CURRICULUM AND PEDAGOGICAL DEVELOPMENTS WITHIN UNIVERSITY SURVEYING & GEOMATICS COURSES

GARFIELD OSBOURNE YOUNG
M.Eng.Sc, PDE, BSc(Hons.)

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ABSTRACT

In the last three decades there have been major changes in *how* surveying is practiced, and *what* surveyors have been trained and educated to do with the new expertise that technological advancements offer. Within surveying communities it is generally acknowledged that the changes within the profession have brought about an urgent need for change in educational programmes if they are to have relevance to contemporary practice.

The thesis reports on a research study which explored the nature and impact of the educational strategies used in university surveying courses. The study employed a nested case study approach at two levels. Firstly, fifteen initial case studies of university programmes from thirteen countries provided a broad perspective of surveying education across the world. Secondly, two of these programmes were selected for in-depth comparative case studies to provide deeper understandings of the educational systems in two distinct contexts. The enquiry methods for the initial case studies included documentary analysis and interviews of senior academics and representatives of professional surveying bodies. For the two in-depth case studies, the enquiry methods included observations of pedagogical activities, focussed group discussions and interviews of university staff and students as well as professional surveyors. The interviews were recorded and thematically analysed.

Some concepts from Bourdieu's theory of practice were useful in coming to understandings about the interrelationship between the field of surveying education and the field of surveying practice. The study identified tensions and prospects within and between the programmes studied and between them and the profession. The key issues that emerged were: the predominance of highly discipline specific curricula with some indication of a shifting to a more broad-based education; tensions between industry expectations and the academic focus; a high level of interest in the university courses from the profession and uncertainty about the real meaning of geomatics and its relevance to local surveying communities. The findings have critical implications for how surveying/geomatics educational courses are developed in the future. The empirical evidence led to the development of a proposed improved model for contemporary surveying/geomatics education.

Dedicated to Andrew B who continues to inspire me to good works

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Foremost I thank The One who caused the promise to become reality – my Lord and Saviour Jesus Christ. I do all things by His strength and for His glory.

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GLOSSARY OF TERMS

Surveying	The study and practice of earth measurement and earth representation. This includes data collection and the management of the resultant spatial information for decision-making regarding all land related activities. The term is often used in conjunction with land (land surveying) to differentiate it from other fields of surveying such as quantity surveying, valuation surveying and building surveying.
Geomatics	An umbrella term under which traditional surveying and more modern technology-induced sub-disciplinary groups fall. These sub-groups include remote sensing, GIS, global navigation satellite systems etc. Geomatics is also viewed as a more appropriate terminology for describing modern technology-based surveying. At certain points in the thesis, the terminology is used inter-changeably with 'surveying' since in practice they are sometimes used in this way.
GIS	This refers either to Geographic Information System or Science. A GI System is a computer-based, map-informed technology that enhances the manipulation of spatial data and the management of the information it produces for decision making in many fields. While the actual machinery and processes represent the GI systems, the study of this process is referred to as GI Science.
Geoinformatics	The raw meaning is earth related information. However the term is used in some instances to define courses of study in Geomatics that have a focus on GIS and the management of spatial data.

FIG The abbreviations FIG represent the International Federation of Surveyors (initials derived from the French terminologies). This is an international professional organisation that represents the interests of surveyors worldwide. Its membership includes professional organisations, affiliate groups, academic and corporate groups from all sub-fields of surveying.

RICS The Royal Institute of Chartered Surveyors (RICS) is a professional body that provides qualifications and oversees standards in land, property and construction. They offer professional accreditation to both educational programmes and professionals within the identified fields.

Curriculum architecture

A comprehensive view of an educational system associated with an identified field of study. This includes considerations for the design, delivery and evaluation processes used to achieve desired learning outcomes.

Pedagogy The practice of teaching and learning with recognition for the complex mix of factors that influence this dynamic interaction.

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

All professions… have been changed by digital technology, but none so radically as the practice of land surveying. (Hubbard, 2009: p. v)

1.1 Introduction

As a direct result of over two decades of work in surveying education and surveying practice, I have been an avid witness and contributor to changes in the discipline. The introductory statement in this chapter by Hubbard essentially sums up how significantly technology has impacted surveying practice. As a surveying educator, I have a strong desire for a deeper understanding of the dynamics at work between the practice of surveying and the related education systems. I seek to understand the complexities involved in developing and delivering surveying education to meet the very dynamic demands of the profession in its complex modern context. Additionally, I see professional education as encompassing the more formal institutionally based system of arranged learning experiences as well as the interactions between this system and the associated profession(s). Broadly speaking, this study explored issues related to surveying education with a view to developing a clearer understanding of this field of study based on empirical data.

This chapter offers an introduction to the study and a narrative 'map' that provides direction through the thesis. A brief introduction to the research is followed by more extensive writings that contextualise the study, and an outline of my background as a researcher follows. It offers some insights into the genesis and development of my interest in research in surveying education. Next, I identify specific areas of interest for research and provide an account of the significance of the study. The final section outlines the thesis structure.

1.2 Research context: contemporary surveying & the 'geomatics paradigm'

Land surveying is arguably one of the oldest known professions, with its recorded history dating back to the ancient Egyptians who used ropes with knots for land measurements which they recorded on stone tablets (Kavanagh, 2003). Attesting to the relevance of context in exploring matters relating to this profession, the Royal Institution of Chartered Surveyors (RICS) described surveying as the most diverse profession on the planet (Chartered Surveyors Training Trust, RICS, 2010). However, the aspects of this 'diverse' profession that is focussed on in this thesis do not cover the wide range of sub-disciplines under the RICS's umbrella but more so those covered under one of the institution's seven groups called *The Geomatics Group*. The disciplinary focus of this group more closely reflects aspects of the discipline represented by the International Federation of Surveyors (FIG).

Closely associated with the development of the science of earth measurement (surveying), and the art of map making (cartography), are developments in trigonometry, astronomy and geometry. Surveying instrumentation and the measuring techniques they afford have changed over time but most significantly in recent decades (Enemark, 2004). A timescale of the developments in surveying technologies is illustrated by Staiger (2009) (see **Figure 1**).

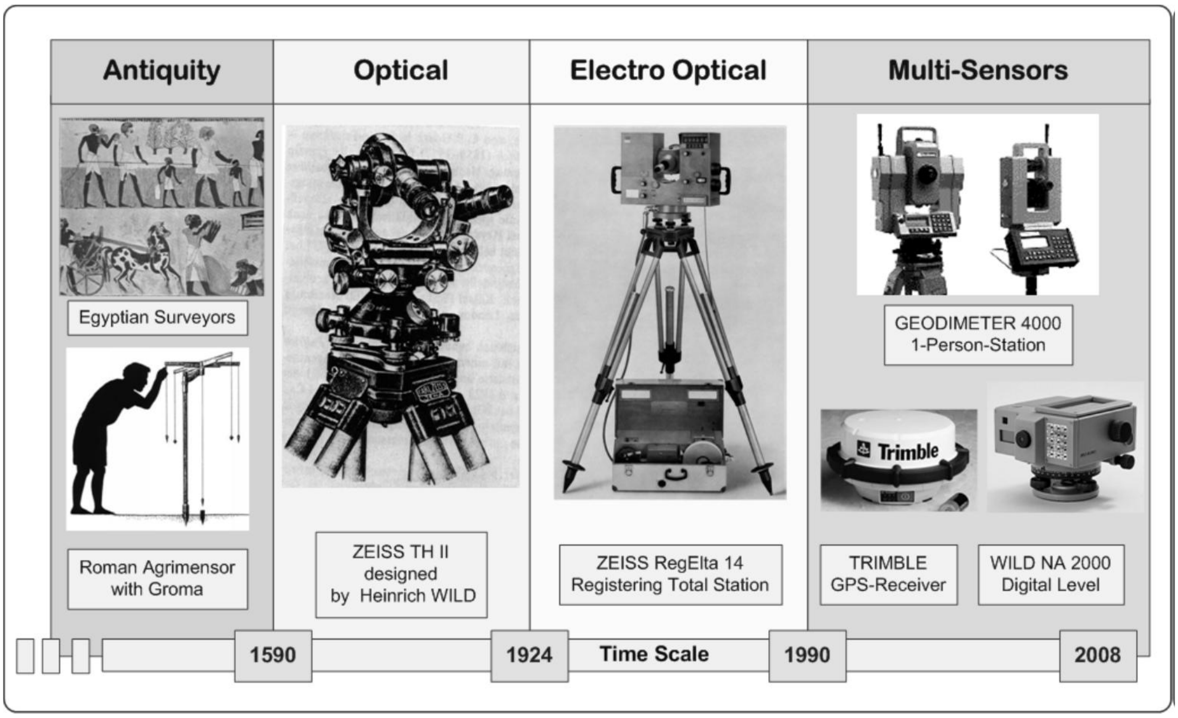

Figure 1: The four phases of surveying technologies (Staiger, 2009)

The use of satellites, information and other technologies has influenced significant changes in the methods of collecting, processing and presenting surveying data and artefacts. Many of the measurements traditionally done by the professional surveyor, no longer require professional engagement as the advancements render them simple technology-enabled activities, capable of being executed by technicians with short-term training. The traditional role of the surveyor, within this scenario, is perceived to be under threat (e.g. Psarianos, 2001), prompting an expansion in the professional scope of modern surveyors. Hannah, Kavanagh, et al. (2009) perceive that the new technologies and new opportunities have enabled surveyors to broaden their skills and competencies. This widening of professional activities has led to a redefinition of the role of contemporary surveyors. Perhaps the most prominent redefinition is the one accepted by the FIG in 2004:

> A surveyor is a professional person with the academic qualifications and technical expertise to conduct one, or more, of the following activities: to determine, measure and represent land, three-dimensional objects, point-fields and trajectories; to assemble and interpret land and geographically related information; to use that information for the planning and efficient administration of the land, the sea and any structures thereon; and, to conduct research into the above practices and to develop them. (FIG General Assembly, 2004)

While the FIG's definition reserves the traditional measurement functions, it also includes newer aspects such as the land administration and research. Professionals such as Schulte (2005), identifies the enhanced business prospects that this change in defining the roles of the professional surveyor offers. He perceives that surveying has transitioned from a profession with a single focus on earth measurement to one with a broader focus incorporating geoinformatics and moving towards an even further extended scope to include geo-services. Staiger (2009) adds that in the past, the focus of surveying was on 'mastering the instrument', whereas today the focus has changed to 'mastering the entire process'. This speaks of an expansion in the competencies required of modern surveyors in many countries. To support this claim Hannah, Kavanagh, et al. (2009) state that modern surveyors have competencies in excess of two hundred. However, they point out that this diversity of functions could mean one of two things. Firstly, that surveyors have become multi-talented professionals, or 'specialist generalists'; secondly, and on a more sinister level, it could suggest that the profession is challenged in defining its core expertise.

In a growing number of countries, the widening activities associated with modern surveying have brought about increased recognition, amongst practitioners and educators, of a paradigm shift in surveying practice. In this thesis, this shift both in *how* modern surveyors carry out their functions relative to traditional surveying practice, and the widening scope in *what* modern surveyors do, is referred to as the 'geomatics paradigm'. This shift has influenced changes to the titles accorded to the academic discipline and the practice of modern surveying. The terms *geomatics*, *geomatic(s) engineering*, *geospatial Engineering* and g*eoinformatics* are terminologies which are gaining increasing popularity as more appropriate descriptors for modern surveying. The equivalent terms used to describe the professional are *geomatician*, g*eomatic(s) engineer*, g*eospatial specialist* or some term that uses the prefix *Geo* or the term *Spatial*. The more popular term - *geomatics*, as a new way of conceptualising the modern surveyor, is believed to have gained prominence beginning with its use in Canada in the 1960s (Potuckova, 2006). According to Kemp (2008) the term is derived from the French word *géomatique* with roots 'geo' meaning Earth and 'informatics' with the parts 'informat' representing information and automation and 'ics' representing science. Kemp (2008) further explains that the earliest known documentation of the term was used by the French Ministry of Equipment and Housing (cf. Commission Permanente de la Géomatique) in the 1970s. However, it was not until some years after that the term was used in French Canada to define what was then perceived to be the modern way of describing those professionals involved in the collecting, handling and processing of spatial data (Ibid.). Ipbuker (2010) adds that Laval University, in 1986, officially changed the title of its surveying programme to Geomatics and that it was the first academic institution to do so. This he states spread to other parts of Canada including the English speaking regions and also to other parts of the world. Not only were university departments and programme titles changed but also some professional groups and government departments adopted the new term in their names (Ipbuker, 2010).

Natural Resources Canada (NRC) describes Geomatics as 'the science and technology of gathering, analyzing, interpreting, distributing and using geographic information' (online). They see geomatics as encompassing 'a broad range of disciplines that can be brought together to create a detailed but understandable picture of the physical world and our place in it.' The range of disciplines listed by NRC under the geomatics umbrella includes surveying, mapping, remote sensing, geographical information systems (GIS) and global navigation satellite systems (GNSS). The NRC sees geomatics as an emerging technology sector with relevance to a wide and growing range of human activities. The application of new technologies to the practice of surveying is generally associated with its perceived expanded functions as alluded to by Mahoney, Hannah, et al. (2009):

> new technologies and new opportunities have enabled surveyors to broaden their skills and competencies, and as a result they may be involved in such diverse activities as estate management, digital image processing, boundary demarcation, engineering design, and satellite orbit analysis (p.1).

So how does this new way of conceptualising the profession impact the educational systems within it? The Geomatics Division of a University of New Brunswick justifies the use of 'geomatics' in place of 'surveying' by stating that 'Geomatics became part of our new name to reflect the … expanding interests.' (online)

Thus, Geomatics is one way of describing what Konecny (2002) refers to as a new integrated academic discipline. **Figure 2** illustrates Konecny's perspective of geomatics education as integrating studies in traditional surveying with more modern technologies. The model shows typical foundational subjects such as mathematics and physics along with newer technology-related subjects such as artificial intelligence and satellite technology. The model also shows wide ranging outputs from geomatics education programmes. These include traditional surveying features such as topographic and thematic Mapping and cadastre along with new methods of carrying them out such as remote sensing. Importantly, the model also shows that areas such as law, real estate management, economics and spatial data management have relevance to this 'new' umbrella discipline. These illustrations highlight a clear augmentation of the knowledge and skills content in contemporary surveying/geomatics courses.

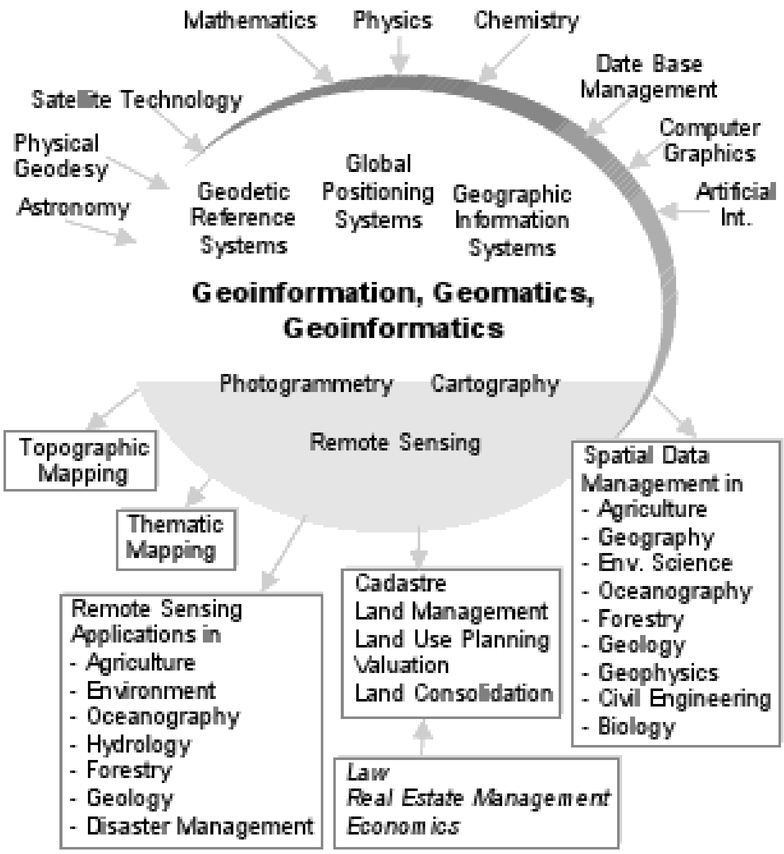

Figure 2: Illustration of elements of geomatics (Adapted from Konecny (2002))

Some members of the surveying community believe that the profession stands to benefit from this new image as the old image had become inappropriate and unattractive (Onsrud & Pinto 1993; Psarianos, 2001). This is often considered to be the case because of the perception that surveying is largely vocational with a focus on its more technical functions (Enemark, 2008). It is believed that this perception has been a primary contributor to recruitment challenges faced by many surveying departments within universities around the world. This has reportedly led to the discontinuation of several university surveying courses in several countries (see e.g. Ossko, 2008; and Hannah, Kavanagh et al., 2009).

In response to this student recruitment challenge, the FIG, other surveying professional bodies and a number of universities have embarked on marketing drives to promote the profession and surveying/geomatics education as a viable higher education option that offers qualifications for a wide range of professional engagements. Two prominent examples are the promotional videos produced by The Association of Canada Land

Surveyors and The Association of Ontario Lands Surveyors (http://vimeo.com/11095284) and the Dublin Institute of Technology's Geomatics video (O'Connor, 2011) . The former video, produced by professional surveying groups, highlights the relevance of traditional surveying functions to contemporary societies. The latter video, produced by an educational institution, shows a much more diverse range of professional activities under the umbrella of *Geomatics*. Promotional materials, such as these, present Geomatics as a diverse discipline that includes traditional functions along with an expanded range of applications in areas such as land administration, disaster management, traffic management, accident reconstruction, crime fighting, forestry, facilities management etc. Tools such as these, promote the discipline as offering a range of career specialisations that is hoped to yield benefits in regard to increased female enrolment (Dasse, 2001) as well as students from more diverse academic backgrounds with wider fields of interests (Gagnon & Bedard, 1996). However, although enrolment has increased in some Geomatics programme, the name change has not had as significant an impact as anticipated (Hannah, et al., 2008).

Mahoney et al. (2005) argue that the disagreement between the definitions of the role of the surveyor by the International Standard Classification of Occupations (ISCO) and the FIG is symptomatic of 'a major crisis' for the profession because:

> when viewed from a global perspective, the surveying profession not only has a wide range of competencies, but also significant variations both in how these specialism are grouped as a profession and within professional practice (p. 3).

From a global perspective, there is a disparate range of activities associated with surveying. This reality underlies a lack of cohesion, focus and a single identity for the surveying profession (Mahoney et al., 2005). Moreover, these issues have implications for surveying/geomatics educational programmes.

