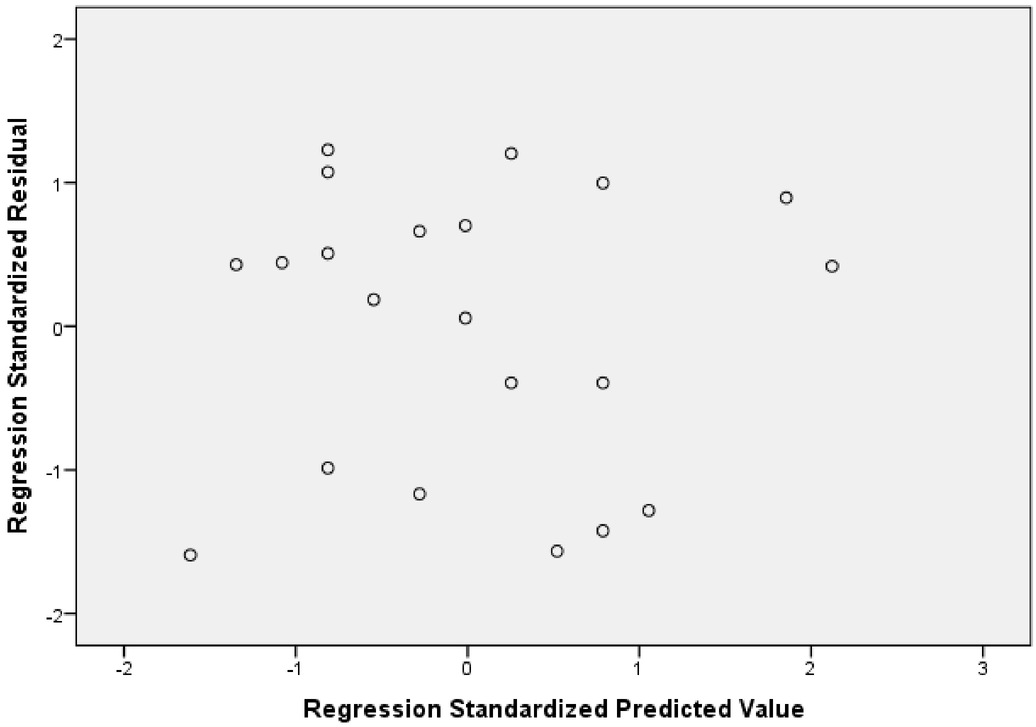
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: Sem_1



Scatterplot

Dependent Variable: Sem_1



Appendix 15

Output data from SPSS for simple linear regression analysis of test and Semester 2 marks for Electrical Power Engineering students.

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Test[b]	.	Enter

a. Dependent Variable: Sem_2

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.787[a]	.619	.599	5.48848

a. Predictors: (Constant), Test

b. Dependent Variable: Sem_2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	928.704	1	928.704	30.830	.000[b]
	Residual	572.346	19	30.123		
	Total	1501.050	20			

a. Dependent Variable: Sem_2

b. Predictors: (Constant), Test

Coefficients[a]

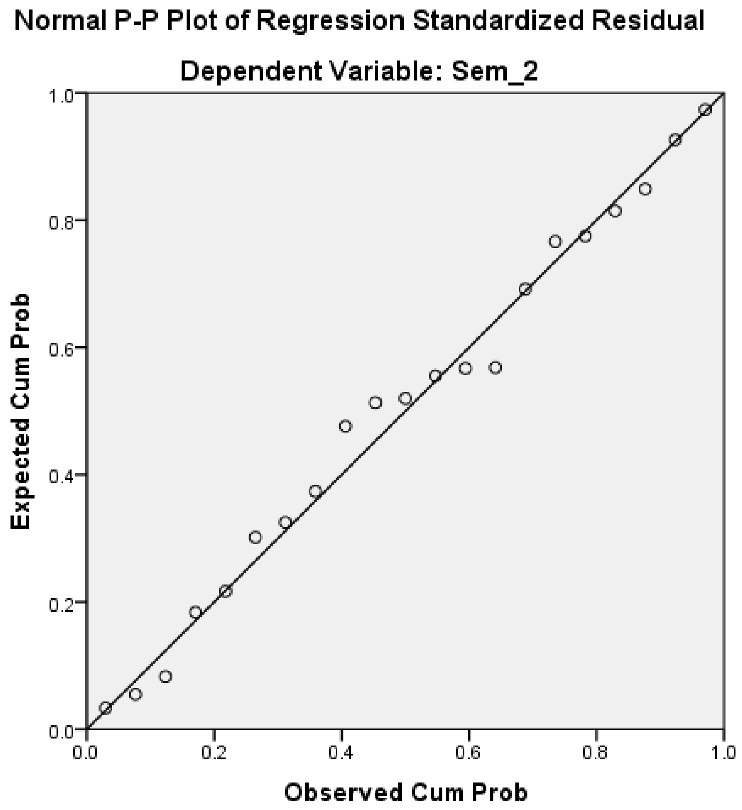
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	41.791	4.123		10.137	.000
	Test	.364	.065	.787	5.552	.000

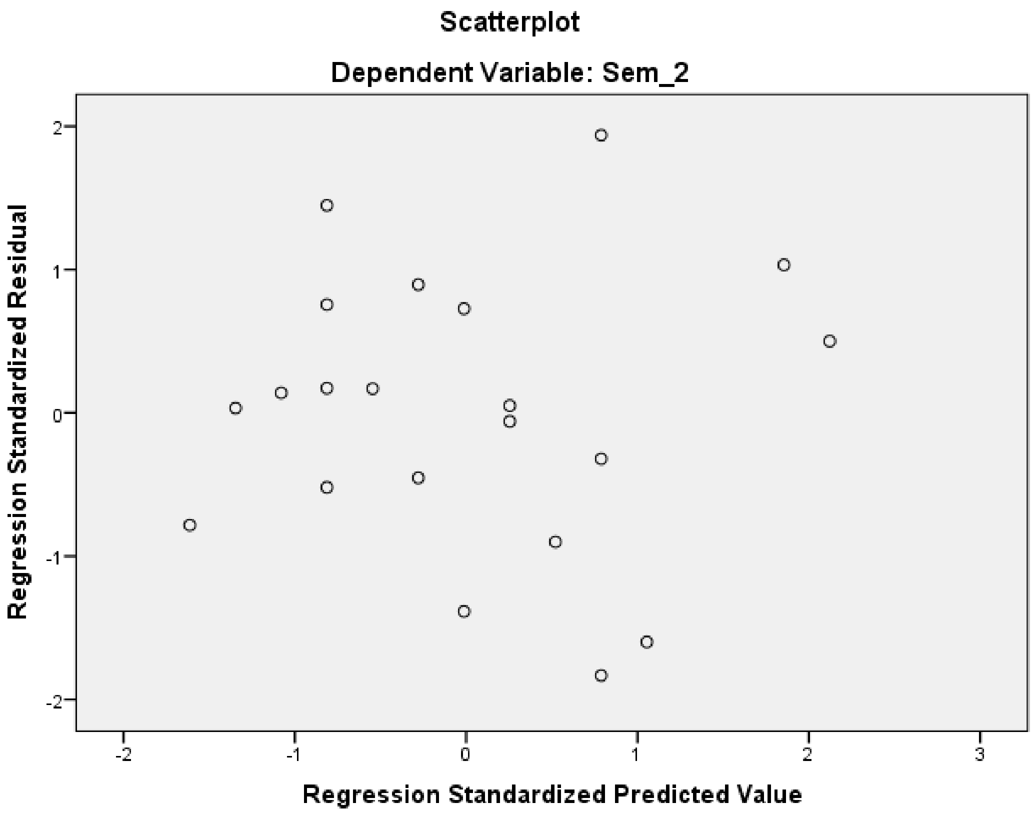
a. Dependent Variable: Sem_2

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	52.6999	78.1536	63.6952	6.81434	21
Residual	-10.06302	10.63698	.00000	5.34951	21
Std. Predicted Value	-1.614	2.122	.000	1.000	21
Std. Residual	-1.833	1.938	.000	.975	21

a. Dependent Variable: Sem_2


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Sem_2
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: Sem_2
Regression Standardized Residual
Regression Standardized Predicted Value
-2
-1
0
1
2
3

Appendix 16

Output data from multiple linear regression defining semester 2 as the dependent variable and age, test score, degree percentage and English as the independent variables. (Enter method)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	English, Age, Test, Degree_UG[b]	.	Enter

a. Dependent Variable: Semester_2

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.795[a]	.631	.539	5.8816

a. Predictors: (Constant), English, Age, Test, Degree_UG

b. Dependent Variable: Semester_2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	947.550	4	236.888	6.848	.002[b]
	Residual	553.499	16	34.594		
	Total	1501.050	20			

a. Dependent Variable: Semester_2

b. Predictors: (Constant), English, Age, Test, Degree_UG

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	43.655	12.935		3.375	.004
	Age	.051	.230	.035	.221	.828
	Test	.383	.088	.828	4.375	.000
	Degree_UG	-.082	.193	-.081	-.425	.677
	English	1.030	2.733	.061	.377	.711