Changes in professions have reciprocal effects on the educational programmes associated with them (Herrington et al., 2005). The implications of the changes in the surveying/geomatics profession for the associated educational programmes, have been the subject of numerous discussions amongst international surveying practitioners and surveying education communities (see e.g. Rouch, 2001; Nwilo & Olasegun, 2002; Witte & Heck, 2002; Celik, Gikas, et al., 2006; Enemark, 2007; Markus, 2005; Ossko, 2008; Enemark, 2009). However, very few empirical studies have been carried out in this area. The most extensive study found in this area was commissioned by the European Council of Geodetic Surveyors and conducted and reported by Allan (1995). This study investigated the functions performed by surveyors in Western European countries and their arrangements for professional education and training. This was done against the backdrop of the Treaty of Rome (1957) which established the European Community. Within this context, consideration was given to what would be required to harmonise surveying educational qualifications within Western Europe (Allan, 1995). This study confirmed that there existed wide variations in both the practice of surveying and the systems of training and education in Western Europe. Allan (1995) indicated that the mission to harmonise educational system would involve many complexities that may render such an ambition impossible. Mahoney et al. (2005) agreed that unifying the surveying profession in terms of its roles, functions and education, may be an overly ambitious goal, at this time. Notwithstanding these claims, the desire to establish a minimum standard for surveying practice and education, not only in Western Europe but globally, is seen as an imperative (Hannah, Kavanagh, et al., 2008, Psarianos, 2001). The creation of common markets and economic communities is not unique to Europe. The Caribbean Community (CARICOM) Single Market and Economy is another example of inter-country policies and actions that have implications for professional and educational standards within regions. This means that professional harmonisation may impact the surveying profession in all countries.

Historically, persons were trained for many professions through systems of apprenticeship (Clarke, 2012). This is also true of the surveying profession, as will be discussed in chapter 2 of this thesis. Young people (traditionally men), with a proclivity for mathematics and the outdoors, were encouraged to join surveying departments where they would serve a period of apprenticeship under experienced surveyors. Some form of examination, usually set by a government-appointed board, would later determine if the apprentice qualified for professional certification. This initial approach to training was followed by a gradual introduction of formal education. The earliest form of education for work was organized in such a way that basic knowledge could be developed within a classroom setting, and applied skills could be developed on the job (Finch and Crunkilton, 1999). Later, technical education institutions began offering full-time formal training. The professional bodies and the government land agencies were typically instrumental in developing surveying curricula for the technical institutes.

The training offered by these early institutions, typically focussed on competencies in the use of instruments and in carrying out the technical functions, but had little, if any focus, on the development of skills such as critical thinking and managerial capabilities. Technical institutions such as the College of Arts, Science and Technology in Jamaica and the North East London Polytechnic (NELP) in England were later upgraded to universities, which led to the upgrading of many surveying courses to undergraduate degree courses (some polytechnics offered degrees in surveying before their upgrade to universities). Though the upgrade brought changes to the curricula, universities have been widely criticized for under-preparing students for the surveying profession. In fact, some industry members believe that, some 'upgraded' university courses are less effective at preparing graduates for work compared to the college courses they replaced. It is for this reason that Mattsson (2001) purports that the scope of the profession in many countries is wider than the education provided by their respective universities. However, it can be argued that industry's dissatisfaction with university graduates reflects industry's narrow focus on specialised skills related to the operations of their business, and not a wider professional development. This is important to note since narrow specialist skills alone do not represent the full range of competencies that an expansive surveying educational programme needs to develop (Hannah, et al., 2008).

Notwithstanding, there is agreement within academia and the surveying industry that changes in industry and the expanded range of modern surveying functions have created new educational demands. These changes, coupled with dwindling or static interests in the profession in many countries (e.g. Fairlie, Mahoney et al., 2010), have generated much interest amongst universities and the profession in developing new and improved educational strategies. Within this modern paradigm, education is perceived to be a critical means by which this rapidly evolving profession will find a secure place in contemporary times and in the future (Enemark, 2002b). Prendergast (2006) notes that the character of the surveying market has changed and so surveyors need new skills to compete. He agrees that education is a critical agent for developing these 'new' skills. Enemark (2000) suggests that the educational profile of modern surveyors should encompass three key areas - measurement science, spatial information management, and land management capabilities. He believes that education programmes can facilitate this development by adopting a number of curriculum and pedagogical shifts. Specifically, he speaks of changes from subject-based curricula to project-organized curricula; from pedagogies that focus on specialist skills to ones that develop managerial skills; from class room lecture-based courses to virtual academies; and from vocational training to lifelong learning.

A cursory comparison of various contemporary university surveying curricula showed several variations in content composition and pedagogical strategies. This was confirmed by Allan (1995), who found that surveying courses in seventeen Western European countries had vast variations in their compositions and emphases. There is evidence that surveying continues to be concerned with measurement but is now encompassing other areas such as Geographical Information Systems, Satellite Navigation Systems and Remote Sensing; and with aspects of social sciences including the management of spatial data and the administration of wide ranging land related issues among which the legal aspects of land transactions is included.

Within this atmosphere of intense change those universities that continue to offer surveying/geomatics courses, grapple with keeping the education in pace with the developments in surveying practice. Though it has been said that educational programmes must change in order to produce graduates with relevance to the modern world, there remains the need for a clearer understanding of how various educational approaches impact surveying education and professional practice. Additionally, it is not yet clear what role is played by stakeholders in the construction of Geomatics as a new way of perceiving and understanding modern surveying practice and education.

1.3 Researcher's background and research interests

Jones et al. (2006) explain the importance of situating qualitative research 'within compelling interests that lead to unsettled questions which are typically related to [one's] life experiences' (p.2). It is on this basis that I provide a reflection on my personal development as a surveyor, an educator and researcher. These insights have ontological and epistemological relevance, and offer some explanations for my choice of research area and the decisions I have taken regarding the methodological approach employed for this study. My belief concurs with Jones et al. (2006) that social research should be conducted with these positions clearly outlined as it allows one to 'situate the study within one's worldview' (Ibid.).

1.3.1 Early tertiary education

Perhaps the most significant formal experience that impacted my tertiary education and ultimately my career choice was my secondary school education. I attended a technical school in Jamaica which employed a curriculum that incorporated an academic programme with a vocational emphasis. My chosen vocational area was *Building* which included those subjects considered relevant to pursuing a career in fields related to the built environment. Consequently, surveying was one of the subjects I was introduced to within this vocational stream. Students at my school sat British-based examinations in the final year of school. Of those subjects I sat, I performed best in mathematics and surveying.

As was typical of students leaving the technical schools, I enrolled in a technical college where I completed certificate and diploma courses in land surveying. The explicit aim of the certificate course was to produce surveying technicians - specialists in field measurements and map production. Graduates from this course were typically employed in the lower level technical positions within the lands and surveying industry. The diploma course, had higher matriculation requirements but could also be accessed by graduates from the certificate course, which was the route I took. At that time the diploma was the academic requirement for professional surveying qualification within many Anglophone Caribbean countries.

Within the course, I found that the pedagogical approaches used supported the development of disciplinary knowledge and skills. Also, there was a minimal attempt to provide exposure to the development of more generic professional competencies. The teaching and learning activities involved significant amounts of group work which were usually necessary for students to execute numerous field-related activities. Field exercises typically followed a short series of lectures. In lectures, students were instructed in the fundamental principles and methods to be applied in the practical exercises. Students were supervised in instrument manipulation, booking, computational techniques and drafting methods. The teaching sessions were interactive with regular questions and answers and lecturer-student as well as student-student interchanges. A significant amount of learning occurred during field exercises through lecturer-student interchange but mostly through student-student interactions. Only during initial stages of the practical exercises would groups have direct supervision by the lecturer. This meant that most of the application activities were carried out independently of the lecturer. The in-field interactions between students occurred either between students within the same group or across groups. The learning activities between students went further, as students frequently consulted other students at a more advanced level in the course for their perspectives on aspects of the syllabus that they found difficult or were uncertain about. On reflection, I realise that students considered the lectures as a critical resource for examination preparation, but the application techniques were mostly developed through consultations with other students.

In my experience, surveying knowledge was significantly facilitated through social interactions by which students both used and produced surveying artefacts. This knowledge building scenario resonates with concepts of social constructionism as Crotty (1998) defines it.

> [Social] constructionism is the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context (p. 42).

Additionally, the surveying profession played a role in the knowledge building process. Professional surveyors were often invited into classrooms to do guest lectures. This created a sense of connectedness to the profession, and allowed students to relate current learning to real world practices. Also, a proportion of the academic staff were themselves professional surveyors who lectured on a part time basis. This meant that examples cited in lectures, and sometimes exercises done in practical sessions, were authentic surveying jobs for real clients. Furthermore, the professional body and the government Lands Department had representations on an Advisory Committee that evaluated and monitored changes to the curriculum. As president of the student-run surveying club, I sat on this committee for a year in the capacity of student representative. This gave me insights into how the profession, through the Advisory Committee, influenced the programme. In this capacity, the surveying profession has played a role as a partner in education. Learning then, for surveying students, resulted from a multi-dimensional interchange involving primarily three stakeholders as illustrated in **Figure 3**.

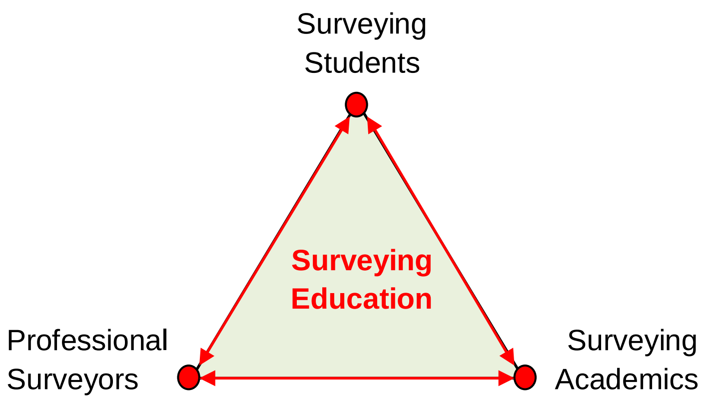

Figure 3: Stakeholders in the surveying education process

1.3.2 My introduction to teaching

My first job after college was a teaching position in the same college. Incidentally, my approach to teaching was largely influenced by the pedagogical approaches used by my college instructors. However, from my new perspective, I had a heightened appreciation for how the physical facilities influenced the pedagogical approaches employed by lecturers. The small classrooms were conducive to interactive teaching, and the expansive campus, with its rolling topography, afforded a variety of field scenarios for practical surveying exercises. During my tenure as lecturer, I witnessed increased involvement of professional surveyors in the education process. This development was generally viewed as progressive as it provided a greater exposure to industry standards and expectations.

As a college lecturer, I felt that it was important that the students were encouraged to be actively involved in the learning process, particularly because the course had a vocational emphasis. Typically, a small part of the cohort was mature students with surveying industry experiences, and I valued the input of the students who had such experiences. The younger/inexperienced students and I learned ‘authentic’ surveying from them. It struck me that I was as much a learner in my classes as I was teacher. Making this explicit felt a bit radical to me, but I was encouraged by the results it yielded for both my students and me.

1.3.3 Industry experience

My interactions with students with industry exposure eventually sparked in me a desire to obtain my own industry experience. It became clear to me that students placed a high value on knowledge that resulted from real life experiences. As I did, they believed that theoretical knowledge was a necessary component of surveying education but grossly incomplete without practical activities that bear some resemblance to professional practice. Gaining industry experience was an important step for me to take in order for me to better facilitate authentic learning. Hence, I left teaching and worked for eight years in two separate surveying jobs. Firstly, as a government surveyor in another Caribbean country then as a survey manager in a private surveying firm in Jamaica. Both the overseas and local exposures proved invaluable as they stimulated new meanings to my conceptions of surveying knowledge applied to real world situations. This told me that although the course made links with industry practices, there are some things that can only be learned through working in industry for some extended time.

1.3.4 Early education in social sciences

Through my work as a government surveyor and manager of a surveying office, I gained access to a university-based management course. The exposure to a range of social science issues and subjects influenced my approach to teaching and learning.

Perhaps the greatest impact was my new perspective on learners as an equal partner in the teaching and learning process.

1.3.5 Second tenure as educator

After several years in industry I again accepted a teaching position in the same educational institution at which I had once taught. The institution had been recently upgraded to university status. With an education in social science, I began to make linkages between my teaching practices and social theories. This allowed me to build meaningful relationships with my students by involving them in the learning process in a way that was not typical of general teaching practices within my academic unit. Along with my academic duties, I functioned in a number of other positions including student welfare officer, examination coordinator and coordinator of student academic advisement. These positions allowed me privileged interactions with a wide cross-section of students, and gave me insights into issues that students struggled with as well as opportunities to explore ways of overcoming them. As a result, I developed numerous new instructional materials and assessment procedures in an effort to improve student achievements. This resulted in many positive student evaluations as well as recognition by the University. My efforts had an obvious impact on student learning and their development as novice professionals.

1.3.6 Higher education – a mix of engineering & social sciences

During my tenure as assistant lecturer, I pursued part-time postgraduate study in a blend of distance education and short study visit at an Australian university. Before this, it was difficult for me to appreciate a distance approach to surveying education, as I felt that the absence of the ‘human element’ would dilute the educational standard. Although this took some time and effort to embrace as a legitimate educational approach for my specialisation, I eventually learned to engage with my online class and other resources such as video lectures and multimedia field demonstrations. The social aspect, which I initially felt was missing, was actually present virtually. I completed the course and earned a Master’s degree in Surveying and Spatial Information Systems. At that time, ‘Geomatics Engineering’ was an alternative title to my course. This was my first encounter with the terminology as a course title. The university at the time was considering reversing its decision to change the course title from *Surveying* to *Geomatics Engineering*. I chose *Surveying and Spatial Information Systems* as I believed the alternative would not be as easily recognised by non-surveyors and some older surveyors.

This post graduate qualification led to my promotion to lecturer. Subscribing to the tenet of life-long learning, I enrolled in a Post Graduate Diploma course in adult education. As a research project in this course, I investigated assessment strategies used within my university's surveying programme. It was at this point I developed a keen interest in researching issues relating to surveying education.

1.3.7 Emerging self

My training, education and work experiences in surveying, management, public administration, engineering and adult education have resulted in an eclectic mix of skills and interests, that I have used in my work as an educator and as an educational researcher. Thus, I view myself as not neatly fitting into any one research paradigm, but rather as inclined to employ research approaches based on what I perceive to be most appropriate. Wellington's (2000) view on this issue supports my position that quantitative data can provide structure to some aspects of many types of research but that qualitative data 'gives richness and colour' (p. 19) to them. Whereas qualitative data may be better for some studies, interpretation is always an aspect of coming to decisions about our subject of research, be it in engineering, surveying or social sciences. Wellington (2000) describes as 'false polarization', the contrasting of quantitative paradigm from the qualitative paradigm as if they were opposite ends of a spectrum. This view concurs with my belief that there is always an element of interpretation in all research and that interpretations are never totally free of value judgements. This contrasts with the view that 'every research tool or procedure is inextricably embedded in commitments to particular versions of the world and to knowing that world' (Hughes, 1990: p.11). Generally then, as a researcher I do not adopt any extreme positions in this quantitative-qualitative debate. However, specifically for this study, I believe an approach that is closer to the qualitative end of the spectrum is more relevant based on the aims of the study. This will be discussed at length in Chapter 4. However, at this point it is useful to state that for this research I employed a multi-case study methodology. This was considered to be appropriate for answering questions about educational strategies in varying contexts. More importantly, the methodology aided the collection of rich data that informed the development of a proposed improved educational model for modern surveying.

Throughout my schooling and higher education, the forming of my identity as a surveyor, educator and researcher has been profoundly influenced and sustained through my interactions with an array of individuals and groups. It is as a result of this that I believe that educational approaches are best determined through processes that give recognition to, and make maximum use of social arrangements. I believe that taking advantage of the social arrangements within educational programmes involves understanding the learners' characteristics, the nature of the subject matter, industry (professional) requirements and the role of teachers. Education, I believe, plays a crucial role in helping individuals achieve professional ambitions. Therefore, I see educational research as serving an important role in unearthing understandings and perspectives that will help educators to be more effective at, not only imparting knowledge, but inspiring confidence in students to pursue lifelong learning, which will ultimately benefit professions.

1.4 Researchable issues

The relevance of educational strategies to particular disciplines is a growing area of interest among academics and educational researchers. This area of research offers important insights into professional education in all fields and, therefore, will be explored in the literature review. *How is surveying taught and learned? Are there characteristic features of the professional discipline that influence educational strategies employed within surveying programmes? What factors influence decision making in surveying courses? Who are the main players in the field of surveying education and what rules of operation are at work and to what end?* These are all questions that underlie researchable issues.

Much attention has not been given to the nature of the relationship between surveying practice and the educational strategies employed within surveying education programmes. Therefore, it is useful to consider, for research, the socio-cultural contexts of surveying education and explore the nature of the relationship between the education systems employed and the nature of modern surveying practice. I believe the education of surveyors cannot be legitimately conducted, divorced of input from the surveying profession. This conviction concurs with Allan's (1995) that 'the education and training of a specialist group, such as geodetic surveyors, cannot be isolated from the vocational activity it seeks to serve.' (p. 5)

For administrative and economic reasons, surveying programmes are often grouped with other fields within universities. However, for effective professional preparation, there may be disadvantages to these arrangements that have not yet been explored by research. Are educational strategies used in, for example, civil engineering, appropriate for surveying education? How can we come to a better understanding of the impact of surveying education on student preparedness for work? These questions are related to those asked earlier but emphasise the issue of work readiness. It has been argued that particular educational strategies are better at professional preparation in disciplines such as surveying.