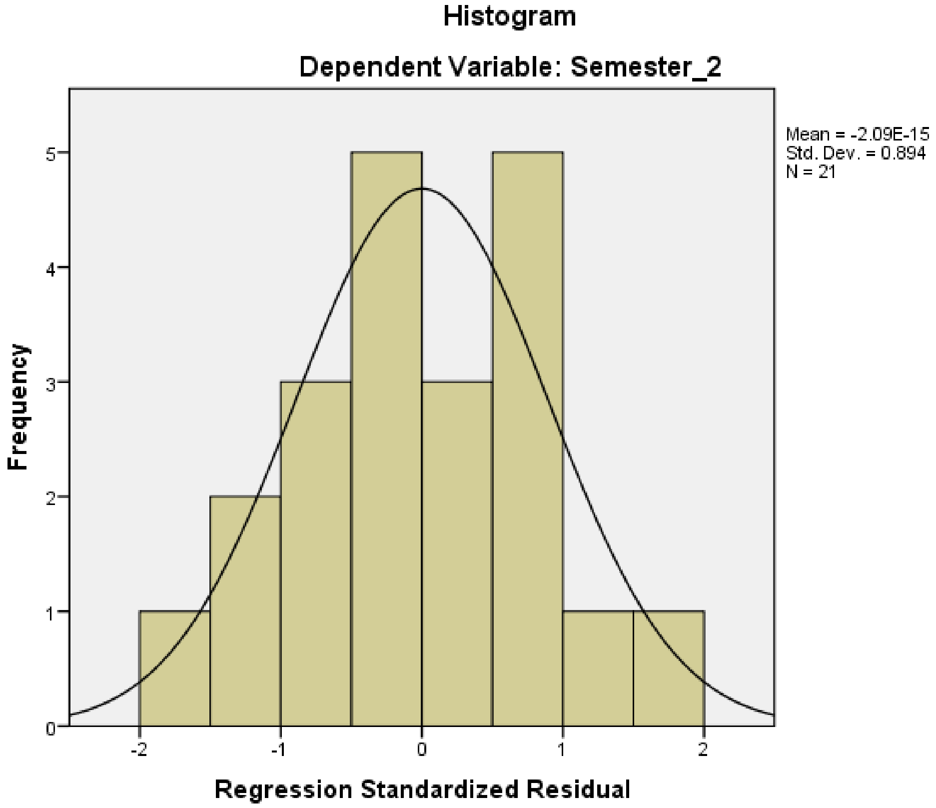
a. Dependent Variable: Semester_2

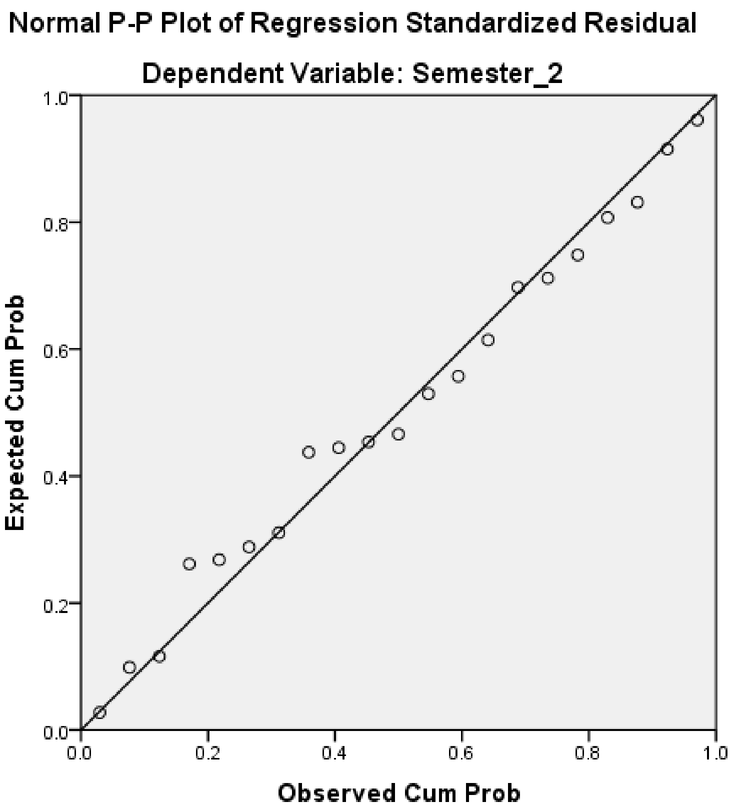
Residuals Statistics[a]

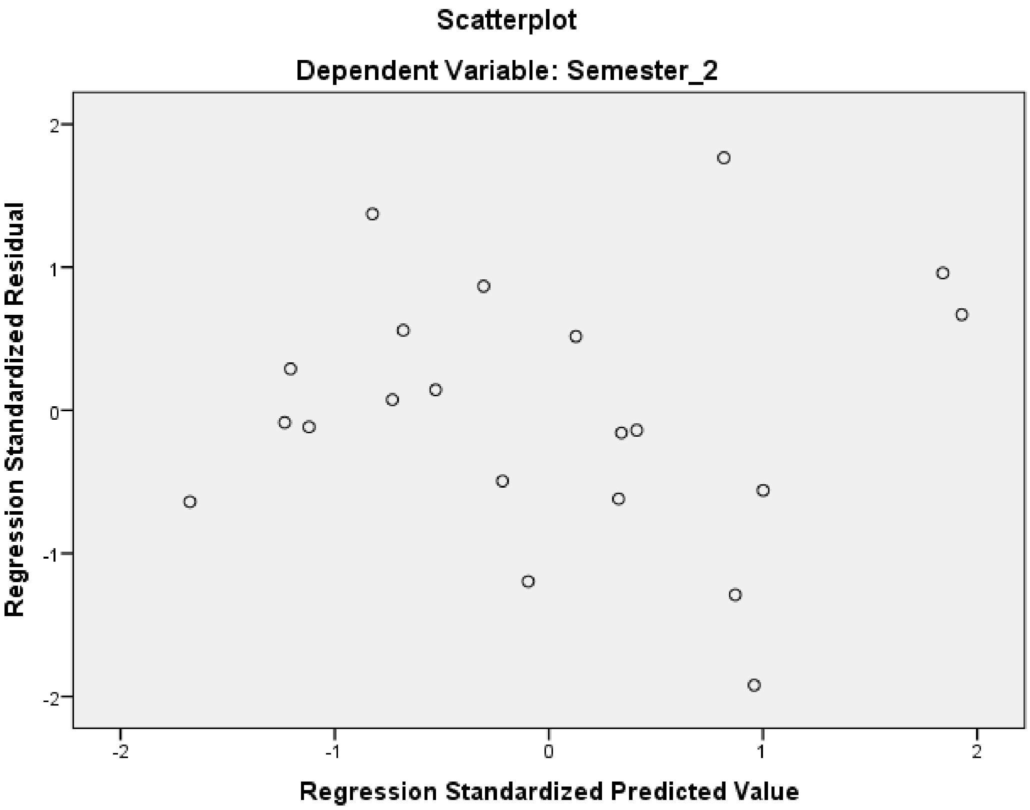
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	52.157	76.966	63.695	6.8831	21
Residual	-11.2955	10.3782	.0000	5.2607	21
Std. Predicted Value	-1.676	1.928	.000	1.000	21
Std. Residual	-1.920	1.765	.000	.894	21

a. Dependent Variable: Semester_2

Charts


Histogram
Dependent Variable: Semester_2
Mean = -2.09E-15
Std. Dev. = 0.894
N = 21
Frequency
0
1
2
3
4
5
-2
-1
0
1
2
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Semester_2
Expected Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0
Observed Cum Prob


Scatterplot
Dependent Variable: Semester_2
Regression Standardized Residual
Regression Standardized Predicted Value
2
1
0
-1
-2
-2
-1
0
1
2

Appendix 17

Output data from multiple linear regression defining semester 2 as the dependent variable and age, test score, degree percentage and English as the independent variables. (Stepwise method)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Test	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Semester_2