Innovation in educational approaches has also been promoted as relevant to the modern demands in surveying (Enemark, 2009; Bennett, Ogleby et al., 2009). With only one known surveying programme employing a radically innovative approach to educating students on a wide scale, this again leads to other researchable questions: *How do innovative educational strategies impact surveying education? What are the implications for adopting similar strategies in other contexts?*

The Education Council of the American Society for Mechanical Engineers (ASME) is an example of a professional association that endorses research into educational strategies for their profession. According to Laity (2004), the ASME sees educational change as necessary in the context of 'new and rapidly emerging technologies and disciplines, national and global trends, societal challenges for the 21st century, and associated opportunities for the profession.' Laity's (Ibid.) description of contemporary mechanical engineering practice is also true of other professions including surveying. Engineering schools are now expected to be accountable for the knowledge, skills and professional values that their students acquire in the course of their education (Rugarcia et al., 2000). There is, therefore, a well-established basis upon which to conduct studies into the educational strategies used in specific disciplines to explore the mutual impact between education and profession. Acknowledging the trend of investigative studies in the scholarship of teaching and learning in some disciplines, highlights the paucity of studies in other disciplinary areas such as surveying. This, again, identifies an area of research interest: *What can we learn from more in-depth empirical studies within surveying education, and what might the findings say about professional educational broadly?*

Surveying is traditionally considered to be a narrowly defined field of study and area of professional practice. It has been acknowledged by professional surveying bodies, e.g. the FIG (2011) that it continues to be narrowly defined in a number of countries. However, there is evidence that a growing number of surveying courses have widened the range of their subject offerings. This is most often credited to the impact of modern technology on surveying methods (e.g. Prendergast, 2006) and changes in land-related markets and society in general (see e.g. Enemark, 2009; Mahoney et al., 2005). Curricula that offer a broader approach to educating surveying students are sometimes criticised for producing graduates who are weak in the technical areas. Conversely, some of the courses that are organised around well-defined specialisations are sometimes criticised by professional surveying groups, as over emphasizing the technical aspects of the discipline at the expense of more generic professional skills. The former scenario can have the effect of coercing universities into creating curricula with a narrowly defined focuses while the latter can influence a change to more generic courses. Whatever the perceived issues are with existing surveying courses, changing curriculum content is widely supported among surveying education communities. The greater issues then, seem to lie with *how the curriculum is designed and delivered, where the emphases are placed and what pedagogical approaches are employed.* These too are researchable issues.

Within the context of a changing and highly differentiated surveying discipline, there is a need to understand how educational programmes are impacted and the reciprocal impact different educational strategies have on professional preparation. I am interested in understanding the what, how and why of contemporary surveying education. *What are prominent features of contemporary surveying education? How are education strategies used in the discipline? How are the variations in educational approaches constructed and sustained?*

It has been shown that surveying practice has changed profoundly over recent decades. The surveying profession, in its diverse forms in many countries, and within its international professional groups, has been affected by these changes in diverse ways. Aligning educational programmes with the practice of surveying has been recognised as a problematic venture. It is seen as a challenge to both universities and the profession and is understandably of great interest to surveying students. The FIG has led an initiative to harmonise some of the roles of the surveyor in the many countries it represents. The study by Allan (1995) underlies a desire to unify the profession amongst Western European countries. Even within states of the same countries such as in the USA and provinces in Canada, there are variations surveying practice. This has meant that licence to practice in one jurisdiction is often not transferable to another. This is true for the Caribbean even within the framework of an established common market and economy. Having a clear understanding of the challenges facing surveying education will have more than academic value but also practical worth in coming to decisions regarding the future of this important profession. As Enemark (2009) maintains, land is linked to most if not all human activities and so the roles of land professions represent fundamental functions for sustainable development in all nations.

1.4.1 Research objectives & questions

The preceding discussion of my research interests highlights a primary underlying interest in empirically based knowledge about the nature and impact of contemporary educational strategies employed in university-based surveying and geomatics programmes. On the basis of numerous claims that the educational strategies employed have deficiencies, the research aimed to assess the status quo and to propose an improved model based on empirical data. Specifically, the study sought to:

- Develop a holistic and contextually based understanding of the nature and impact of educational strategies employed within university-based surveying courses.

- Consider how the curriculum and pedagogical issues relate to issues of change within professional surveying practice, and the likely implications for students' preparedness for contemporary professional engagement.

- Utilise the findings in the development of a proposed improved educational model for surveying/geomatics education.

Together, these objectives point to the main research question:

How can a holistic understanding of contemporary practices and issues in surveying education aid in the development of an improved educational model?

'Holistic' implies a multi-perspectives approach that includes the developers, users and beneficiaries of surveying courses. It is also implied that there are issues and practices that impact the development of surveying courses. Some sub-questions were extracted from the main research question:

a) What defines and distinguishes educational strategies used in university-based surveying/geomatics programmes?

b) How do the educational strategies employed, impact students' preparedness for surveying/geomatics work?

c) What fundamental issues underlie decision-making in contemporary surveying/geomatics education?

d) What may be proposed as an improved educational model for surveying/ geomatics?

1.5 Rationale of the study

While there have been few studies that investigated surveying education, they are limited in scope and mostly localised within individual universities. For example, in their longitudinal study of trends in the building surveying education programme at one UK University, Parsons et al. (2007) found that much revision of the curriculum was done as a result of changes in practice and that there was a significant increase in dependence on technology in teaching methods and in surveying practice. They observed that some key competencies were downplayed as a result of new content included to take account of changes in practice. Parsons et al. (2007) concluded that 'some of the changes made to the teaching of building surveying over the last 30 years may not be beneficial to the students now studying degree courses'(p.10). This study was conducted on a narrow area that is not generally associated with the functions of surveyors in many other countries. Similar studies and wider research exploring more extensive issues relating to curriculum and pedagogy's relationship with preparedness for work is also needed for land surveying and its related sub-disciplinary areas or the wider geomatics group. It is believed that this study will contribute to a clearer understanding of the impact of educational strategies on professional preparedness, generally and in particular, within surveying. The degree to which this is currently understood is considered to be particularly limited primarily because of the expansive changes that have occurred in the discipline and profession over recent decades.

The Allan Study (1995) which is the most extensively known study in surveying education explores education and practice in the discipline in a more broadly defined sense than in the study described by Parsons et al. (2007). However, three things are noted in regards to the Allan Study. Firstly, it was limited to a relatively small geographical area; secondly, it was an evaluative study and, therefore, limited in its exploration of the identified issues through established theoretical perspectives; and thirdly, the pedagogical issues investigated were limited and did not address the possible relationship between pedagogical approaches and expected learning outcomes. This study seeks to build on existing knowledge by exploring similar issues and more among much more diverse contexts.

Additionally, this study offers a new perspective in looking at contemporary surveying education as it also explores the nature of the relationship between key agents in the field. Some of Bourdieu's concepts from his theory of practice are used to explore how the relationships between agents in the field influence the strategies employed in educational systems. Importantly, this theoretical focus helped to frame some aspects of the findings within contextual settings. This framework gives an account of the how surveying education is constructed through the input of the range of identified stakeholders (social agents) in the various contexts. These are discussed in more details in Chapter 4 of this thesis (Research Methodology). Furthermore, this study compares one conventional surveying programme with a more innovative one.

The findings from the study will hopefully have practical relevance to universities offering surveying programmes and to professional surveying bodies that seek to develop the discipline. This it will do through helping to illuminate issues in surveying education that are key influencers of development in this field. A clearer understanding of contemporary surveying/geomatics education from a wide spectrum of countries, some with unique characteristics, can aid international surveying organisations such as the FIG and RICS and accrediting bodies in determining standards for the profession within the perspective of regionalisation and globalisation. Beyond that, a new understanding of the relationships that exists between educational systems and their associated professions, and between learning outcomes and the curricular and pedagogical approaches employed, will add to what is already known about profession-oriented courses.

The development of a proposed new model will be the outcome of this empirical study. This model will result from a consideration of the key issues that emerged from the study and deeper consideration of how these may be explained using some Bourdiean concepts. The aim is not so much to add to theory, but rather, to use the concepts as a tool for coming to an understanding of how the observed systems work within different contexts by using a common framework. This approach will allow for comparison without ignoring contextual differences.

1.6 Thesis structure

The thesis is divided into nine chapters presented in a quasi-narrative style with headings and sub-headings to enhance its readability.

Chapter 1 provides an introduction to the study and a background within which the study is situated. Firstly, the study is contextualised to provide an understanding of contemporary surveying practice and education. This is followed by an outline of the researcher’s background to offer some insights into the genesis and development of the researcher’s interest in surveying education. The first two sections provide a logical flow into exploring identifiable areas of interest for research and also a rationale that explains the significance of the study. The final section outlines the thesis structure.

Chapter 2 provides a historical account of surveying in regards to its practice as a profession and also in regards to surveying training and education. It scans the practice of surveying from prehistoric periods to modern times.

In Chapter 3 an expansive review of literature relevant to higher education curriculum and pedagogy is discussed. Additionally, issues relevant to professional education are explored against the backdrop of historical linkages between the national/regional contexts represented in the study and the educational systems that developed as a result.

Chapter 4 explains the development of a methodological approach for the study. It explains the links between the researcher’s ontological and epistemological standpoint and the theoretical perspective used, and how these relate to the methodology and enquiry methods used.

In Chapter 5, the findings from the study of fifteen surveying/geomatics curricula are discussed. The chapter presents contemporary issues that emerged from the data as major factors impacting the educational system in the discipline.

Chapters 6 & 7 are dedicated to presenting empirical findings from the two in-depth case studies. In chapter 6, the findings are discussed relative to the findings from the more comprehensive case studies. In chapter 7, the discussion takes a comparative approach relative to the wider case studies and also the first in-depth case study. Some of the findings are framed relative to theoretical concepts covered in the literature under the themes that emerged from the data.

Chapter 8 provides a discussion of the findings and explains the development of a contemporary model of surveying education. The chapter also discusses contextual issues relevant to the application of the developed model.

Chapter 9 is the final chapter and where conclusions are drawn from the findings; reflections are made on the research approach, and implications of the findings discussed along with recommendations for further studies.

CHAPTER TWO

Surveying practice, training and education – A historical perspective

If you would understand anything, observe its beginning and its development.
(Aristotle)

2. Overview

This chapter provides a historical account of surveying in regards to its practice as a profession and also in regards to training and education within the discipline. This account reinforces the contextual framework and serves as a basis upon which to evaluate contemporary surveying practice and education in the various contexts included in the study. It scans the practice of surveying from prehistoric periods to modern times. Though it is recognised that Africa and Europe incorporate key locations in ancient surveying history, the earliest historical account is presented in a separate sub-section on the basis of the pioneering work of those early contributors and not based on geography. Thus, the account is presented in the order: Egyptians and Sumerians, Greeks and Romans, Post-Roman Europe and The British colonies. This is followed by two reviews. The first review concerns surveying education in the countries included in the study; and the second is a brief review of three international professional bodies that are considered to have the greatest impact on the surveying profession and influence on surveying education programmes. In the latter part of the chapter, a discussion on the literature highlights features of the historical account that have particular relevance to this study. This provides a basis upon which educational systems employed in surveying programmes in the various contexts can be explored.

2.1 Introduction

In Chapter 1, it was mentioned that surveying has a long history dating back to the ancient Egyptians. One has to be cautious in exploring surveying history, as it is not limited only to accounts that bear the surveying label. The histories of cartography and land surveying are intertwined since map making is invariably a product of surveying and often carried out by surveyors themselves, who are typically trained in the art of mapmaking. Developments in trigonometry, astronomy and geometry also have close links to the history of surveying. The historical account, divided into eras

(Egyptians and Sumerians, Greeks and Romans, etc.) will explore the links between the development of surveying alongside advances in mathematics, astronomy and cartography.

2.2 Ancient surveying

Evidence of pre-historic methods used to measure and represent land forms and features are typically linked to archaeological finds. There continues to be new archaeological discoveries, some of which depict very early maps which indicate pre-historic activities associated with land measurement and representation. These discoveries are made in diverse parts of the world suggesting that for as long human history can be traced, there are indications that humans have used various means of depicting their geographical locations. There are numerous writings on ancient Egyptian and Greek contributions to earth measurements and map making, but increasingly artefacts are found in other parts of the world confirming similar activities in diverse locations in ancient times. For example, China's contribution, though not as widely publicised, has been noted by writers such as Needham (1959) and Menzies (2003). Adams (1912) refers to map-making activities of primitive peoples in South America and Greenland. An article published in the Telegraph newspaper states that an archaeological artefact found in a Spanish cave represented the world's oldest map (Govan, 2009). The article states that the stone tablet found in a cave shows etchings that represent the geography of the area in which it was found. This artefact was analysed to date over 14,000 years and is believed to be the oldest known representation of landscape in map format. While it can be argued that some of these artefacts are geographical representations, the use of associated earth measuring methods that may have supported them are mostly inferred. Similarly, the use of markers to delineate land boundaries also appears to be an old practice. Biblical references to boundary marks reveal that the physical division of land was also practiced in the Old Testament era. The quoted verse from the Bible was written over 3000 years ago:

> Cursed is the man who moves his neighbour's boundary stone. (Deuteronomy 27:17, Holy Bible, New International Version)

Much of the written historical account of surveying, starts with the region that is often described as the *cradle of civilisation*. Even though this term is used to describe several places over a variety of eras, the region often associated with this term, as it relates to surveying measurements, is within the plains of the Tigris and Euphrates rivers, an area which is also historically known as Mesopotamia (Chiera, 1956).

2.2.1 Egyptian & Sumerian surveyors

Ancient inhabitants of the regions of Mesopotamia are credited with leaving many pieces of evidence that point to early surveying practice (Chiera, 1956). Early forms of land measurements on clay tablets were found in the plains of the Tigris, Euphrates and Nile rivers; and numerous extant clay tablets show the plans of ancient cities and agricultural areas (Richeson, 1966). Boundary stones used to mark land divisions have survived for centuries and stand today as evidence of early survey work. Many of these, according to Richeson (1966), date to earlier than 1000 B.C. Richeson also states that the walls of Egyptian tombs depict records of surveys conducted along the Nile valley showing dimensions, areas, quality and taxes due. Such findings support the historical account that land measurement was practiced along the Nile to replace boundaries displaced during flooding (Crone, 1953).

The Egyptian pyramids stand as testaments to the advanced engineering knowledge and skills of ancient Egyptians engineers and surveyors. It is clear, from the accurate layout of these ancient structures, that the ancient Egyptian surveyors had an excellent grasp of mathematics and were able to develop means of setting out complex structures with great skill and precision (Smith et al., 2006).

The equipment used by ancient surveyors known in ancient Egypt as *Harpedonapata* (Rope Stretchers) was crude compared to modern equipment, but it is clear from the structures they left behind that they achieved marvellous outcomes using them. Drawings on the walls of ancient tombs illustrate land measurement practices and the use of equipment such as ropes, rods and some forms of levelling devices (Richeson, 1966). A trace of the development of surveying instruments can reveal much about the development of science and technology as the discipline is intrinsically linked to both fields. Paulson (2005) points out that the intellectual knowledge of Egypt was intertwined with Hellenistic systems. Hence, ancient Greeks developed much of their scientific knowledge on the basis of the knowledge of Egyptian rope stretchers (Brock, 2004).

2.2.2 Greek & Roman surveyors

An important aspect of any discipline is the documenting of its fundamental principles in a way that allows for their propagation. One ancient Greek contribution to surveying is *The Treatise on the Dioptra* written by Hero of Alexandria in A.D. 100. 'This is…the earliest extant book to be written on surveying; here the fundamental principles of surveying land originated.' (Richeson, 1966: p. 4). Richeson further points out that, ancient records show the transferal of Egyptian and Greek land measuring and recording methods into Roman practice. Whereas the Greeks are credited with early advances in mathematics and science, the Romans are credited with adapting the mathematical and scientific principles into practical surveying methods. Based on the historical account found in the literature, the Egyptians and Greeks are more accurately credited as scholars who portrayed surveying as a scholarly discipline. Then again, Romans did contribute to the progression of the science of earth measurement, and are better credited with finding ways to apply the science to workable solutions that could be utilized to meet societal needs.

Much of what is known about early theories on the shape and size of the earth is credited to Greek mathematicians, scientists and astronomers. The Greek philosopher Anaximander is believed to have constructed the first map of Greece in the 6th Century BC (Crone, 1953). However, the first map of the world is believed to have been constructed by Pythagoras (1st century BC) who is also credited with promoting the idea of a spherical Earth (Campbell, 1981). The belief that the earth is spherical was an idea radically different to the previous belief promoted by Homer in the 9th century BC that brought forward the idea that the earth was a plane disc surrounded by a constantly moving ocean river (Brown, 1979). Other famous contributors to the early work in the science of earth measurement include other Greek scholars such as Aristotle (4th century BC) who incorporated theories of gravity in the determination of the shape of the earth and Eratosthenes (1st century BC) who first calculated the circumference of the earth (Crone, 1953). The Greco-Roman contribution to the sciences of earth measurement and earth representation continued to progress into the 1st century AD. Ptolemy (79 - 168 AD), a Roman mathematician, astronomer and geographer lived and worked in Egypt; and is well known for making significant progress in the scientific study of geographical locations in many places around the globe and their accurate representation on maps (Berggren and Jones, 2001).

2.3 Post-Roman Europe

Europe's historical dominance, as a world power and the subsequent associations forged by their imperial rule, has meant that many of the systems employed in other parts of world reflect aspects of European methods and values. This is true of surveying education and practice as will be demonstrated using Britain as a case.

After the fall of Rome, many of the surveying instruments and methods survived and were further developed in continental Europe (Richeson, 1966). Richeson sees this as continental Europe's primary contribution to the discipline in the post Roman era. The Italian, French, English, German and Swiss are prominent in records of developments in surveying instruments that resulted in the proliferation of surveying activities worldwide and improvements in measuring accuracies during this era.

> During the 13th and 14th centuries there was … growth in technology, demanding new and better scientific instruments as well as a higher degree of accuracy in measurements. (Richeson, 1966: p.24)

Markedly, the growth and development of science and technology significantly enhanced the art of surveying. Germany and Switzerland are noted for early advances in photogrammetry, which was a technology that facilitated relatively quick and accurate topographic surveys of large land masses (Macdonald, 1996). However, Britain's contribution is being focussed on because of its historic impact and, arguably, on-going influence on a large number of post-colonial countries around the world.

2.3.1 Britain

Land measuring techniques used in Britain were based on a number of factors including but not limited to, methods borrowed from other societies. Richeson (Ibid.) refers to a number of the influencing factors: agricultural practices (methods of cultivation e.g. the open field methods practiced by the Saxons in Britain), conquest and settlement patterns (e.g. tight control on lands administered by the Feudal system that existed in Britain after the Norman conquest in 1066), economics (e.g. late 15th

century economic boom in Britain brought about an increase in the value of arable lands which cause increased demands for surveyors and the beginning of enclosing[1] in the 16th century), taxation practices, etc.

Richeson (Ibid.) identifies the 16th century as the beginning of modern surveying. The developments during this century were partly a result of changes in land tenure and agriculture, as well as advances in navigation and military practices, which both depended on and utilized ever increasing direction-determining and distance measuring devices. These developments contributed to improvements in measuring methods, from chain surveying to more scientific methods based on applications of proven mathematical principles. The need to be able to give accurate layout and area of land became more and more important, as European countries expanded economically and increased their claims on overseas territories. By the 19th century, surveyors could more readily afford state-of-the-art instruments allowing them the ability to execute surveys of greater accuracy and produce reliable and detailed maps.

The 20th century saw increased mechanisation in the discipline and the notable introduction of electronic and photographic techniques. These applications were particularly useful for the survey of large areas such as entire countries. The technology did not only impact surveying operations in Europe, but in its colonies in Africa, the Americas and the Pacific regions (Macdonald, 1996). By this time Britain had expanded its empire to more countries than its European rivals (Parry, 1961).