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.787[a]	.619	.599	5.4885

a. Predictors: (Constant), Test

b. Dependent Variable: Semester_2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	928.704	1	928.704	30.830	.000[b]
	Residual	572.346	19	30.123		
	Total	1501.050	20			

a. Dependent Variable: Semester_2

b. Predictors: (Constant), Test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	41.791	4.123		10.137	.000
	Test	.364	.065	.787	5.552	.000

a. Dependent Variable: Semester_2

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Age	.043[b]	.292	.774	.069	.957
	Degree_UG	-.107[b]	-.629	.537	-.147	.711
	English	.083[b]	.569	.576	.133	.979

a. Dependent Variable: Semester_2

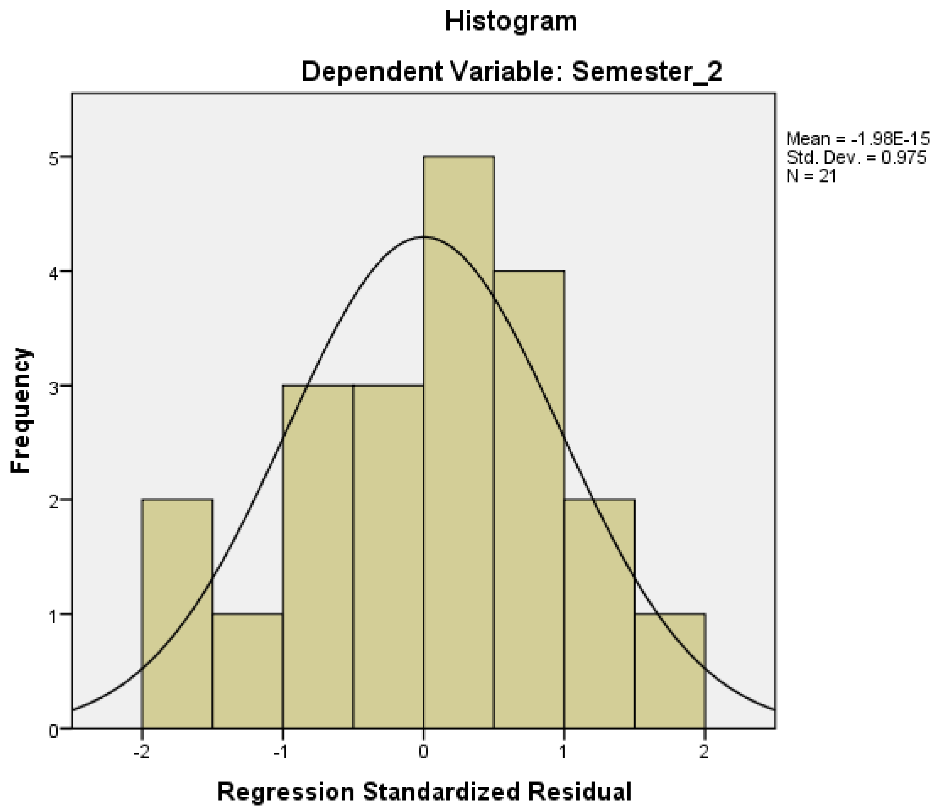
b. Predictors in the Model: (Constant), Test

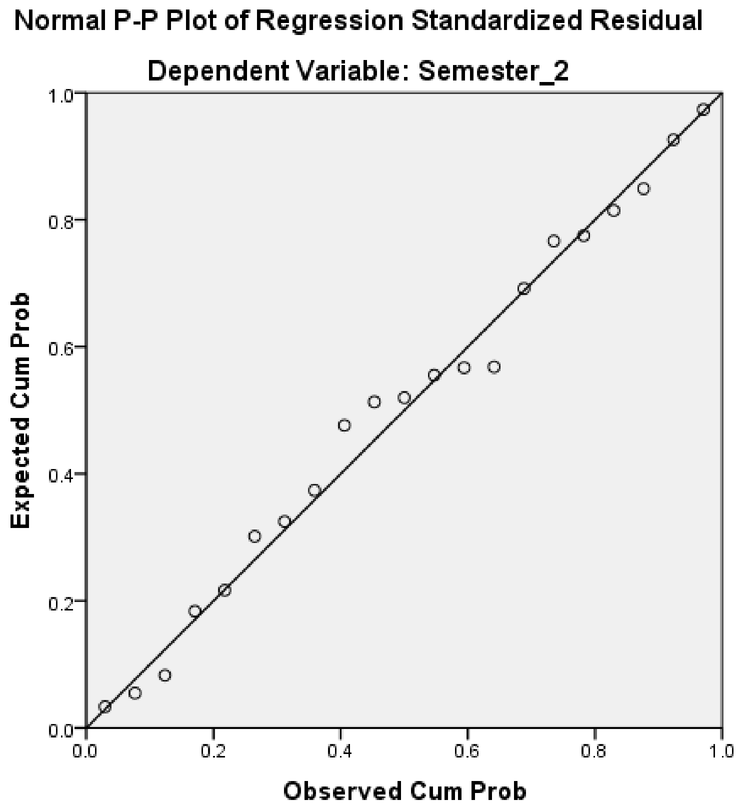
Residuals Statistics[a]