It will be shown that Britain has had significant influence on its former colonies' surveying systems and practices. However, though basic surveying networks and measurement techniques are almost universal, Britain's cadastral practices are different to those of most other countries. England and Wales have a general boundary system as opposed to fixed (measured) boundaries in an established cadastre. According to the official website of the UK's Land Registry (http://www1.landregistry.gov.uk/), 'a title plan with general boundaries shows the boundary of a property in relation to a

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[1] Enclosing was the process of combining the strips of the open fields into large fields and then enclosing larger fields with fences, hedges, or other boundaries. (Richeson, 1966; p. 29)

given physical feature on the ground, such as a wall or hedge, as identified on the Ordnance Survey map. The red edging on a Land Registry title plan is therefore not definitive as to the precise position of the boundaries.' In all the other countries accounted for in this thesis, a certified surveyor is required to set precise physical boundary marks at the turning point of land boundaries. From the surveyor's measurements, computations of the boundary courses and the enclosed areas are done for all properties to be registered in a national cadastre. This difference has significance for the role of the surveyor in England and Wales in regards to cadastral Surveying. This means that land surveyors in England do not play a significant role in the demarcation of property boundaries or in the legal transactions that are involved in the transferring and registering of land (Maynard, 2000).

2.3.1.1 British Military Surveys, Ordnance Survey & Directorate of Overseas Surveys

A historical account of surveying in many jurisdictions would not be an accurate reflection without inclusion of the contributions from military forces such as the British Royal Engineers. Map reading, positioning and navigation are technical surveying activities, which are also important to military strategies. Surveying activities have always and continue to be taught and practised in military forces. Additionally, the exploits of army personnel often predispose them to knowledge of land terrains over vast areas. For these reasons, the British military has been involved in the early surveying operations in many countries. Their involvement, for example in the work of the Ordnance Survey (OS) and Directorate of Overseas Surveys (DOS) illustrate their contribution to surveying operations.

Ordnance Survey (OS) was established in Great Britain in 1791 as a state-run organisation charged with overseeing national mapping exercises (Macdonald, 1996). Macdonald (1996) describes the operations of OS as 'an impressive and successful example of a well-planned and scientifically based approach to national mapping' (p. 8). However, he further adds that Britain's overseas territories in the early years of OS significantly lacked surveying activities and products. The Royal Engineers officers played an important role in providing scientific and managerial expertise to the OS's operation. Similarly, many of the early directors general of the OS were military officers. Furthermore, the Royal Air Force was also involved in the taking of aerial photographs from which maps were produced for vast areas of lands in the colonies.

Surveying operations in former colonies of Britain (Africa, the Americas and Asia) are intrinsically linked to imperial directives and approaches. With the OS responsible for surveys within Britain, the Directorate of Colonial Surveys, (later named the Directorate of Overseas Surveys (DOS)) was established in 1946 (Macdonald, 1996). DOS's primary role was to oversee large scale geodetic and topographic surveys of British overseas territories. Over the DOS's 38 years of existence, it engaged European surveyors along with local surveyors, trained by them, in each colony to execute early surveying operations that produced national geodetic networks and detailed topographic maps of these countries. Scientific surveying operations (geodetic surveys) were necessary to provide the basis for more detailed topographic surveys which were considered to be a crucial prerequisite for national development in regards to planning and economic activities. Baroness Chalker of Wallassey in her forward to Macdonald (1996) underscores the importance of surveying operations in these countries:

> Topographic mapping forms the framework on which all other information is assembled; without it, all development, from the most elementary formulation of policy to the planning of operations, is liable to disaster…. Mapping underpins many of the activities of government, commerce and industry. (p. xii).

It is clear then, that surveying operations in former colonies have historical linkages with Britain. Within these regions, both the systems used and the nature of the products from surveys in the early days as well as later surveys reflect this colonial heritage. These are later explored in the accounts given of surveying in the Americas and Africa.

2.3.2 Brief histories of surveying in Denmark, Finland and Hungary

Denmark has a recorded history of organised surveying activities from the 1800s. The Danish Geodetic Surveys was established in 1816 which was charged with the setting up of a control network over the country with links to neighbouring countries (Enemark, 2002b). The mapping of the country gained significant momentum in the 1960s with the application of photogrammetric techniques.

In his account of the history of surveying in Denmark, Enemark (2002b) identifies an early concentration of the profession on cadastral surveys mostly carried out by professional surveyors with licences to operate private practices. This he says has changed significantly since the 1960s and currently a large majority of surveying operations involving non-cadastral activities are carried out by non-surveying private businesses. Enemark (2007) sees this as being directly related to increased activities in areas such as engineering surveying and topographic surveying and unconventional activities such as GIS and land management. Denmark has a national cadastre that was set up for the purpose of taxation (Enemark, 2002b). Enemark (2002a) also states that the Danish cadastre is credited to the work of surveyors and is considered to be the basic infrastructure for managing economic interests in land as well as supporting environmental and development interests. Thus, the surveying profession is seen as performing a crucial function in national development.

Enemark (2002b) asserts that over the last three decades the practice of surveying in Denmark has been remarkably transformed. He states that, whilst in the 1960s cadastral functions dominated the activities of the surveyor, in 1997 that function only accounts for 20 percentage of the surveyors work. While the survey reported by Enemark (2002b) shows a remarkable reduction in cadastral activities it shows increases in areas such as planning and land management, engineering surveys and other areas.

In 2002 there were about 900 active surveyors in Denmark, an amount Enemark (2002b) believes is small relative to the size of the country and the extent of surveying work yet to be done. The profession is supported by a national association of chartered surveyors and the membership is made up of licensed surveyors operating private surveying practices, as well as surveyors employed to the public sector and others employed to non-specialist surveying private firms. In fact, Denmark's surveying profession has very close links with the FIG with one Danish surveyor serving as president. Furthermore the FIG headquarters is located in the Danish capital city.

Like Denmark, Finland is a Scandinavian country. Both countries have shared histories in many regards as well as profiles relating to the surveying profession. According to the summary analysis of European surveyors done by the Order of French Chartered Surveyors (date unknown), both Denmark and Finland have almost identical overall population and similar ratios of surveyors to national population. Finland's surveying practice has particularly been historically linked to Sweden's surveying practice as the country until 1809 was politically linked to Sweden (Häkli, 2003). Finland's Ordnance Survey started in 1633 when one surveyor was sent to Finland from the Swedish Corps of Surveyor-Geometers (Häkli, 2003). This core of surveyors executed several of the early topographical and cadastral surveyors in Finland. However, it was not until Finland's political independence from Sweden that published maps showed Finnish lands separate from Swedish lands. Häkli (2003) further adds that though the Swedish surveying and map making techniques influenced similar activities in independent Finland, that they developed their own surveying and mapping characteristics. He adds that this was further influenced by the Russian military who carried out mapping exercises in Finland for distinct military purposes. As have been shown, surveying has played an important role in the development of Finland. Notably, surveyors in Finland have executed functions that include geodetic, cadastral, engineering and topographical surveying as well as real estate related functions. However, since 1993 the University programme has offered two specialisations allowing students to focus on either real estate economics or Geomatics (Viitanen, 2007). As in Denmark, professional certification can only be accessed by individuals with Master's degree qualifications from the prescribed university programme. Viitanen (2007) indicates that the majority of surveying operations is carried out by the National Land Survey Department and so most graduates from the associated university programmes find employment in the public sector.

Hungary is the third mainland European country represented in this study. Surveying practice in this central European country has had a long history with recordings from the mid-16th century (Mugnier, 1999). The practice of surveying in Hungary has been influenced by the country's colourful political history with several changes from an early independent Kingdom, to membership in the German-Roman Empire, to the Austrian-Hungarian Monarchy, to a democratic republic, to Soviet led communism and now a political democracy and market economy (Ossko, 2010). Mugnier (1999) notes that under the Austrian-Hungarina Empire, private topographic and cartographic activities were done. He notes that there have been five distinct topographic surveys of the country. The distinctions related primarily to the techniques used and in some cases to the purposes for which they were executed. Mugnier (1999) indicates that some topographical surveys were done for military purposes. However, the main purpose for resurvey was the use of different reference datum, due in some cases to improvement in scientific knowledge and technology, and in others reflecting political associations (Mugnier (1999). The earliest cadastral surveys were executed for land taxation purposes and the land cadastre established in 1875 under the Austrian-Hungarian Monarchy (Ossko, 2010). Cadastral surveying is conducted by licensed surveyors and the majority of such surveys are done by private surveyors (Ossko, 2010).

2.4 Surveying in British Colonies

2.4.1 North America

North American surveying has historically been associated with explorers and land developers as the expansive landscape was very attractive to a number of imperial rules. The surveying profession in America continues to have a primary connection to the establishment and management of property boundaries and regulations vary according to state laws (Frank, 2008).

In highlighting the important role played by surveyors in the development of America, Hubbard's (2009) declaration speaks of the nature of the work of early American surveyors and the calibre of individuals involved in its execution:

> …the United States [of America] is a nation formed by surveyors, people whose chief task is marking borderlines upon the land that cleanly apportion its surface into discrete parcels, each destined to be the sole property of some identifiable person, entity, or government.

> Surveyors call such an apportionment a cadastre, and the achievement of such a perfect, no-conflicts allotment of the earth's surface— not just on maps but upon the land— is the great aspiration of the surveying profession. That our three greatest presidents held to that idea in their formative years must say something about the character of our nation in the first century after its independence, when the continent seemed a tabula rasa [blank slate] upon which any pattern of boundary lines could be written. (pp. ix-x)

The quotation makes reference to the well-known fact (among surveyors worldwide) that former US presidents Washington, Jefferson and Lincoln were surveyors in their early years before serving their country in its highest office.

The nature of the practice of surveying varies according to states within the USA. However, cadastral surveying has been the predominant professional engagement of American surveyors (Frank, 2008).

2.4.2 The West Indies – Case of Jamaica

The West Indies is geographically linked to the Americas, and where surveying is concerned, there are some common historical facts linking countries within this geographical zone. For example, surveying exercises were carried out in the West Indies by the DOS starting in the 1940s following control survey work by the Royal Engineers (Macdonald, 1996). However, before this era a large amount of plantation surveys were conducted in some Caribbean countries (Higman, 2001). Higman (Ibid.) makes particular reference to the Jamaican plantation society, highlighting evidences of large scale surveying activities. The historical account of surveying in Jamaica has some resonance with other Caribbean countries as there are some commonalities in their historical experiences.

For Higman (2001), no forces were more influential in the shaping of the modern social and economic structure of tropical America than slavery and the plantation society. He states that, throughout the 18th and 19th centuries, Jamaica was dominated by large plantation landholdings. The stock of plantation maps in the National Library of Jamaica has significant amounts of survey data showing evidence of colonial surveys. Estate mapping became popular amongst wealthy British residents who were eager to show their land holdings in overseas territories. After emancipation, the work of the surveyor remained important because of the resulting rapid and extensive readjustment of settlement patterns creating subdivisions. Higman further explains that:

> the fortunes of the Jamaican surveying profession in the eighteenth and nineteenth centuries mirrored those of the plantocracy. In the period of planter prosperity, surveyors charted the expansion and refinement of the slave plantation system, finding continuous employment from the inevitable boundary disputes. (p. 19)

He elaborates that after emancipation, these activities created a vital record of the transformation of patterns of land tenure and use. The demand for surveying services reached a peak in the decade beginning in 1834. Although they were servants of their employers, the surveyors did inject their own ideas and attitudes into the plans they produced, and so took an active part in the creation of the island's social organization and landscape.

As the island moved into Crown Colony government, the decline in the plantation economy contributed to the emigration of foreign surveyors. During the Crown Colony period, government surveyors appointed to each of the three counties were responsible for establishing parish and county boundaries and to oversee the increasing demand for land following emancipation. 'Surveying in Jamaica from this point on, became largely a private enterprise controlled by law and custom.' (Higman, 2001 p. 30).

In the early days of English colonization all of the island's surveyors were immigrants, trained in European techniques and practices. While it is true that European surveyors continued to work in Jamaica, it is believed that during the period of greatest activity (1780 – 1850), Jamaica-born creoles dominated the profession.

Surveying methods used in Jamaica in the 18th and 19th century included chain and compass. In 1555 the theodolite was invented but did not come into wide use until a telescope was added in 1720. Surveyors' field notes of the 18th and 19th centuries showed angles no more precise than half a degree. This suggests that the more precise theodolites were not in use in the island until the late 19th century.

There was a general absence of people with military experience engaged in surveying in Jamaica. This was cited as one reason for the slow introduction of what was then the more advanced technique of triangulations introduced in France in the 17^{th} century and developed through the British Ordnance Surveying after 1780.

> In general it was rare for engineers to be employed in plantation surveying in Jamaica and rare for local surveyors to perform topographic work, though some did take levelling contracts for road, railway and canal routes… Andrews, suggests, 'the engineer was not cheap enough for estate surveying and the estate surveyor not skilled enough for trigonometry or topography'. (Higman, 2001: 58)

Higman (2001) noted that this pattern was typical of surveyors in metropolitan areas and so did not indicate a relative backwardness of Jamaican surveyors.

Contemporary Jamaican surveying practice is still prominently related to cadastral work. Thus, the profession continues to benefit from laws that regulate the practice of cadastral surveying. However, according to the UTech programme document (UTech, 2009) there has been an increasing involvement of surveyors in civil developments as with the modern highways built in the last two decades. Traditionally there has also been mining related work within the bauxite industry. However, the industry has suffered a decline which negatively impacted the surveying industry as much as the recent decline in the building and construction industry did. With a growing surveying education programme and increasing involvement in non-traditional areas, particularly GIS related, the surveying profession in Jamaica is still largely seen as playing an important role in the society.

2.4.3 Surveying in Africa

With much of the ancient history of surveying credited to the African continent, it is interesting to note that many of the countries on the same continent have had very different histories as it relates to the science and practice of surveying. Ancient Egyptian surveyors have been looked at in the earliest section of this chapter; so this section is a brief look at surveying activities in the wider continent.

In a report commissioned by the United Nations Habitat (2001), thirty African countries in the Sub-Saharan and South Eastern regions of the continent were evaluated based on the status of land surveying and large scale mapping. The report identifies the inadequacy of land surveying information as a major constraint to effective land management in Africa. Land surveying is presented as one of the principal factors in human settlement, an activity that remains a contemporary problem in many African countries. The report points to surveyors as playing an important role in sustainable urban development and an aid to urban infrastructure planning and development.

The inadequacy of surveying activities in many African countries is blamed for unplanned settlements and the many social and economic ills that this often generated. With extensive areas of lands not surveyed, or with undated or unreliable survey data, Habitat (2001) maintains that there is a real need for extensive surveying operations. Therefore, the surveyor is seen as playing an important role in many countries on this large continent. Chodota (2001), in giving an overview of the state of surveying in Africa, makes reference to some characteristic features of surveying in a large part of this continent. He states that most of the official mapping agencies are centrally run government departments, and that cadastral surveying and mapping activities generate substantial revenues for central governments. However, Chodota (2001) points out that, budgetary constraints restrict the pace of technology injection in the surveying and mapping processes. He adds that 'the slow introduction of technology is further complicated by inflexible and outdated laws that do not make provisions for change in techniques and methods' (p. 7).

As relating to the education of African surveyors, Chodota (Ibid.) mentions that there are several universities across the continent that offer surveying degree courses. This, he argues, explains why some of those countries have an adequate supply of surveyors. He however, identifies southern African countries, as experiencing shortages of surveyors and a much wider shortage of trained surveying technicians. He also points out that 'most universities have revised curriculum and adopted new courses to cater for new technologies' (p. 9).

Macdonald (1996) provides some evidence that the DOS was operating in several countries in Africa from as early as the mid-1940s. This work was to establish geodetic control and topographic surveys to be used for various projects in developing local economies. These exercises were led by DOS surveyors supported by local surveyors and local support workers trained for the job by their European employers.

Africa is often referred to one country, but I think it is important to note that the over 50 countries represented on the African continent have variations: some vary significantly relative to others in terms of cultures, economies, education, surveying industry, etc. South Africa, for example, has a history coloured by the now defunct system of apartheid that impacted all areas of life. Land tenure, for example, was one area impacted by the racist system and resulted in 75% of the land reserve barred from the largely black population. It is important to note that while these differences are recognized, a more generalised account of the state of the land surveying in Africa is sufficient for the purposes of this study.

2.4.4 Surveying in Australasia

The Chinese have also made early contribution to the science of earth measurement and map making. Needham (1959) outlines that in the 11^{th} century the Chinese had already developed the use of the magnetic compass for direction determination. This precedes the European records of the use of this device which Needham identifies with an Englishman about A.D. 1180. Other countries in this extensive region have their own histories as relating to the practice and development of the surveying profession. However, since Australia and New Zealand are the two countries from that region that are included in this research, those two countries will be briefly focussed on.

2.4.4.1 Australia

Australia is a vast continent nation with the Aborigines known as its earliest inhabitants. The Aboriginal and Torres Strait Islander peoples developed an intimate knowledge of the land and its environment and produced unique forms of Indigenous cartography (Neate, 1999). However, the arrival of the European settlers introduced new ways of dividing the land and mapping its vast areas. A Dutchman, is credited with being the first to sail and chart the Australian coast. Nevertheless, the more substantial influence on surveying operations began with the British colonisation in 1770 when the southern region was established as a penal colony (Land Services of Southern Australia (LSSA), 2011). According to the LSSA,

> the early surveyors of South Australia were both explorers and planners, constantly venturing into uncharted territory as well as mapping out the invisible foundations of the future capital city, towns and roads of the new colony and the State. (online)

Tweedie (2010) adds that the surveyors/explorers had varying backgrounds. He describes some as having military background; others as government employee, and another set as adventurers who were part of privately funded expeditions.

In Australia, regional bodies govern surveying activities, and professional organisations support and monitor the profession. The Surveying & Spatial Sciences Institute (SSSI.org.au) describes its function as representing the interests of surveying and spatial science professionals in both Australia and New Zealand. It further states that its scope includes land surveying, engineering & mining surveying, cartography, hydrography, remote sensing and spatial information science. Surveying continues to be an important profession within Australia with very strong cadastral focus. Furthermore, in areas where mining is central to the economy, mining surveying is common place.

2.4.4.2 New Zealand

The earliest organised surveying operations in New Zealand are believed to be linked to Polynesian navigators, explorers and settler (Robertson, 2010). Robertson credits the Maori settlers with making records of locations of resources during their early explorations. Robertson further states that when Europeans started to settle in New Zealand in the early 1800s, there were already established settlement patterns and land use arrangements. However, no substantial surveys were carried out until more Europeans settled in the country and the demand for land intensified. The first European surveyor arrived in New Zealand in 1834 and executed surveys in Auckland (McRae, 1981). As economic activities increased and more settlers arrived, surveying activities increased. Coutts and Grant (2009) note that 'most of New Zealand was opened up for settlement by European by those early surveyors' (p. 4). However, the earliest periods of organised surveying operations were conducted under different provincial directives and guidelines and this created inconsistencies in methods and standards (Robertson, 2010). In light of this, the situation was later addressed through the appointment of a surveyor-general in charge of all the surveys in the country, which led to the rationalisation of surveying and the establishment of a national system (McRae, 1981).