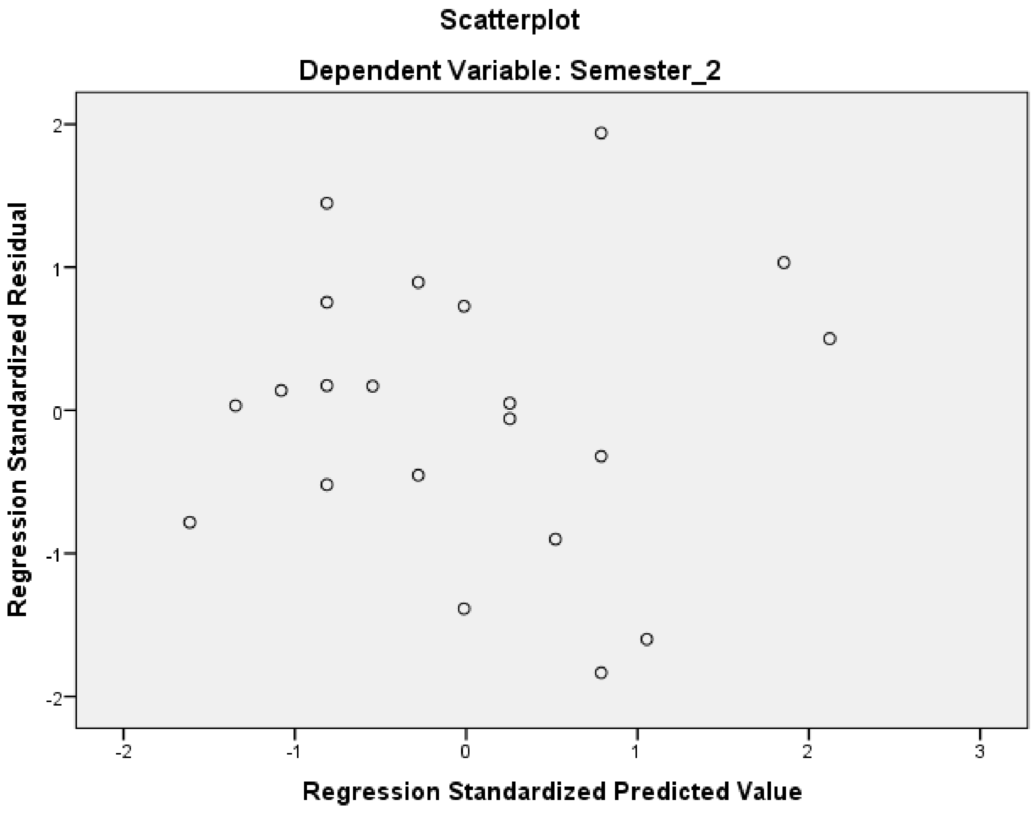
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	52.700	78.154	63.695	6.8143	21
Residual	-10.0630	10.6370	.0000	5.3495	21
Std. Predicted Value	-1.614	2.122	.000	1.000	21
Std. Residual	-1.833	1.938	.000	.975	21

a. Dependent Variable: Semester_2

Charts

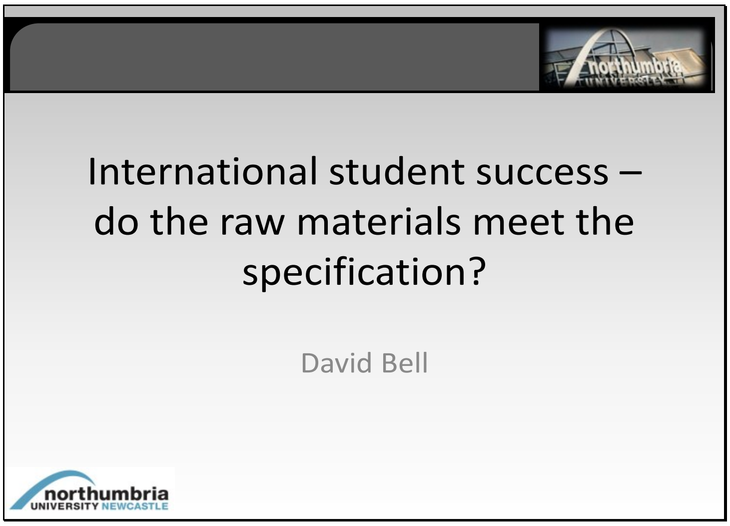



Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Semester_2
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0

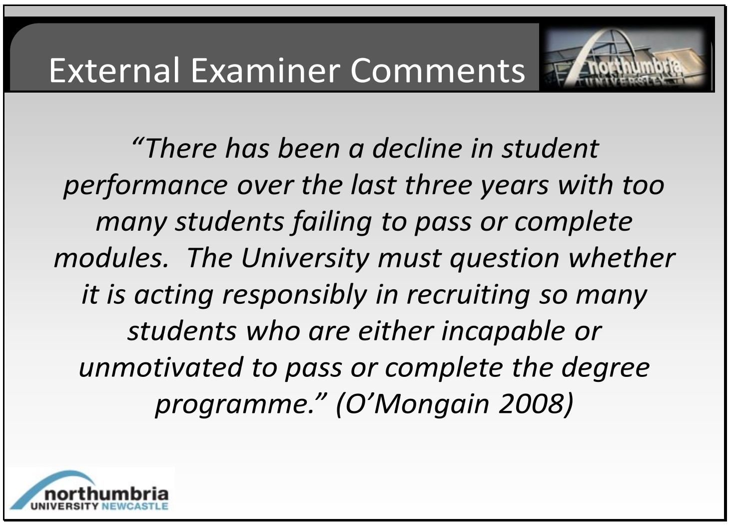

Scatterplot
Dependent Variable: Semester_2
Regression Standardized Residual
Regression Standardized Predicted Value
-2
-1
0
1
2
3

Appendix 18 **Presentation given at Three Rivers Conference 27th March 2014**

Slide 1



Slide 2



Slide 3

Slide 4

Predictors of academic success

English Language

- Not clearly established (Graham 1987; Cook, Evans et al. 2004)
- Limited but significant (Abel 2002; Yen and Kuzma 2009)
- Argue against using English (Light, Xu et al. 1987; Seelan 2002)

Entry tests

- GMAT, GRE, GAMSAT "*fails to consider the significance of content knowledge*" (Mathews 2007)

Previous academic performance

- High UCPA tends to lead to high GCPA (Alias and Zain 2006)
- Diagnostic mathematics test (Robinson and Croft 2003)

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Slide 5

Postgraduate student recruitment

Process

- Academic entry requirements
- English level
- Special conditions

Northumbria's comparator group (18 Institutions, 50 Programmes)

- Academic - 48% (24) Same, 40% (20) Higher and 12% (6) Lower
- English – 52% (26) Same and 48% (24) Lower
- Special – "degree in a cognate area"

Comments

- Higher UG can Lead to higher PG (Alias and Zain 2006)
- Hull ask for higher academic and lower English than Northumbria in CS
- Academic ability has a greater impact on success (Cownie and Addison 1996; Horspool 2006; Seelan 2002)

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Slide 6

What knowledge should students have?