Contemporary New Zealand professional surveyors carry out a wide range of functions, including cadastral, topographical, engineering surveys and land planning (Otago University surveying handbook, 2009). The New Zealand National Institute of Surveyors describes the surveyor as having expertise in the science of measurement and the gathering and applying spatial information to a wide range of uses. Unlike most of the contexts in this study, surveying in New Zealand has been described as still a popular discipline for school-leavers. Otago University is the only university in New Zealand that offers the professional degree course for surveying. Hannah, Kavanagh, et al., (2009) asserts that

> To the author's best knowledge the school of surveying at the University of Otago is the only program in the English speaking world that is heavily oversubscribed with students (150 students competing annually for the 60 places available in each new intake class). This has only come about after many years of a targeted publicity campaign consisting of clear simple messages that have been directed towards high school students and their teachers.

New Zealand has reciprocal arrangements with Australia that allows surveying qualifications in one country to be accepted in the other. This means that Otago surveying graduates can work as surveyors in Australia (Coutts, 2011).

2.5 Training and education of surveyors

Markedly, no record of formal training of surveyors in ancient times has been found. However, several historians account for various aspects of training and education in later eras. This section will explore the history of surveying training and education highlighting features considered to have particular relevance to the study.

Of significance to the development of higher education in Britain, is the establishment of Oxford University in 1170 and Cambridge University in the 1300s. Advances in mathematics (particularly, trigonometry and geometry) and astronomy had particular relevance to the educational development of the discipline of surveying in the English speaking world. However, though scientific knowledge was being developed, the practicing surveyors in the early years were not fully aware of them and so unable to apply them to their work. Richeson (1966) notes this point as relating to the education of early British surveyors:

> … the average surveyor did not have sufficient mathematics at his command to make use of either the methods of triangulation or the instruments to apply these methods. (p. 10)

The production of surveying texts is also an important aspect in developing formal education in the discipline. The first English texts believed to be directly surveying related, date back to the early 1500s and included content not only related to land measurement but also estate management. Richeson (1966) indicates that the initial publications presented land measurement in a separate text from instructions to land stewards and overseers of manors. In the latter part of the 1500s, there were attempts to merge the technical aspects of the discipline with the managerial aspects in a unified text. However, there appeared to have been an underlying belief that the land measuring aspect of surveyors' work needed a distinct and definitive text that presented practical principles and techniques to be used by those who practiced the skill.

> Benese's (book of 1537)…represents the first real attempt to put into the hands of the surveyor or land measurer, as distinguished from the 16th century manager of a manor, a simple, practical treatise on land surveying. (Richeson, 1966: p.36)

Whereas the early directors and deputy directors of the DOS were military officers, there were civilian officers e.g. a geography graduate who worked as the assistant of the first chief cartographer at the DOS (Macdonald, 1996). There is no evidence of the nature of training that was undertaken by employees with non-surveying qualifications, but there are indications that these persons underwent some amount of training to learn specialised surveying and cartographic skills. Macdonald (1996) indicates that a small core of ex-Royal Engineers with wartime experience provided the expertise and carried out training exercises.

Overseas surveying offices operated under the supervision of the DOS and principal surveyors were appointed to each. Macdonald (1996) regards the appointment of a British Honduran citizen with Canadian degrees as a field surveyor, as an unusual practice. Recruits were trained to fill cartography positions. The role of the military in early survey work was not limited to Britain's Royal Engineers. Macdonald (Ibid.) indicates that the DOS also employed surveyors and cartographers from the Polish Army. These men were sent on assignments in various overseas territories.

Shortages of equipment in times of austerity led sometimes to improvisation. Macdonald (1996) mentions that DOS staff assembled plotting machines, found in a warehouse, and taught themselves how to use them. These machines, he said, were used in the West Indies. In his account, Macdonald (Ibid.) makes reference to competing private surveying enterprise in the 1940s that sometimes attracted the trained personnel from the DOS.

Although land surveying operations have been carried out for a long time, surveying as an academic course in many of the contexts in the study was introduced in universities at various times but predominantly in the 1960s (see **Table 1**). In Britain, formal land surveying training started with the RICS establishing an education system to prepare enrolees for licensing examination (Allan et al., 2008). This course lasted for two years, for the first examination, and a further two years for the intermediate examination. Later, a fifth year was added for preparing students for the final examination. Allan et al. (Ibid.) further outline that ‘recruitment varied considerably, both numerically and regarding entry qualifications’ (p. 2). These RICS examination preparation courses led to the development of a course in land surveying in 1949 at the South West Essex Technical College (SWETC) (Ibid.). Notably, a joint honours degree course which included land surveying was offered by Newcastle University (NU) in 1964. Additionally, a degree with a singular surveying focus was offered by SWETC in 1968 (Ibid). This college became North East London Polytechnic and then the University of East London (UEL). Although a number of other universities have offered surveying and surveying related courses in England, UEL and NU are the only two currently offering surveying and mapping sciences (geomatics) Bachelor’s degrees.

Table 1: University-based surveying degree courses in focus countries

Country	No. of Universities offering Surveying Degree Courses	Year programme started in selected university	Reference
Denmark	1*	1974	AAU programme document
England	2	UEL: 1949 & 1970 NU 1954	UEL programme documents NU's PD
Finland	2*	1858 & 1908	Viitanen (2007)
Hungary	2	1962	www.uniwest.hu, 2010
Canada	4	1960	Dir of Undergrad studies
USA	58	1990	FIG & nmsu.edu
Jamaica	1	1990	UTech programme document
Trinidad	1	1980s	UWI Programme document
Egypt	2	1963	Senior Academic (Surveying)
South Africa	6	1967	Programme Leader CPUT
Uganda	3	1990	Senor Academic (Makerere)
Australia	4	UNSW: 1957 USQ: 1967	UNSW website, 2011 USQ website, 2011
New Zealand	1	1968 & 1978	Senior staff Otago University

* Course combines Bachelor's & Master's Degrees

In the context of British colonies, the highest surveying positions were occupied by expatriates with academic degrees or military training from the Corps of Royal Engineers. The members of the support technical staff were traditionally trained through in-house apprenticeship arrangements. With many of the former colonies gaining independence, there was a gradual change in the composition of the localised surveying practice. Macdonald (1996) notes that British surveyors were seconded to the overseas territory in the 1960s and 1970s 'to train local candidates for the post[s]'(p.139). However, he notes that the training exercises were not always successful as surveying was not widely viewed as a high status profession:

> It was common to find that, in a developing country, greater status attached to office-bound jobs and that these attracted the more competent and ambitious applicants. This led to difficulties in recruitment and longer timetables for self-sufficiency…the organization [DOS] argued that the problem lay in the poor status that land surveying enjoyed in the minds of local people leaving higher education. (p. 139)

It seems ironic that a discipline, with such a robust background in sophisticated applications of mathematics, astronomy and navigation, as well as associations with prominent personalities, would be challenged by low recognition of the value of the profession. From as far back as the 1950s, strategies were put in place in an effort to attract bright individuals to the profession. Over the period 1958-1984, the DOS, in collaboration with the British Council, arranged for the education of individuals from former colonies in British colleges and universities in surveying related courses specially tailored for them (Macdonald, 1996). This was in addition to training formally organised within offices of the Directorate. Macdonald (Ibid.) states that the education had a more technical focus but that it broadened the students' capabilities in 'many other ways' (p.141). A formal course was established in 1975, at the North East London Polytechnic, to educate middle managers in Survey and Lands departments overseas (Macdonald, 1996.). The educated personnel filled positions once held by British nationals in a progressive move that eventually nationalised all surveying positions. Macdonald (1996) also mentions that the *Empire Survey Officers' Conferences* were a forum for the discussion and analysis of more scientific aspects of surveying by British surveyors, and where senior surveyors in overseas offices of former colonies were trained. He notes that conferences were common among the scientific disciplines in Colonial times and was an important means of providing on-going training to surveyors. However, he identifies dissatisfaction expressed by some surveyors of overseas territory with the choice of topics for the conferences. They perceived, according to Macdonald (1996), that the concentration on low-technology methods in the discussions was suppressing progress in the discipline in the overseas territories. These accounts highlight the importance of the relationships between the social elements within surveying practice, training and education.

Eventually, technical colleges were established to carry out the training of surveying technicians, a few of whom later achieved professional qualifications through attachment with expatriate chief surveyors. The eventual upgrade of vocational institutes to universities in many European countries as well as in other parts of the world, led to the upgrading of vocational qualifications to degrees. The University of Nottingham, a university recognized for its research focus, has a unique position in regards to surveying education as it offers only postgraduate qualifications in the field. Many surveying students, who choose academic careers in either teaching or research, are associated with these so-called academic universities.

The educational and professional profiles of surveyors are likely to be different in different countries. Allan (1995) confirmed this to be true in regards to Western European countries. The desire to harmonise the educational and professional profile of the surveyor within this jurisdiction has been officially pursued since 1972. As a matter of fact, in that year the Comité de Liaison des Géomètres Européens (The Council of European Geodetic Surveyors) was formed to oversee the process of harmonising the profession, including surveying education amongst member states of the European Economic Community (EEC). The study by Allan (1995) which investigated the functions, education and training of surveyors within the EEC, revealed that the surveying profession in different countries, had differences in the scope of activities as a consequence of the profession being developed along different lines. He also identifies variations in the educational patterns, which he notes are partly due to the scope of the profession in each country's context, and partly because of differences in the authoritative body that confer professional qualifications. In some countries this is done by the State, whereas in others, this function is entrusted to the surveying profession.

In regard to training and education in Oceania, Coutts and Grant (2007) state that early surveyors were men, either trained in the British military or who learned from others and demonstrated their capabilities to a governmental official. As described by Coutts and Grant (Ibid.), a system of apprenticeship developed in which trainees were attached to surveying crews led by a qualified surveyor. The trainee would be taught the skills for the job and write an examination set by Survey Board. These were only two aspects of the certification process. After passing the written examination, the trainee became eligible to submit plans from approved projects and for an oral examination by the surveyors' board. This was a process that took at least four years but invariably took more. The introduction of university-based surveying courses in the 1960s changed this system. Coutts and Grant (2007) note that Otago University is the only institution in New Zealand that offers the course required to become a professional surveyor. Hannah (2006) notes that the educational system for surveying shares many similarities with the systems in Australia. The first qualification offered in New Zealand was a Diploma which was later upgraded to a four-year Bachelor of

Surveying degree. Four-year degrees are also typical of Australian programmes (Bennett, Ogleby et al., 2009).

Surveying education in Denmark and Finland has a unique place in this study as in both cases a Master’s degree is required for professional qualification. Viitanen (2007) explains that the Finnish education for surveyors was based on a system of apprenticeship until the mid-1800s when formal surveying education was introduced in technical schools. He adds that the university-based education started in 1908 but that various changes have been made to the curriculum over the years. Enemark (2003) notes that surveying education in Denmark is solely based on the curricular innovation termed problem-based project-oriented learning. This is further discussed in the second in-depth case study.

2.6 Professional surveying organisations

All countries in the study have established professional surveying organisations that promote the development of the discipline and ensure that agreed standards are upheld by all practitioners. More importantly for this study, is the fact that these organisations also influence the development of educational programmes for the discipline of surveying/geomatics through their accrediting/partnership arms. The FIG and the RICS are more prominent in terms of the scope of their influence and the ICES to a lesser degree in that regard. Each of these organisations will be looked at separately.

2.6.1 International Federation of Surveyors (FIG)

According to its official website (http://fig.net), FIG is the premier international organization representing the interests of surveyors worldwide. It is a federation of the national member associations and covers the whole range of professional fields within the global surveying community. It provides an international forum for discussion and development aiming to promote professional practice and standards. The organisation was founded in 1878 in France and was assigned the name Fèdèration Internationale des Gèometres now more widely known by the English equivalent - International Federation of Surveyors. It is a UN-recognized non-government organization, representing more than 100 countries throughout the world and its aim is to ensure that the discipline of surveying and all who practise it meet the needs of the markets and communities that they serve. According to the organisation's official website (FIG.net) FIG aims to,

> enhance the global standing of the surveying profession through both education and practice, increase political relations both at national and international level, help eradicate poverty, promote democratisation, and facilitate economic, social and environmental sustainability (online at http://fig.net).

FIG organises conferences and workshops on a regular basis, to offer forums for debating a wide range of issues that concern the surveying profession. These are organised through ten commissions of which professional education is one.

2.6.2 Royal Institution of Chartered Surveyors (RICS)

The RICS is a professional organisation that has been associated with high standards for the surveying profession since the 1800s. Its official website (rics.org) states that RICS was established in 1868 by a group of surveyors. It further states that the organisation was born of a need to oversee set standards for professionals involved in the broad range of land, property and construction operations, which at the time were perceived to be driven by the rapid development and expansion of the industrialised world. The RICS currently provides professional qualifications to a wide range of areas not limited to land surveying as defined by the FIG. The aspect of the organisation that is most closely related to the land surveying profession is the Geomatics Professional Group. This Group represents 'professionals involved in the science and study of spatially related information and is particularly concerned with the collection, manipulation and presentation of the natural, social and economic geography of the natural and built environments' (RICS, 2010).

The organisation administered professional examinations for many years but since the early 1990s, has increasingly offered professional qualifications through higher education institutions' accredited courses. Currently, 500 university courses are accredited by the RICS. Professionals holding 'chartered surveyor' status from the RICS are highly regarded in many countries. The organisation's headquarters is based in London but it has offices in six geographical regions. This structure supports over 100,000 members in a range of surveying disciplines including geomatics (land surveying) in more than 100 countries.

2.6.3 Institution of Civil Engineering Surveyors

According to the handbook of The Chartered Institution of Civil Engineering Surveyors (ICES) (2010), it is an international qualifying body dedicated to the regulation, education and training of surveyors working within civil engineering. The institution provides membership to individuals qualified to work in geospatial engineering or commercial management within civil engineering. In its organisational structure, land surveying is listed as one of the five 'Practices Committees' under geospatial engineering. The other areas within that group are, however, generally associated with the practice of land surveying: engineering surveying, G.I.S., hydrographic surveying, and photogrammetry and remote sensing. This shows that the ICES's structure has a wide scope in regards to the professional development of surveyors in a broad spectrum of areas. The institution has various centres in the United Kingdom as well as centres in Hong Kong and the United Arab Emirates.

ICES also offer accreditation to educational programmes in areas relevant to civil engineering surveying. Of the forty three accredited courses listed by the ICES in its Accredited Courses listing (ICES, 2010), twenty six are listed under geospatial engineering. Both UK universities' undergraduate surveying courses included in this study have been accredited by the ICES.

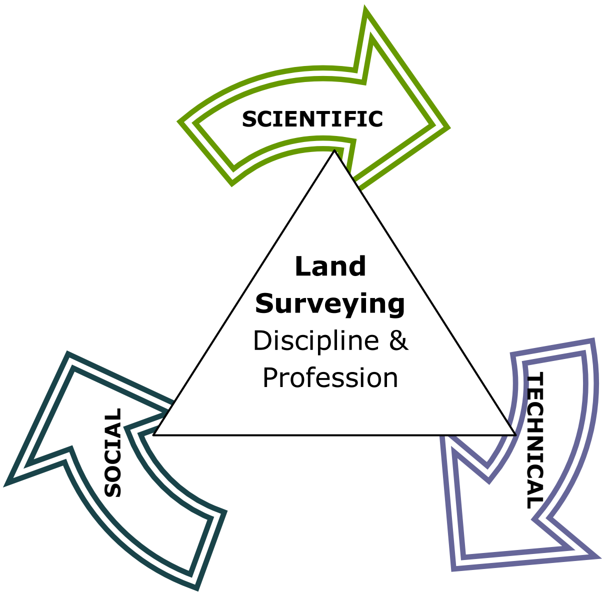
2.7 Summary discussions

2.7.1 Features of the surveying discipline & profession

Having given an account of the history of land surveying from its very early years, a number of observations emerge. The oldest artefacts reveal that the more technical aspects of surveying were developed based on scientific principles. During the Hellenistic Era, the scientific aspect of the discipline had a significant boost, which laid the foundations for the Romans to develop measurement technologies. This technological development continued in Europe and other parts of the world after the fall of Rome. As societies developed, people increasingly began to lay claims on lands, thereby bringing about an increased demand for land surveys. As such, there came a point in history, that the more practical aspects of surveying became more important than the development of its scientific aspects. As civilisation progressed, economic activities were increasingly tied to the land. Boundary demarcations, allotments and land entitlements became sought after almost as a human right. Concurrent with this, was an increase in boundary related disputes, which saw the surveyor playing an important role in bringing resolution to these situations. As a consequence, this brought about an increased awareness of the social aspects of the profession.

These three facets – scientific, technical and social (illustrated in **Figure *4***) have always been components of the surveying discipline, but at various points in history there have been variations in the focus placed on each aspect.

Figure 4 : Illustration of three facets of land surveying



History has shown that the scientific aspect is credited to a select group of scholars and the technological aspects to a much wider and dispersed group. The more obvious functions of the land surveyor involve the demarcation of boundaries, the layout of subdivisions and civil works, and the production of maps and plans. Evidently, these functions are important, but there are others relating to the more scientific geodetic surveys and the more social land management aspects. The social aspects of the discipline were evident in the duties of the surveyor, for example as caretakers of the manor during the reign of the Normans in England and the intervener in boundary disputes between neighbours in the Jamaican plantation society context. However, historical accounts do not often highlight the importance of the social aspects of the discipline. Higman (2001) in describing the surveyor as 'social engineer' and Hubbard (2009) in his view of the surveyor as 'cultural guide', both make reference to important aspects of the social dimension of the profession.

Hubbard's (2009) account of the impact of surveying operations on the physical and cultural layout of America concurs with Higman's validation of the social aspects of the surveyor. He purports that American identities are defined by boundaries (such as state, city, town, etc.).

> We see our American world through the lens of boundaries, even though we know deep down, that these lines were drawn across the land in the most capricious ways. (Hubbard, 2009L: p. xi)

To validate his claim, Hubbard (Ibid.) compared American boundary-formation processes to that of Italy, a nation relatively much older in terms of human settlement and cultural development. He points out that before physical borders were established between Italian regions, 'distinctive cultures existed in various locations of the country.' (p. xi). The assignment of borders proceeded through a difficult process that attempted to 'encompass cultural patterns felt to be similar enough to constitute entities.' (Ibid.). The historical sequence, he points out, was different in America. In most cases, American boundaries (states, cities, towns, etc.) were established before human settlement and the subsequent formation of cultural patterns grew to conform to these artificial boundaries.