Process

- Five specialist programmes identified (ME, EPE, MCE, CNT, *CS*)
- "*Expert opinion*" from Module and Programme leaders used to create a 20 question MCQ test on underpinning knowledge
- Fundamental subject knowledge questions and questions on knowledge expected to underpin the "*deepening*" modules
- MCQ test given to final year UG students in subject discipline (ME *n=38,* EPE *n=29,* MCE *n=11,* CNT *n=10*)

Results

- All generally normally distributed. Means:- ME=55.0%, EPE=64.3%, MCE=60.9% and CNT=73.5%
- Using a pass mark of 50% - 78.9% (30/38) passed ME, 86.2% (25/29) passed EPE, 81.8% (9/11) passed MCE and 100% (10/10) passed CNT

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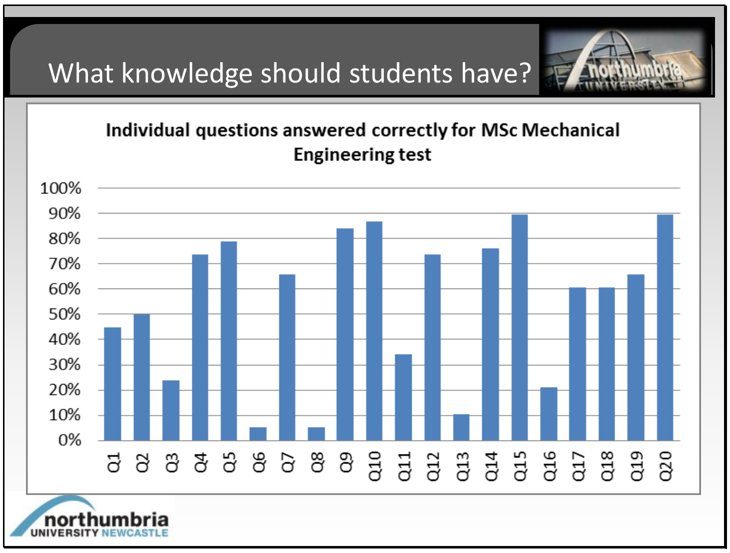
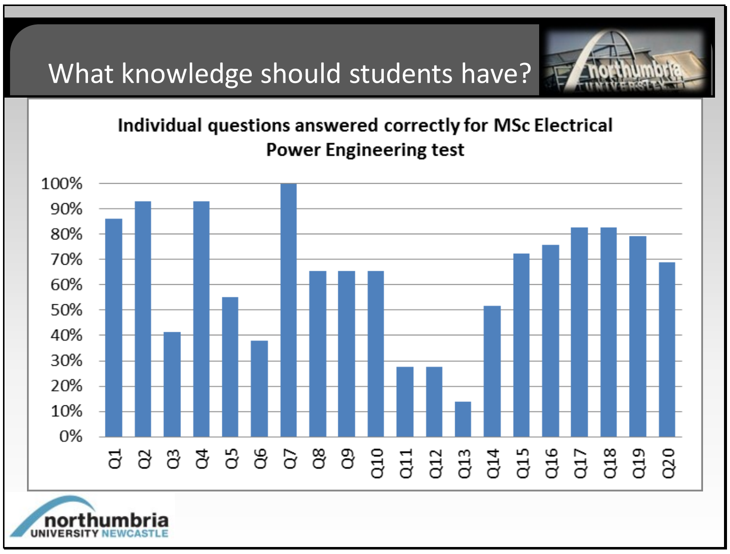
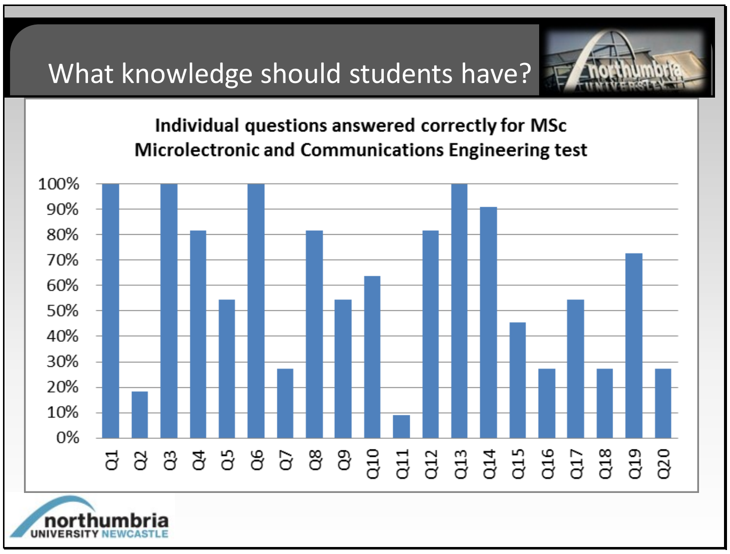
Slide 7



Slide 8

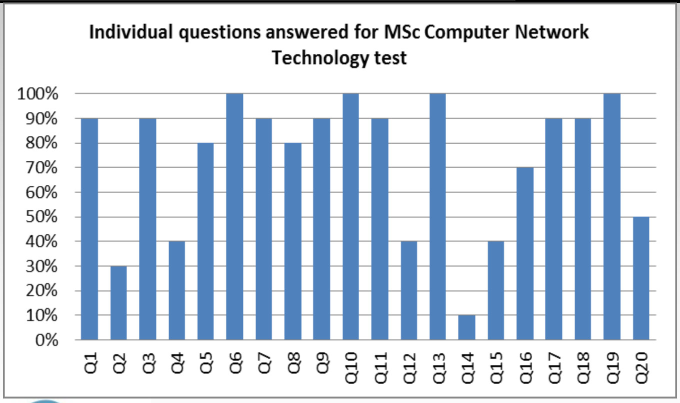


Slide 9



Slide 10

What knowledge should students have?



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Slide 11

Correlation between knowledge and degree result

		(ME_UG)	(ME_test)
Mechanical Engineering UG degree results (ME_UG)	Pearson's *r* *p* (sig 2-tailed)	1	0.350* 0.031 38
MSc Mechanica (ME_test)	*p* (sig 2-tailed) N	0.031 38	1 38
		(EEELC_UG)	(MCE_test)
EEE Light Current UG degree results (EEELC_UG)	Pearson's *r* *p* (sig 2-tailed) N	1 11	0.227 0.503 11
MSc Microelectronics and Communication Engineering test results (MCE_test)	Pearson's *r* *p* (sig 2-tailed) N	0.227 0.503 11	1 11
		(EEEHC_UG)	(EPE_test)
EEE Heavy Current UG degree results(EEEHC_UG)	Pearson's *r* *p* (sig 2-tailed)	1	0.422* 0.023 29
MSc Electrical P results (EPE_test)	*p* (sig 2-tailed) N	0.023 29	1 29
		(CNT_UG)	(CNT_test)
Computer & Network Technology UG results (CNT_UG)	Pearson's *r* *p* (sig 2-tailed) N	1 10	0.264 0.462 10
MSc Computer Network Technology test results (CNT_test)	Pearson's *r* *p* (sig 2-tailed) N	0.264 0.462 10	1 10

* Correlation is significant at the 0.05 level (2-tailed)

Test score of 50% equates to Degree score of 58.2%

Test score of 50% equates to Degree score of 62.7%

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Slide 12

UG and PG student knowledge

Process

- Four specialist programmes identified (ME, EPE, MCE, CNT)
- MCQ test given to incoming PG students in subject discipline (ME *n=15,* EPE *n=16,* MCE *n=21, CNT n=5*)

Results

- All generally normally distributed. Means:- ME=59.3%, EPE=60.2%, MCE=56.3%
- Using a pass mark of 50% - 93.3% (14/15) passed ME, 66.7% (14/21) passed EPE and 81.3% (13/16) passed MCE
- Using an "Independent samples test" none of the means were statistically significantly different between UG and PG students
- Overall the UG students performed similarly to the PG students
- There were some statistically significant differences on individual questions.

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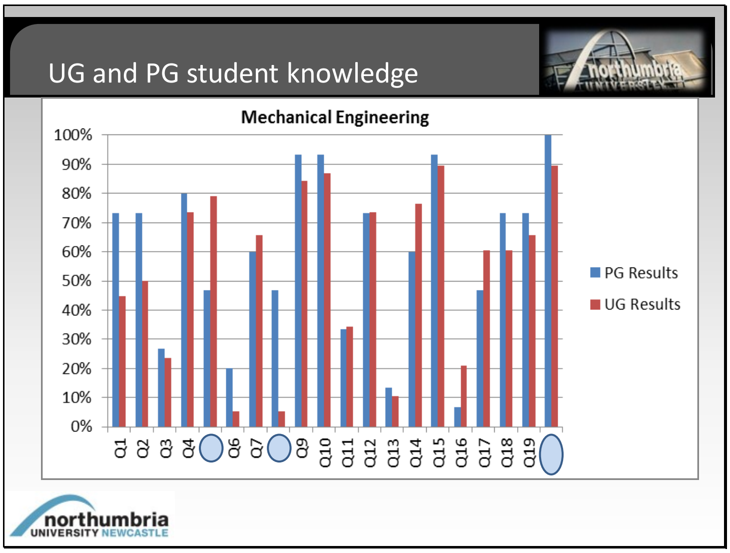
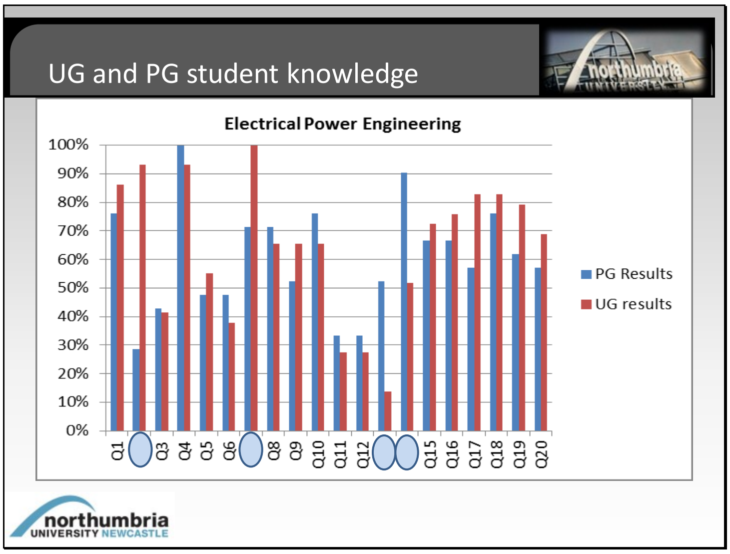
Slide 13