> To the originators of the Rectangular Survey, the system was merely an efficient, fool-proof way of apportioning the public lands. But once people began to live their lives within those rectangular boundaries, those borders…came to acquire meaning, significance. (Ibid. p. xii)

Hubbard identifies the variation in historical sequence between Italian regions and American states, and the impact both cases had on distinguishing cultural patterns. Essentially, he perceives the Italian approach to be less effective at physically separating cultural groups, but both approaches appear to reinforce the role of the surveyor as 'social engineer'. In either case, the surveyor played a role in defining boundaries that were influential in the cultural patterns that developed within the defined spaces.

In another sense, the work of European surveyors in colonial lands brought about the imposition of foreign approaches to social arrangements to the indigenous and slave populations in some colonies. Higman (2001) points out that the societies under slavery, such as the plantation period in Jamaica, experienced the imposition of European style spatial layout of land. The straight geometric layout of land boundaries, which is the European approach to spatial organisation, was different to the more fluid and natural lines associated with the African culture from which the slaves were taken.

> The slave plantation system, a product of the European model, sought to impose a total imperial design on man and the land. It defined boundaries precisely and attempted to apply the rules of monoculture at every level. Within the plantation system, however, slaves were sometimes able to pattern small areas according to their own conceptions of spatial order. Thus the internal arrangement of village, provision ground and mountain frequently followed rules fundamentally different to those applied to the large unit. (p. 291)

Higman (Ibid.) believes that planters, missionaries and surveyors shared a common view of the ideal human landscape. Their actions, according to him, were in an effort to establish order where they perceived disorder. The principle of geometric organisation was, therefore, evident in the planning of slave villages and carried into post-emancipation township layout and the allotments that were put in place for the subsequent resident plantation labour force.

Higman (Ibid.) identifies an important observation that highlights European influence on the way surveyors perceive their work in Jamaica. This evaluation may have some resonance with surveying operations in other post-colonial contexts.

> The primary obligation of the surveyors of Jamaica was to record the landscape as they found it. But they were themselves products of the European branch of their craft and shared the essential geometric ordering concepts of their employers. In the transformation of the landscape which occurred in some regions of the island after emancipation, the surveyors applied the same set of spatial rules, dividing the land into rigidly defined geometric units. It mattered little whether their employers were planters or missionaries. In this way, the surveyors were tools of economic and cultural imperialism… (p. 291)

The African cultural practice, as it relates to land-use was, however, not fully suppressed. Higman further identifies that the decline of the plantation system led to the sale of plantation lands. The surveying operations, during this time, seldom imposed geometric principles. Instead, in many instances the boundaries followed the natural topography of the land as was more in line with African practices. Higman (2001) describes the result as a complex creole mosaic with geometric aspects and more organic boundaries. 'The landscape mirrored the structure and constituents of the society.' (p. 291). This account speaks to the power of influence a surveyor has on cultural developments.

Changes in surveying techniques and in the functions of the surveyor have been noted at various points in history. Though it is believed that the nature of contemporary changes are unprecedented (Enemark, 2002b; Hubbard, 2009), in some senses, the history reveals what might be best described as a cyclical process in land surveying development. The fact that contemporary technology has offered innovative approaches to the execution of surveying activities, is not enough to disregard what history has shown is an on-going change process in the discipline. In this regard, history shows that there has been an on-going shifting of focus in various aspect of the discipline as influenced by factors such as economic trends, scientific boom, settlement patterns, etc. If indeed we are at a point in history that the scientific, technical and social aspects of surveying practice and surveying education are conceived as an inseparable integrated whole, then perhaps the change is unprecedented and warrants research level investigations.

2.8 Relevance of historical account to the study

The preceding discussion identifies some issues arising from the history of surveying within the identified contexts. It has shown that some features are unique to a country or group of countries linked by geography or history. I believe that, if professional education is to have relevance to the profession it serves, it needs to be grounded in an understanding of how history influences practice (in the profession and in education). History is considered to be important in a way that embraces aspects of Bourdieu's concept of habitus. Habitus here is seen as:

> a system of lasting and transposable dispositions which, integrating past experiences, functions at every moment as a matrix of perceptions, appreciations and actions and makes possible the achievement of infinitely diversified tasks. (Bourdieu & Wacquant, 1992 p.18).

The way the surveying profession is perceived within the various contexts of this study, can be partly understood by tracing its history. Perceptions about what surveying is and what surveyors do, are shaped by human processes through human interactions. Meanings do not come out of nowhere, but are, instead, the result of people making claims about phenomena. How surveying and surveyors are perceived is partly a product of history and is played out in ways determined by groups of individuals. The realties are socially constructed and change over time in systems of power relations and through negotiating tensions. These elements of the discussion have resonance with Bourdieuian concepts of field, habitus and capital as outlined in chapter 4. These theoretical concepts offer a framework with which to consider how the relationships within the field of study and the negotiation of tensions between agents influence outcomes. It is for those stated reasons that the incorporation of the historical account of surveying is considered relevant to the study.

CHAPTER THREE – LITERATURE REVIEW
HIGHER EDUCATION & PROFESSIONAL DEVELOPMENT

3.1 Introduction

Higher education plays multiple roles in societies, some of which are more symbolic and others more functionalist and utilitarian. Separate from university's symbolic roles of reproducing societal norms (Arrow, 1973; Bourdieu, 1997), there is a clear functional role that universities play in the perpetuation and development of professions for the good of individuals, professional groups and societies at large.

University education is well established as the requirement for professional recognition in many fields. Hence, higher education stakeholders (students, professionals, governments and university staff) expect that university education should convey knowledge and competencies that have work relevance. There is a range of perceptions regarding what is considered relevant professional education. At one extreme there is a narrow concentration on knowledge and skills specific to a particular profession, and at the other, there is liberal education that seeks to develop more generic intellectual competencies that prepare individuals for professional engagements in a less direct way. The literature suggests that, these ways of categorising higher education are largely based on the knowledge content of curricula. However, since similar knowledge content can amount to different outcomes, based, for example on the pedagogical strategies employed, other aspects of higher education should rightly be considered in the evaluation of educational relevance to professional development.

While traditional pedagogical approaches are still widely used within universities, alternative pedagogies are employed which are sometimes considered to be more effective at preparing individuals for professional engagements. Some examples of these are critical pedagogy, competence-based learning and transformative learning (Kelly, 2009 and Kegan, 2009). These pedagogies seek not only to transform students into productive citizens, but more importantly, to provide them with skills to think critically and autonomously in ways that may challenge the status quo within higher education and within professions (Mezirow, 2002).

Although there has been a long standing association between university education and work, the literature on professional higher education is replete with the dissatisfaction of industries and professions with the work-related capabilities of graduates (De la Harpe et al.). Particularly amongst non-university based stakeholders, there is wide consensus that universities are failing to meet the expectations of professions. Although it may be argued that the orientation of industry has distinct characteristics to that of academia, it is undeniable that the two social systems are fundamentally interrelated. The on-going debate in the literature highlights tensions between these two sectors. These are manifested in a number of ways that influences professional education development. This reality explains the continuing quest to find ways of better understanding systems of professional education for particular national and professional contexts. This will hopefully contribute to the strengthening of these educational systems in ways that enhance knowledge and skills that have relevance to contemporary practices.

Central to the debate about what professional education should constitute, is a difference in the perspectives from universities and from professionals within industries. Another important element is the perspective of students who access higher education so that they can improve their social and economic capital. Conversely, professions tend to be more concerned with narrow work-relevant competencies. These multiple facets demonstrate that consideration of relevant professional education is a complex matter, since profession-relevance is not a fixed concept. These issues, which influence higher education systems, will be reviewed in two broad areas: firstly the dichotomous relationship between higher education and professions, and secondly, models of professional education. The review of models of professional education will consider how issues such as the academic-professional dichotomy impact on systems of professional education.

3.2 A dichotomous relationship between education and vocation?

A review of academia’s role in professional preparation and its impact on professions, offers some useful insights into the nature of the relationship between the two fields – academia (in particular, university) and profession. A contemporary notion of universities’ primary role is the conveying of general and specific knowledge and competencies that have relevance to professional practice (Watson, 2000; Billet, 2009). The question of relevance is central to the debate about appropriate educational programmes for professional preparation. But how is educational relevance determined? Relevance can be explored by considering the role of universities vis-à-vis the needs of professions.

The human capital perspective has become a popular way of conceptualising university's role. In this sense, the role of higher education (HE) is to provide opportunities for individuals to enhance their human capital and so improve their work-relevance in order to increase productivity in work. The human capital framework assumes that HE is an investment in humans which results in economic productivity (for example, Becker, 1994 and Schultz, 1980). It is a practical way to frame higher education, since studies have shown that one of the primary reasons people select career pathways is their expectation of resultant future economic benefits (e.g. Berger, 1988; Bavel, 2010). Thus, universities are expected to develop and deliver programmes with direct relevance to work.

Of necessity, this rationalistic and functionalist perspective includes considerations for the changing demands of work as brought on by technological advancements, and views education as a means by which individuals are prepared for these changes. Yet, this approach has been criticised as not satisfying professional requirements. Usher, Bryant, et al. (1997) argue that this 'dominant paradigm has failed to resolve the dilemma of rigour versus relevance confronting professionals' (p.143). Notwithstanding criticisms such as this, in the context of a growing trend in privatising universities and the use of business models in the marketing of HE programmes, there is an increasing practice in modelling HE in human capital terms. In recognition of this reality, UNESCO (2009) states that the 'massification of the HE sector globally, its development as a competitive enterprise, globalisation and internationalization are factors that have intensified the demands for universities to have market relevance.' Within this scenario, university education will continue to be evaluated based on the perceived relevance to productivity. Hence, the human capital perspective is important when considering educational relevance to contemporary professions.

Additionally, the literature highlights the importance of the socialising functions of universities. Historically, universities have played a role in the preservation of the norms and values of societies (see e.g. Sutz, 2007; Bourdieu, 1997). In this regard, Arrow's (1973) proposition that universities act essentially as a filtering mechanism bears some resonance. Thus, universities are seen to reproduce societal norms by sorting, selecting and allocating individuals for positions in society. By meriting individuals with academic and vocational qualifications at varying levels, the qualifying agency (university) classifies individuals and conveys information about their social capital (Bourdieu, 1997). This 'sorting and selection' process remains a necessity to support hierarchical structures that exist in many professions. For example, in professions such as many of the sub-branches of engineering and in surveying, there are qualifications at the technician level and at a higher professional level. These academic and professional qualifications are aligned to different levels of work within the related industries. Within such contexts, academia is expected to target the different levels within the hierarchy, and in this sense, reproduces the norms of societies. Thus, practices within industries continue to influence the systems of education for professional preparation. Therefore, it is important to consider local contexts and histories if a holistic approach is to be taken in developing educational models for professions in their contemporary states.

Another feature of university's socialising role is that it shapes students' attitudes, values and socio-communicative competencies, for professional engagement (Teichler, 1999). These socialising elements foster competencies in individuals and contribute to their development as functional members of specialised communities (Hall & Buttram, 1994). To this end, many professional groups are integrally involved in the educational programmes associated with their professions. This socialising perspective would likely incorporate the development of the cognitive and technical aspects of a field alongside the social elements. In addition, and sometimes more predominant, is the development of moral attributes such as appropriate behaviour, discipline and work ethics (Parsons, 1991). This socialisation characteristic of HE allows participating individuals to get on the inside of a form and to, in a sense, be indoctrinated into particular professions, thereby gaining the requisite symbolic and cultural capital (Bourdieu, 1997) necessary for access to and active engagement within professional groups.

From the various perspectives examined, it can be surmised that models of HE are influenced by multiple factors. These include a desire to build human capital; and the socialisation of participating individuals for a range of professional engagements within a stratified society. In these senses, education is transferable to different forms of capital that lead to the reproduction of social positions in societies (Bourdieu, 1997). The degree to which the varying perspectives inform HE sectors and professional groups, determines how professional education is modelled. It is understandable then that the effectiveness of professional education is a concept dependent on dominant perspectives. Context is therefore an important consideration when evaluating educational effectiveness.

The literature reveals mounting concerns about the efficacy of universities in the preparation of students for successfully coping with the demands of professions within a super-complex modern scenario (Mortimore 1999). However, satisfying the desires of all stakeholders is a difficult task, if at all possible. The growing demands on universities in an age of knowledge explosion, makes it increasingly difficult for these institutions of higher learning to provide both the knowledge-based curriculum along with the training aspects for professions (Paisey & Paisey, 2004). Herrington and Herrington (2005) acknowledge the challenge to universities by stating that:

> in the wider community it has become increasingly clear to employers of university graduates and governments that fund universities, that university learning outcomes are lacking, and no longer meet the needs of a dynamic and changing workforce. What employers, governments and nations require are graduates that display attributes necessary for knowledge building communities: graduates who can create, innovate, and communicate in their chosen profession. (p. 18)

Satisfying the changing demands of industry becomes even more difficult as a result of intense growth in knowledge and technologies which fuel significant changes in professions. Such changes are evident in many professions such as medicine (e.g., McClellan, McGinnis et al., 2008), surveying (e.g., Enemark, 2002b, Hubbard, 2009) and engineering (e.g., Duderstadt, 2008). As Duderstadt states:

> powerful forces, including demographics, globalization, and rapidly evolving technologies are driving profound changes in the role of engineering in society. The changing workforce and technology needs of a global knowledge economy are dramatically changing the nature of engineering practice, demanding far broader skills than simply the mastery of scientific and technological disciplines. (2008 p. 1)

Hence, if university courses are to have relevance to professional practice, they must account for changes within the profession. Moreover, if professions are changing their methods and use of knowledge, then the associated educational programmes should not remain static in their content and methods. How then do universities address these dynamic demands? While it is expected that strategies will vary, based on factors such as the nature of the professional discipline and the national context, there exists a wide range of approaches perceived to have a variety of impact. These will be explored later under the sub-heading ‘models of higher education’.

In contrast to what the literature highlights as the typical feedback from the profession, Vaatstra & DeVries (2007) argue that the skills required in modern day labour markets are becoming less discipline-specific and more generic. The term ‘generic skills’ is perhaps a synonym for what Atkins & Beattie et al. (1993) and Barnett (1994) refer to as a shifting from pure knowledge acquisition towards broad employment-related outcomes. Thus, universities are expected to foster generic and reflective competencies in their students if, by the time they graduate, they are to be prepared to satisfy work demands which go beyond a primary focus on specialist theoretical knowledge.

In spite of on-going challenges faced by universities in their quest to meet professional requirements, these institutions are still seen as best placed to provide the learning experiences to fuel a highly skilled society in an age of knowledge explosion (King, 2008). However a change in the approach to educating for professions is seen as an imperative. The exact nature and role of universities and the adaptations they have to go through are not yet clear (Amaral & Jones et al., 2002). Amaral & Jones further add that many scenarios have been developed and predictions formulated, but that the knowledge needed to make better-founded, valid interpretations of the change process that currently characterizes higher education is often lacking.

In agreement with Herrington & Herrington's (2005) earlier claim, Goldberg and Traiman (2001) argue that the educational models used in universities, have failed to adequately prepare students for professions. A particular concern of many critics is the pedagogical strategies employed. In spite of seemingly increasing interest in innovating university teaching and learning, the reality in many universities is a manifestation of traditional pedagogical approaches (see e.g. Rugarcia et al., 2000; Golberg & Traiman, 2001). Even in contemporary university settings, large lecture theatres, centre-staged with discipline experts transmitting theoretical knowledge to passive learners is still commonplace (Golberg & Traiman, 2001). This reality persists even though it is widely considered to be ineffective in fostering authentic learning (e.g. Golding and Vallence 1999; Watson 2000; Parsons and Hoxley 2007).

One indication of a desire to embrace or to give the impression of professional values within universities is the popular use of terms like 'generic skills' and 'employability skills'. However, diverse meanings ascribed to these terms, make it difficult to determine which specific skills are being targeted within professional programmes. However, there are some practical ways in which profession-related skills have been targeted. For example, the effective preparation of students for profession is now broadly perceived to be contingent on universities offering authentic learning experiences (Watson, 2000; Parsons & Hoxley, 2007). Authentic learning typically refers to learning that involves real-world problems and projects with relevance to the learners' professional interests (Herrington & Herrington, 2005). Learning based on authentic tasks is thought to engage students in exploration and enquiry, offering them opportunities for social discourse, with resources to support the pursuit of solutions to meaningful problems (Kukulska-Hulme & Traxler, 2007). Again, the term 'authentic learning' is a debated subject. Beetham and Sharpe (2007) argues that lab and field activities that mimic real-world, work-based tasks do so within artificial contexts with anticipated methods and outcomes and so in essence are not authentic. Conversely, Margeston (1998) believes that the task itself is not what defines authenticity, but rather the process involved in coming to solutions. Hence, models of 'authentic education' will vary depending on the philosophy of those who inform the development and delivery of the curriculum.

3.3 'Camps' within higher education

In spite of many descriptions of higher education offerings, what emerge, are primarily three camps – firstly, a generic and generalised education, secondly a highly discipline-specific and vocationally oriented education; and thirdly, a hybrid type education bearing elements of the other two. Advocates of the first camp take a broad view of education, and see this approach as being beneficial for general intellectual development, with loose, but important applications to professions (Ditmore, 2001). Within this perspective, higher education is not limited by narrow specialist requirements, which some believe are more appropriately learned within the work context. The view that liberal education can effectively prepare students for professions (Brezis and Crouzet, 2006) remains one philosophy that informs HE in the sense that:

> universities conduct scientific research without concern for potential commercial application, and (teach) liberal education without seeking to train business and professional men and women but to produce inquisitive, thinking, creative citizens (Brezis and Crouzet, 2006 p.1).

It is purported that the generic competencies developed within this environment produce graduates with generic skills that can be adapted to various professional contexts. This perspective is in contrast to the view that preparation for a profession requires a socialisation within the narrow specialisation with distinct vocational content and form. This latter position may be truer for some professional disciplines than others. This is so because some disciplinary fields have distinct practices that are best learned through specialised education. This second camp represents a much more popular view of effective and relevant university education. Terms such as competency-based curriculum and career-oriented education are increasingly used to refer to university courses which emphasise narrow specialisations within particular fields (Tritton, 2008; Kuijpers, M., & Meijers, F., 2012, etc.).

In lamenting the trend in changing from more generic education to more career-centred education, Ditmore (2001) states that:

> Throughout the 1900s, one of the primary goals of higher education was to provide students with the means to think critically and act logically. This ideal of educating well-rounded thinkers was primarily the characteristic of Liberal Arts colleges and universities who could provide degrees in specified areas along with studies in mathematics, science, languages, and culture. Today,

> however, Liberal Arts colleges and universities have veered from strong Liberal Arts curriculum to a career-based focus. (p.1)

While the educational model employed may have a leaning towards the first or the second camp, Diamond (2009) indicates that contemporary education should seek to capture elements of both camps. This represents the third camp that is a hybrid with elements of the two first camps.

> A principal function of any higher education system is to provide the professional people that a modern society needs to function and grow. … these professions each have their own ways of speaking, thinking and acting, and … these are as important as raw subject knowledge in the process of turning from a newly-arrived student into a functioning and skilled specialist. Our research also shows that higher education institutions should take a broad view of their role. As well as specific subject knowledge, higher education should increase students' self-awareness and make them into motivated lifelong learners. (Diamond, 2009 p.3)

The generic-specialists consideration is really a consideration about content and scope of curriculum. Also, there is the consideration of theoretical versus practical elements within professioinal courses. While it is understandable that the content knowledge of a discipline requires some theoretical focus, in a seemingly growing number of contexts, there is an expectation that the gap between theory and practice must be bridged in order to improve graduates' work-readiness. Smeby (2007) sees this as a challenge to universities:

> Professional learning is … a challenge to educational institutions. It is not just a matter of how to disseminate discipline-based theoretical perspectives and practical skills, but also how to bridge the gap between theory and practice. (Smeby, 2007, p. 207)

This 'gap' is described by Bourdieu (1997) as inherent differences in the values or capitals of each field. This viewpoint explicitly acknowledges resultant tensions between these related social settings, and proposes that the power relationship between them is a key determinant of educational and professional outcomes. Therefore, it is not surprising that, while professions value narrowly defined disciplinary knowledge and the associated practical skills, the values traditionally upheld within universities are theoretical knowledge and broad intellectual development that are less directly associated with work (Cohen et al., 2009).

The literature illustrates a two-fold challenge to contemporary universities in regards to offering effective and relevant education to the satisfaction of their stakeholders. These include designing and delivering educational programmes that balance specific work preparation (vocational training) with traditional higher education theoretical values; and also balance knowledge and competencies that are more generic with those that are specialist.

The view that universities serve to train individuals for practical and technical work (Solbrekke & Karseth, 2006) finds little support among proponents of traditional values. In fact, it has been argued that training for practical and technical work often termed 'vocational education' is not the mandate of universities. This viewpoint purports that universities should be concerned with higher learning, unlimited by narrow education and training within strict professional boundaries (e.g. Barnett 1994). A distinction is made here between what Anderson (1982) described as procedural and declarative knowledge. The former referring to knowledge about how to perform tasks (know how); and the latter to a more descriptive knowledge about something (know that). Vocational education and training are often perceived to be about procedural knowledge. However, there is no real total separation of the theoretical aspects of a field from its practical aspects. But distinctions are made based on whether emphasis is placed on the theoretical or the practical. The former, traditionally viewed as more appropriate for university education, and the latter more associated with vocational training (Assiter, 1995). Here a distinction is made between education and training. In this frame of thinking, training is more closely associated with skills, narrowness of application and instrumental value. Education in this framework is more concerned with the acquisition of knowledge, understanding, broad cognitive perspective and intrinsic value.

The characteristics associated with 'education' are widely perceived to be higher level competencies and are generally justified by higher qualifications with higher status and better paying jobs. From this viewpoint, 'education' opens possibilities for individuals through exposure to a wide range of knowledge. On the other hand, learning with a predominantly vocational focus is seen as serving a primarily utilitarian outcome as illustrated by a narrow emphasis on mastering definite skills (Lehmann, 2009).

The term ‘vocational’ has to be used cautiously since it is accorded different meanings in different contexts. Moodie (2008) in coming to what he describes as a practical definition of the term ‘vocational education’, identifies three classifications. The first, which he refers to as the epistemological definition, views vocational education as relating to a distinctive way of knowing or learning. He then proposes definitions based on teleological and hierarchical considerations. In regard to the teleological; vocational education is based on a distinctive purpose such as preparing students for a vocation. The hierarchical consideration views vocational education as relating to classifications of occupational, educational or cognitive levels. Based on these considerations Moodie (2008) proposes that: ‘[vocational education] is the development and application of knowledge and skills for middle level occupations needed by society from time to time.’ (p. 165).

Furthermore, the vocation-education debate becomes more complex when consideration is given to how tertiary education is organised within different national contexts. Moodie (2008) further explains that, whereas some countries have two distinct post-secondary education sectors, the technically oriented vocational education and the higher universities for traditional high status professions, others do not make this distinction. This way of looking at vocational education can be problematic in national contexts where occupations require graduates with a mix of these so-called ‘middle level skills’ with those often seen as being more advanced. Thus, the modelling of higher education in a particular national context is influenced by the structure of its educational system and the nature of the labour market. These will be discussed further, later in this section.

The term ‘vocation’ is also associated with professions and in this context, refers to the activities of professions with a long history of association with universities.

> From earliest times universities have educated doctors, lawyers and clergymen. These distinct professions form a world-view that higher education is related to preparation of professionals. (Reid, Abrandt Dahlgren, et al., 2011, p.10)

Professional, university-based education in these areas and others, such as engineering and surveying, typically emphasise specialised content geared towards preparing individuals for entry into the specified professions. In this sense, university education has vocational relevance. It is understandable then, that increasingly, industry is collaborating with universities in the development of educational programmes (e.g. Gulbrandsen & Nerdrum. 2009; Abramo, D'Angelo, et al., 2010; D'Este & Patel, 2005; Schartinger & Schibany et al., 2001). At the heart of these collaborations, is an expectation that graduates will be better prepared for work, not only possessing intellectual capabilities but also reasonably developed in the practical vocational aspects of the profession.

The expectation that graduates will leave universities with already developed work-ready competencies has to be tempered since many things are learned through actual work. In spite of the increased collaboration between the two sectors, graduate attributes continue to fall short of the expectations of industry. Research by Golding & Vallence (1999) showed that an increasing proportion of graduates, follow their university courses with practical courses at vocationally oriented institutions. This they cite as an indication of universities' failure to adequately prepare graduates to meet market demands. This gap between market demand and academic supply, according to Enemark and Prendergast (2001), may be due to a lack of understanding of how to meet that demand on the part of universities. As it relates to surveying courses, they assert that 'research is needed to determine how successful surveying courses have evolved their content and delivery to provide graduates with the skills and learning ability that the market requires' (p 23). Emerging from this debate, is a recognition of the role of universities in finding ways by which education is 'married' with vocational skills development or as Assiter (1995) puts it 'breaking down the separation of education and the 'world of work' (p. 30).

Contemporary trends indicate that efforts are being made to account for both the work based-capital and more academic capital within university profession-based courses. An illustration of this initiative is 'higher vocational education' (Billett, 2009). This description is used specifically to highlight a shifting away from the more liberal arts focus to more 'occupationally specific courses' (Billet, 2009 p. 827).

Dearing identified key elements of professionalism that should incorporate higher education:

> the essence of professionalism is a thorough and up-to-date grasp of the fundamental knowledge base of an occupation; sufficient understanding of the underlying theoretical principles to be able to adapt to novel circumstances and to incorporate research findings into practice; and appropriate practical skills and professional values (Dearing, 1997).

The key elements for professional education as outlined by Dearing (1997) are fundamental knowledge of the field, an understanding of underlying principles, research applications, practical skills and affective components referred to as professional values. These aspects are widely accepted as relevant either as a whole or in part. However, the literature shows no consensus on how these various aspects of professional development can be successfully incorporated within university courses. Hence, from Flexner's (1915) early definition of the components of a profession to newer conceptions such as 'higher vocational education', there continues to be tension between academia and professions in regard to educational approaches and their outcomes.

The seminal report on higher education commissioned by the British government in 1963 (the Robbins Report) identified from then two distinct elements of higher education: imparting employment skills and developing the general powers of the mind. Those two components are not mutually exclusive. In fact, as pointed out by Dearing (1997) the development of the mind underpins that of many other skills. He reflects what Whitehead (1967) noted several decades earlier as a justification for universities to take a holistic approach to education:

> The justification for a university is that it preserves the connection between knowledge and the zest for life,… by the necessary movement of questions, ideas and scholarship between professional schools and centres of research and teaching in the arts and sciences...uniting the young and the old in the imaginative consideration of learning (Whitehead, 1967, p.2).

As universities attempt to find acceptable balances between theory and practice, generic and specialist knowledge and competencies, there remains a real concern that there is a disproportionate shift towards a greater academic approach and a concomitant shifting from the more practical elements. Associated with this trend, is the risk of professional courses gradually losing their usefulness for professional preparation. The concept of 'academic drift' explains this concern.

3.4 Academic drift

Academic drift describes the gradual reduction in vocational focus and reciprocal increase in the emphasis on academic and more general education. The term was originally used by Burgess (1972), and described by Harwood (2010) as:

> a term sometimes used to describe the process whereby knowledge which is intended to be useful, gradually loses close ties to practice, while becoming more tightly integrated with one or other body of scientific knowledge (p. 413).

The literature speaks of a phenomenon in higher education, in which vocational courses (typically based in colleges and vocational institutes), and professional courses with highly practical orientations (some based in universities), gradually experience a shifting in vocational and professional focus towards more theoretical orientation with enhanced academic values and attitudes. This is often seen as occurring at the expense of those vocational and profession-based competencies that are more valued by professions.

Jonasson (2006) explains that both students and academic staff contribute to this shifting of values:

> Students, along with their aspirations for education credentials, are interpreted as a substantial driving force behind educational expansion. The academic faculty, on the other hand, having similar aspiration for status, affect the internal structures of institutions and of the system, partly as a response to institutional growth and partly as a method to gain status, which leads to the academic drift that we witness. (Jonasson, 2006 p. 4)

Jonasson sees academic drift as starting with students' demands for 'educational credentials of the highest prestige to enhance their opportunities in the labour market and their social standing in society' (p. 292). This view is in contrast to the earlier stated notion that students' are more concerned that educational systems are aligned to professional practice. What is perhaps true, is that both issues of academic credentials and professional relevance, concern university students. However, as Bourdieu (1984) indicated, there exists a power struggle between these competing elements, and the more dominant force will determine the capitals of the field.

Furthermore, it was showed that the aspirations of academic staff also influence academic drift (Kyvik's, 2007). As related to professional engineering practice, Christensen et al., (2011) refer to this specific influence as 'staff drift':

> As an academic orientation differs from the practice-based and industrial and utilitarian orientation for professionally educated engineers in terms of reflectivity, critical orientation, regard for theory and orientation towards research, staff members characterised by an academic orientation will tend to push their institutions towards academic values, practices and attitudes' (p. 292)

Systematic changes have also been cited as contributing to academic drift. Christensen & Erno-Kjolhede, (2011) cite the upgrading of college-based engineering programmes in Denmark and the upgrading of the England and Wales Higher National Certificates and Diplomas (HNCs & HNDs) to degree courses after the passing of the Further and Higher Education Act (1992), as examples of processes that contribute to academic drift. Similar changes in the HE sector have been observed in smaller countries such as Jamaica (Sangster, 2011), and large countries with emerging higher education sectors such as India (Pednekar, 2011). However, the change from certificates and diplomas levels vocational courses to university-based degree courses is widely perceived to be a progressive step. This is echoed by Pednekar (2011):

> There is good news in store for the nearly five lakhs (500,000) students studying in vocational institutes in the state. The state government has decided to upgrade vocational education to create more opportunities for these students by setting up an independent vocational university, adding mainstream degree courses and post graduate options in vocational subjects…to bridge gaps between vocational students and their counterparts in mainstream courses... (Pednekar, 2011)

Without discounting the benefits of the educational opportunities that the upgrading of vocational or technical courses will provide for students, it should also be noted, that changes such as these may have negative repercussions. It has been shown that wide scale changes of vocational courses to degree courses, with increased academic and reduced vocational emphases, can create a gap in industry. Evans (2010) in his criticism of changes in UK vocational higher education system argued that:

> Foundation Degrees have undermined Higher National Certificates and Diplomas which have long been greatly valued by many employers (another example of academic drift is to attach degree to the title and think it is more important!). These forerunner awards were very much vocationally focussed. (p.1)

The gap in industry results from an unwillingness of individuals with higher qualifications (degrees) to work in low-status ‘vocational’ positions with commensurate lower remunerations. Also, the nature of industry in many professions is such that more individuals are required for skilled (vocational or technical) positions than for high profile professional positions. For this reason, changes in the higher education sector require careful considerations of labour-market planning (Grossman & McDonald, 2008). This is important because industries need a flow of qualified individuals for different levels of work and appropriate education and training to enhance productivity. This should not be solely based on current trends, but also with a futuristic view, that predicts changes in profession or even sets the pace for change within professions (Hudson et al., 2005 and Cörvers, 2006).

This phenomenon has links to the classification of higher education universities in the UK. Sanders (2002) refers to the distinction between polytechnics and universities as the binary divide. She highlights John Marenbon’s comment on the issue, which explains, that in the UK context, politics has played a critical role in this labour-market and higher education issue:

> Conservative politicians, as much as Labour ones, believed in the nonsense about making vocational education of equal esteem to academic education. I think the government should have been concerned to see that there existed high-quality academic education for a very small elite, and that there was good vocational training for those who wanted, closely linked to the workplace (Marenbon as quoted by Sanders, 2002, p.1).

This view, suggests that the higher education sector should have distinct pathways. The view also implies the elevation of the more academic approach over more practical, work-specific learning. Marenbon’s argument essentially identifies what he perceives to be a tension in the labour market created by the attempt to unify the higher education sector in the UK. This tension impacts several industries as it relates to producing graduates who are able to function effectively in professional work soon after graduation. The issue of academic drift underlies failings in the management of professional education. The upgrading of work-based courses should not be done in isolation of labour market planning and consultation with related professions. The literature shows that issues are yet unresolved regarding on-going changes to profession-oriented and vocational education and the impact on industries. If the ‘upgrading’ of vocational qualifications to more academic qualifications lead to a devaluation in the capital (economic, cultural and symbolic) (Bourdieu, 1997), then there may be need to rethink division of labour within industry along with new ways of managing educational programmes geared towards professional preparation.

The review will now focus on models of profession-based education employed within universities. It will be shown that the educational models reflect the relationship between universities and professions as much as they are influenced by labour-market trends and historical foundations.

3.5 Models of higher education aligned to professional preparation

It has been shown that curriculum content is an important element of profession-based courses. However an examination of the processes, experiences, contexts, outcomes and relationships of teaching and learning, which together, define higher education pedagogy (UK's Research Assessment Exercise, 2006), is a more comprehensive way of looking at educational models developed and employed to prepare individuals for professions. This position resonates with McKenzie, O'Reilly et al., (1985) who state that "professional competence may be related more to modes of study than to syllabus content" (p: 187).

The literature on higher education pedagogies reveals a complex mix of elements associated with this important aspect of professional preparation. It is seen that a variety of educational models are used in profession-oriented courses. Understandably, their effectiveness is judged on the basis of how well they are perceived to prepare students for work. It is not a simplistic venture to come to a broad understanding of how educational models impact professional preparation. Furthermore, it is problematic to classify models within this genre of education as the methods and styles have varied contextually-based manifestations. Notwithstanding, this reality, there exists some empirical studies that explain some aspects of the relationship between pedagogical approaches and learning. Many pedagogical models have been informed by the study by Marton and Saljo (1984) into approaches to learning. An understanding of pedagogical approaches that encourage deep learning, rather than surface or superficial learning, informed the development of some pedagogical models.

Although, the educational models employed within different contexts have some shared elements, they also manifest distinctive features that are related to professional, institutional, and national idiosyncrasies. Furthermore, some approaches are based on how the programmes developed historically. It may be assumed that all models aim at exposing students to the body of knowledge along with some of the practical skills considered appropriate for the targeted profession. However, there are varying degrees of emphases on the theoretical and practical elements used within these educational models.

The literature identifies a variety of educational models adapted to different contexts. These models may be viewed as existing somewhere along a spectrum or continuum identified by Harden, Sowden, & Dunn (2009) as student-centred/teacher-centred, problem-based/information-gathering, integrated/discipline-based, elective/uniform and systematic/apprenticeship-based. Their study has shown that newer medical schools tend to employ strategies tending towards the left of the spectrum and those universities with more established courses tended towards the right. This trend is not unique to medical education since similar evidence was found in other areas such as engineering (McCahan & Schreiber, 2010). Thus, professional courses in newer universities are more likely to be student-centred, problem-based, integrated, with elective options and more systematic in their curricular and pedagogical arrangements.

It would be too simplistic to attribute the age of the university or course as the primary factor influencing the educational model used. A more complex reality exists in which the culture of the professional discipline, historical development of the profession and the dominant educational culture within which the course operates are factors shown to heavily influence educational models. Although it is unlikely that any course is at any one extreme of the continua mentioned, it is worth considering the features of the models employed in professional courses. These may be classified into five broad groups: apprenticeship, academic, technical competence or vocational, hybrid, and innovations.

3.5.1 Apprenticeship model

An important aspect of work-readiness is the fostering of learning through engagement within professional contexts. Notwithstanding the historical association of apprenticeship with low level technical and vocational skills development, this model of education and training is perhaps the most obvious means of work-specific skills transferral and mentorship for professional preparation. Thus, the apprenticeship model and other models that employ features of apprenticeship are important to consider in an examination of education and training within professional fields.

Professional preparation in many fields has roots in apprenticeship which is a system that strategically links training and education with practice within the working context, under the direct supervision of an expert. Apprenticeship arrangements can be found in the history of training in engineering (e.g. Clarke, 2012), dentistry (e.g. Alfano, 2012), social work (e.g. Wayne, Bogo, et al., 2010) among other professional groups. The model was also used in surveying for the training of individuals in the absence of more formalised education programmes. In many countries, surveyors were trained through attachment with a certified professional surveyor followed by a government board examination (see e.g. Higman, 2001; Enemark, 2003). Although this arrangement had the practical preparation for work as its main objective (Higman, 2001), many also included limited theoretical elements taught through informal arrangements. The apprentice was required to prove his/her proficiency in carrying out practical activities along with some theoretical principles, before earning professional certification. Clearly, the theoretical element would be less prominent relative to the practical.

Learning in this context may be characterised as situated since, as Lave and Wenger (1991) indicate, it is learning that is embedded within activities, context and culture. In essence, apprenticeship involves the yoking of a novice to an expert as a means of transferring skills and developing work-specific competencies in novices. The training, typically involves direct and close supervision by an expert. The level of intervention by the supervisor is gradually relaxed as the apprentice becomes more proficient. This arrangement continues until the apprentice proves competence to work autonomously. Apprenticeships usually precede certification of proficiency through some arrangement such as a government sanctioned professional examination.