Slide 14



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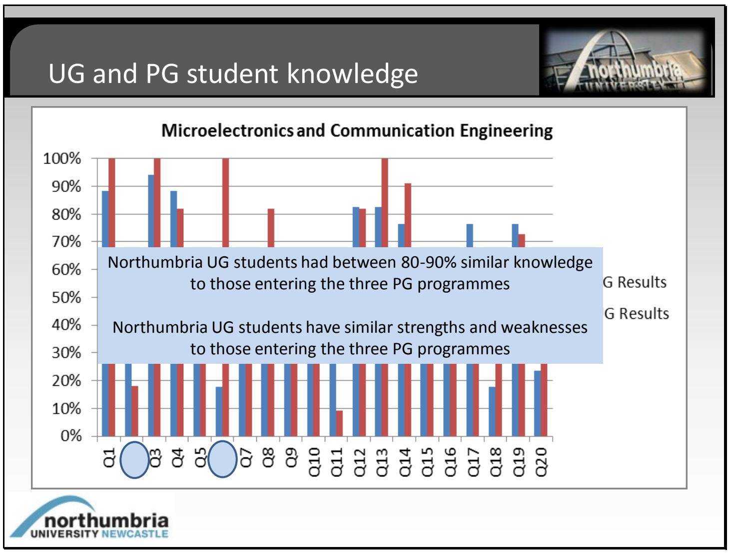

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Underpinning knowledge and academic success

Process for PG students

– Test for relationship between the marks obtained in the MCQ test, Semester 1, Semester 2 and overall average

Results

– **Mechanical Engineering** – no correlation between test score and academic performance. Strong positive correlation between semester 1 and semester 2

– **Electrical Power Engineering** – there is a “moderate to strong” positive correlation between the MCQ test of knowledge and academic performance in semester 1, semester 2 and overall average

– **Microelectronic and Communications Engineering** - no correlation between test score and academic performance. Strong positive correlation between semester 1 and semester 2

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Underpinning knowledge and academic success

Mechanical Engineering Correlations

		TEST	SEM_1	SEM_2	AVERAGE
TEST	Pearson's r	1	.292	.477	.465
	Sig. (2-tailed)		.291	.072	.081
	N	15	15	15	15
SEM_1	Pearson's r	.292	1	.816**	.945**
	Sig. (2-tailed)	.291		.000	.000
	N	15	15	15	15
SEM_2	Pearson's r	.477	.816**	1	.946**
	Sig. (2-tailed)	.072	.000		.000
	N	15	15	15	15
AVERAGE	Pearson's r	.465	.945**	.946**	1
	Sig. (2-tailed)	.081	.000	.000	
	N	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

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Underpinning knowledge and academic success

Electrical Power Engineering Correlations

		Test	SEM_1	SEM_2	Average
Test	Pearson's r	1	.685**	.787**	.762**
	Sig. (2-tailed)		.001	.000	.000
	N	21	21	21	21
SEM_1	Pearson's r	.685**	1	.883**	.965**
	Sig. (2-tailed)	.001		.000	.000
	N	21	21	21	21
SEM_2	Pearson's r	.787**	.883**	1	.975**
	Sig. (2-tailed)	.000	.000		.000
	N	21	21	21	21
Average	Pearson's r	.762**	.965**	.975**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	21	21	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

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Underpinning knowledge and academic success

Microelectronic and Communication Engineering Correlations

		TEST	SEM_1	SEM_2	AVERAGE
TEST	Pearson's r	1	.255	.278	.215
	Sig. (2-tailed)		.341	.298	.425
	N	16	16	16	16
SEM_1	Pearson's r	.255	1	.723**	.953**
	Sig. (2-tailed)	.341		.002	.000
	N	16	16	16	16
SEM_2	Pearson's r	.278	.723**	1	.811**
	Sig. (2-tailed)	.298	.002		.000
	N	16	16	16	16
AVERAGE	Pearson's r	.215	.953**	.811**	1
	Sig. (2-tailed)	.425	.000	.000	
	N	16	16	16	16

**. Correlation is significant at the 0.01 level (2-tailed).

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Entry specification and academic success

Electrical Power Engineering

- Test for relationship between UG degree on entry, MCQ test, semester 1 and semester 2 marks

Results

- Moderate to strong correlation between MCQ test, UG degree on entry, semester 1 and semester 2
- No relationship between the UG degree on entry with semester 1 and semester 2 marks

Conclusion

- Academic degree level is not a good predictor of academic success

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Entry specification and academic success

Correlations between Entry degree, Semester 1, Semester 2 and TEST for Electrical Power Engineering students

		TEST	Entry Degree	Semester 1 average	Semester 2 average
TEST	Pearson's r	1	.537*	.685**	.787**
	Sig. (2-tailed)		.012	.001	.000
	N	21	21	21	21
Entry Degree	Pearson's r	.537*	1	.171	.346
	Sig. (2-tailed)	.012		.459	.124
	N	21	21	21	21
Semester 1 average	Pearson's r	.685**	.171	1	.883**
	Sig. (2-tailed)	.001	.459		.000
	N	21	21	22	21
Semester 2 average	Pearson's r	.787**	.346	.883**	1
	Sig. (2-tailed)	.000	.124	.000	
	N	21	21	21	21

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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Recommendations from research

1. Review current level of English required to study at PG level
2. Review the academic level required to study at PG level
3. Use the results from MCQ tests to review module content where a mark of less than 50% is scored by UG students
4. Use the MCQ tests as part of the admissions process rather than just depending on academic level
5. Use the methodology outlined to confirm the expectations of underpinning knowledge on all specialist programmes
6. Use the MCQ test to help identify shortcomings in student knowledge and provide appropriate interventions for students and feedback to supplier Universities

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Thank you for listening!

Any questions?

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