Although, historically, apprenticeship was based primarily on work place attachments, Lauterbach (2009) demonstrates that the arrangement is also an alignment of formal education with work-specific training:

> Apprenticeship ... connect(s) learning at the workplace with learning at school, and the curricula of these two locations of learning and training are aligned with each other.' (p. 1653).

This perspective combines education with training, a practice that challenges the philosophy of separating vocationalism from higher education. In this sense the university-based theoretical element focuses on the 'why' while the work-based attachment focuses on the 'how' (Harris, Willis, et al. , 2001). Even within the traditionally formalised university courses of theology, law and medicine (Bazerman, 2011), it has been shown that there were elements of apprenticeship. McCahan and Schreiber (2010) indicate that both medicine and engineering relied heavily on this educational model in the nineteenth century. Clinical practice, for example, was largely learned on the hospital wards with real patients under the supervision of professional physicians.

The model has the obvious benefit of promoting the development of core skills and attitudes with immediate relevance to work. It also promotes confidence in apprentices as they become more proficient in the execution of work-specific tasks (Harris, Willis, et al, 2001). Wenger (1999) also points out that learning in a community of practice is not limited to novices, but that the collaborative approach makes way for knowledge construction that involves all stakeholders.

However, where this model is the primary pedagogical strategy, it has been criticised as being labour intensive, with difficulties in assessment of learning and quality assurance (Wright, McDowell et al., 2010). The apprentice may not be readily able to adapt to work settings and scenarios different to those existing in the training settings to which s/he is exposed. So, whereas the apprentice may have highly developed skills in particular areas, the exposure in other areas may be lacking. This situation is a challenge to transferability of personnel from one jurisdiction to another or even from one organisation to another within the same national context. This is of particular concern, since in many professional fields, there is an international market. This concern is of less relevance where the exposure is multi-faceted and deliberately planned to include a wide range of activities associated with the profession.

Another challenge to this model is the risk of confusing the roles and expectations of the learner with that of the novice worker. Conn, Houston, et al., (2011) describe how a tension sometimes emerges within the work-based learning context:

> …sometimes, rather than being seen as complementary and synergistic, there is tension about wanting to make one area of responsibility a priority over the other (p.3)

They further argue that the responsibilities associated with learning and working can be concurrent and complementary. Finding the right balance remains a challenge to universities as discussed early in this literature review.

Additionally, where apprenticeship is the primary pedagogy, structured theoretical elements may be limited. This may be so, even though this aspect of professional education is important for holistic professional development. In spite of these potential shortcomings with an apprenticeship model, it offers benefits that have been recognised by universities, particularly for courses with clear linkages to professional practice such as engineering, medicine and teaching. For this reason, some courses include elements of apprenticeship arrangements. These may manifest in activities such as internships, professional mentorships and residencies. Internships are popular amongst engineering programmes, in which a formal part of the education is a period in industry whereby students engage in supervised work-related activities (see for example, Junaini, Fadzir et al, 2008). Professional mentorship is less used but is also seen in engineering programmes. In this arrangement, students may not enter industry but rather, professionals from industry are invited into the universities to engage students in ways that expose students to professional expectations and values. Residencies are typically associated with the training of medical education as a way to harness the practical skills of senior medical students (Steketee and Bower, 2007). These learning and skills development activities remain relevant and important to professional development. Empirical studies have confirmed that interns are significantly more marketable than university graduates who do not have this element to their education (Gault, Leach, et al., 2010).

It has been argued that the apprenticeship model is no longer sustainable within contemporary professional courses due, for example, to ethical considerations and economic factors. Archer (2010), states that apprenticeship in its traditional form within clinical settings cannot be sustained due mainly to increased enrolment and more stringent ethical implications associated with medical students having direct access to patients. Consequently, simulation of clinical contexts are increasingly being used as a viable alternative to actual work-based learning as part of the medical education (Khan, Patterson-Morgan, et al, 2011). There are indications also that the specific arrangements for work-based apprenticeships have become unsustainable for other professions that traditionally use this approach. However, it is acknowledged that the approach has valuable elements that are useful to incorporate within contemporary professional courses. This is of concern since it has been seen that the approach is most effective as a one-to-one arrangement with one apprentice to a supervisor. Within mass educational settings, as are popular in contemporary contexts, this is not practical.

The literature has shown that apprenticeship arrangements are not as they used to be, yet they maintain relevance to university education in a number of fields. Within many courses, the linking of students with active members of the profession is still upheld as a great value for the development of skills and attitudes for work. Also, it is expected that the theoretical elements of the course covered within the more formal educational settings, will be consolidated and reinforced as students apply them in practical ways in authentic settings. It is clear that the benefits to be derived from apprenticeship arrangements remain relevant to professional education. The challenge to universities is to find creative ways of incorporating elements of this effective pedagogy since it may not be practical to use this approach on a wide scale within the modern context.

3.5.2 Academic model

The 'what' and the 'why' elements of professional education are traditionally perceived as the academic components. These elements are most often associated with universities and the educational model that emphasises content coverage and knowledge transmission. The content is typically transmitted through didactic and lecturer-centred approaches (Entwistle, 1981). A research ethos is also associated with universities, particularly with high ranking ones that are often referred to as research-intensive universities. This categorisation describes an ethos in which research is a central part of the universities' operation and where it is often claimed that teaching and learning is informed by research (Healey, 2005). Although university-based research has made significant contributions to developments within societies, studies have found that research is sometimes emphasised at the expense of teaching and learning (Boshier and Huang, 2008). Hence, universities are frequently cautioned to find a balance between research and teaching and learning to ensure that the latter does not suffer at the expense of the former (Elton, 2001). At the other extreme, the quality of universities is assessed partially on the basis of research activities. For example, the RICS specifies that one of its accreditation criteria is that students are to be exposed to new ideas and that 'standards relate to the higher education institution's engagement with high quality research' (RICS online 2010). This underscores the fact that research remains relevant to professional education.

As discussed earlier in this chapter, a singular academic focus may not be ideal for effective learning within profession-based courses. However, the didactic approach remains 'an economical means of transmitting factual information to a large audience, although there is no guarantee that effective learning will result' (Walkin, 2000) p 55). Large lectures with mixed groups are seen as more economical than specialised small groups with strict disciplinary teaching in more interactive and hands-on pedagogies.

Notwithstanding this reality, Biggs and Tang (2011) believe that higher participation rates within universities along with other factors 'have altered the main mission of higher education and modes of delivery (p. 3). According to them, 'one consequence is that the major thrust in teaching is more on professional and vocational programmes and concerns about teaching effectiveness' (ibid). This is perhaps resulting from university stakeholders' dissatisfaction with the status quo. Hence, universities are now expected to give greater recognition to student needs and to improve the relevance of their educational offerings to work.

Becher's (1994) research focussed on identifying features of professional courses that are distinct and manifest nuances of the profession they are associated with. These have been important elements of identifying what they label ‘academic tribes and territories’. Shulman (2002) took this further to suggest that professional education should seek to identify what educational strategies work best for them by employed what he called ‘signature pedagogies’.

Bennett, Dunne and Carre (2000) proposed that higher education curriculum should be a composite of three interconnected facets- disciplinary, work and generic skills. However, this schema may be more relevant to some disciplines than others. As Barnett and Coate (2005) point out that the emphasis placed on any of these elements is strongly influenced by the disciplinary and professional fields. An exploration of research done in educational development in profession-based disciplines, demonstrates that there are established models adapted to various professional disciplines with nuances based on contexts. University, national educational and professional cultures are all factors that determine the context of professional education systems. Hence, these aspects will be considered in the review of professional educational models. Profession-based education may have an academic focus (the academic model), a vocational focus (vocational model); or a range of hybrid models that incorporate elements of the first two models. Additionally, there exist innovative models with distinct features worthy of separate mention. This latter group includes a range of models that will be explored in a separate sub-section in this review.

Educational systems have evolved to increasingly more formal and sophisticated arrangements within higher education institutions. The proliferation of university courses and the subsequent increase in formal education for a growing number of professions have significantly impacted the educational methods used in professional courses. One approach is the liberalisation of programmes in a way that opens the education to a wider spectrum of knowledge with no significant specialist concentration. Liberal models such as this are viewed by some as having relevance to professional preparation (e.g. Brezis and Crouzet , 2006).

One of the elements of a profession put forward by Flexner (1915) and supported by later researchers such as Fenske and Fenske (1990) is that it must have teachable techniques. Implied here is the need for formal arrangements for the teaching and learning of theoretical principles of a profession. Traditional academic universities typically emphasise the theoretical elements within their courses.

Much has changed since Flexner's essay. Studies have shown that a much more diverse composition of students has to be catered for within universities. The classical model may not have the impact it traditionally had with more homogenous students. Catering for a more diverse group of students, demands different and more diverse pedagogical strategies and curricular arrangements.

An important element of the academic model is that it does not seek so much to convey and develop narrow profession-based learning objectives; rather it seeks to convey a more liberal education. While the subject areas may have specific relevance to a certain profession, there is an emphasis on the theoretical aspects with limited direct input from the professions. With this model, professional preparation is only partially satisfied at graduation. Graduates are expected to follow-up their academic qualifications with requirements from the professional bodies that will authorise their entry into the professions. However, this model has been found to be an inadequate approach as a singular model, for professions such as engineering (Ashford, 2004); medicine (Harden, Sowden, & Dunn, 2009) and surveying (Enemark, 2004). It is suggested that

> … unifying academic and vocational learning can be seen as a possible means of achieving the goals of a learning society, and that the idea of a learning society itself is a way of conceptualizing future learning demands. (Young, Spours et al. 1997 p.527)

3.5.3 Vocational model

An important component of higher education is the development of competencies that have direct relevance to professional work. According to Bennett (2000), within higher education '(it) is no longer what one knows that counts; it is what one can do through one's knowledge' (p. ix). Hence, higher education courses are expected to go beyond knowledge transmission to preparing individuals to apply knowledge within specified fields.

It was shown in earlier discussions, that vocationalism in higher education has been viewed, on one the hand, as inappropriate for university education and more appropriate for lower level ‘technical and vocational’ skills training. On the other hand, vocationalism is seen as beneficial for preparing individuals for all professions, particularly those that have fundamental practical elements such as engineering, medicine and surveying. Setting aside the simplistic distinction of vocationalism and professionalism, it is accepted that within many professional disciplines, such as surveying, the practical elements of the field are not only appropriate for lower level technical staff but also for professionals.

In fact, it has been shown, for example by Powell and Solga (2010), that increased emphasis on vocational education has contributed to strengthening the relevance of higher education in many fields of professional practices. Furthermore, it has been argued that there is increasing convergence of the vocational with what is usually considered to be higher level professional knowledge and skills (Grubb and Lazerson, 2005). According to Grubb and Lazerson, work skills are being driven in “the direction of "higher-order" skills including communications skills, problem solving, and reasoning-the "skills of the twenty-first century" (p.1). This perspective speaks of a change in traditional vocational education and practice towards competencies customarily associated with higher education.

In spite of what Gurbb and Lazerson have observed, much of the literature suggest distinct features of vocational education. Educational models that have a strong emphasis on vocational readiness tend to have distinct specialisation emphasis geared towards professional preparation in narrow fields. Such models tend to involve ‘tools of the trade’, taught by experts in the profession and a pedagogy that emphasises competency building in the practical elements of the field. While the theoretical principles are taught, their application is given greater focus. These activities typically involve learning experiences that closely reflect the realities of practice within the targeted professions.

The model considers what is most important for vocational readiness and makes those the central features of the curricula. In medical education, for example, fundamental biological theories are covered, but beyond that, students need to be able to apply theoretical medical knowledge to clinical contexts. This application may be simulated as in ‘simulation-based-medical-education’ in which the clinical experiences use simulation technology to provide a means for learners to engage in acquisition and practice of clinical skills without using live patients (Ziv, Ben-David et al., 2005). This technique is seen as one way of bridging the gap between changing medical information and currency of curriculum (Okuda, Bryson, et al., 2009) without risking the well-being of patients. Simulation is also used in engineering education to increase student exposure to a variety of industry problems without the associated expenses and complexities that come with work-based attachments (see, for example Balamuralithara and Woods, 2009); Jaeger & Adair, 2010).

Vocational relevance in higher education, though not generally emphasised, is undoubtedly one of the factors that attract students to courses and is of great interest to professional groups. However, there remain questions about the degree of vocational focus and the nature of that focus within profession-based courses. What is evident is that there needs to be adequate theory to be considered a legitimate professional course, but as important, is the need to promote learning for work within the chosen field. Hybrid models exist in various forms and are considered to have a variety of outcomes.

3.5.4 Hybrid model

Increasingly, higher education institutions are strategically combining elements of multiple educational models in an effort to improve student learning and enhance preparation for professional work (Birch, Rickert, et al., 1999). The nature of the hybrid may be as varied as there are courses and would be subject to local (national and university) cultures. Models that sandwich work placement with traditional university-based teaching and learning activities are popular in several profession-based courses such as engineering. Billet (2009) refers to one such model as work-integrated learning. This model requires that students participate in extensive periods of work- placement which are often referred to as internship or co-operative education.

Many hybrid models incorporate available technologies (such as the Internet and personal computers) with traditional pedagogical approaches. ‘Blended learning’ is the term used to describe the combining of face-to-face pedagogies with computer-based technologies for teaching and learning. Within the literature are numerous examples of web-based techniques used in conjunction with traditional teaching and learning methods. Gillet, Geoggroy et al., (2003) and Bui, (2008) explain the application of web-based experimentation in separate engineering courses. This allows for simulations or actual manipulation of laboratory equipment via the Internet supported by tutors. It is seen as a crucial pedagogical technique as it allows for universities to share resources such as laboratory equipment and expertise. The approach is worthy of consideration, particularly for disciplines such as surveying that uses state-of-the-art technologies, many of which are prohibitively expensive, making it is impractical for many programmes to have them. According to Gillet, Geoffroy et al. (2003), this collaborative approach to professional education:

> becomes an important trend in sustaining the richness of learning resources that are provided to engineering students. In such a distributed laboratory scheme, each partner university can focus on maintaining and enhancing a few high quality facilities in its own domains of competencies and excellence, which is an appropriate way to spread the best resources. (p. 389).

This approach is also cited as offering the benefit of cost cutting resulting from reducing the need for the duplication of resources. It also offers flexibility in terms of when students access the learning materials. However, an underlying requirement is that the partner universities have appropriate computer and Internet resources to facilitate this cooperative pedagogy. Also, there is an underlying expectation that the sharing should be mutual. Thus, where equipment and expertise are limited, it may be unlikely that those universities would benefit from this kind of web-based partnership.

Another hybrid that has been used in profession-based education, is the flexible learning approach (Petrov, 2001), which integrates distance learning strategies with on-line learning environments and face-to-face instruction. This approach has been applied to the surveying course at the University of Southern Queensland (Brodie, 2007). The distance element within this surveying programme is considered to be critical for the sustenance of the profession within that region of Australia since the large majority of students are dispersed over an expansive geographical space and are employed in full-time jobs (Young, 1997). In spite of successes in distance education in surveying and engineering, its use remains relatively low compared to the traditional face-to-face approach. Institutions that have employed distance education on a large scale have recognised that this pedagogical mode has unique demands and complexities (Beldarrain, 2006). In spite of these demands and challenges, distance education offers a viable alternative to traditional pedagogy, particularly in contexts where large numbers of students work as they study and require a flexible option for education. Furthermore, studies have shown improvements in student enrolment and course diversity in courses with distance education elements (e.g. Howell, Williams, 2003). Hence, distance education can be a viable for professional courses such as surveying which are impacted by persistent low enrolment numbers (Aina, 2009).

Like other educational models, challenges have been associated with hybrid models. One difficulty identified with the administration of the work-integrated learning is the ability to maintain one standard across various work placements. Researchers have acknowledged that this mode of learning is more unpredictable than the classical didactic approach. However, it is widely accepted that a major advantage is that this approach promotes authentic work-readiness.

Technical and social drivers have challenged the traditional approach to professional education, prompting universities into finding innovative ways of coping with the changing demands. Change is now fashionable and several universities have elements of curriculum and pedagogical innovations with a few implementing wide-scale innovative applications.

A fairly new way of conceptualising higher education students, is as expert students on a trajectory to becoming expert pre-professionals, then novice professionals as they enter professional life (Reid, Dahlgren, et al, 2011). The term expert student for these researchers refers to students who do not merely see themselves as learners but students who are able to 'shift the focus of their learning away from the formalism associated with the university situation towards the exigencies of working life.' (p. 1). Research has shown that the acquisition of knowledge and skills, along with practical exposure, does not adequately give recognition to the fact that individuals develop progressively through various stages. Empirical evidence has demonstrated that stage models are widely adopted within various professions. However, these models have been criticised as veiling 'the more fundamental aspects of professional skill development.' (Dall'Alba and Sandberg, 2006, p.383).

3.6 Innovations in educational models

Although traditional approaches to higher education curricula and pedagogy are still commonplace, innovations in these areas exist at varying levels of concentration. Some models are described as innovative based on how the pedagogies are mixed (some are discussed under the 'hybrid' sub-heading). Innovation is also based on curricular and pedagogical designs that have distinct features relative to more traditional methods.

Higher education innovations have been partially influenced by the paradigm of the 'knowledge society' (Barnett, 2005). This philosophical shift has challenged the traditional view that universities are the predominant producers and transmitters of knowledge (Symes and McIntyre, 2000). The concept of a knowledge society suggests an expansion in the boundaries of knowledge production and transmission. Within this paradigm, knowledge construction involves multiple stakeholders, rather than limited to individuals within educational institutions. Hence, demands by professional groups for educational change, can be viewed as demands for recognition as important parts of the knowledge society. This is not to ignore the idea that professional groups may have narrow expectations of educational institutions for the sole purpose of servicing industry. Whatever the influencing factors, there is evidence of pedagogical and curricular innovations within higher education.

The designing of effective education programmes for professions has been debated vigorously and continues to be viewed as a problematic venture that requires on-going improvement (Roberts & Design, 2007). There exists a real tension in regards to universities providing higher academic education and at the same time offering training that is necessary for integration into professions upon graduation. Innovations spring from a concern to reduce this tension.

3.6.1 Enquiry-Based-Learning

Enquiry based learning (EBL) describes approaches to learning that are driven by a process of enquiry (Kahn and O'Rourke, 2005). Problem based learning (PBL) and project based learning are examples of EBL which are widely touted as promoting active learning and greater student engagement. Traditionally, within higher education, students engage in special projects or research activities centred on organised activities leading to the production of a report or dissertation. With EBL the approach advocates a wider use of project work or research activity, emphasising the use of the project work to master a given body of knowledge and to make connections with existing bodies of knowledge. Tooney (1999) states that this approach distinguishes EBL from the traditional use of projects as merely a support to other forms of teaching and learning. Khan and O'Rourke (2005) explain that in EBL, the teacher establishes the task and facilitates the process but the students pursues their own line of enquiry, draw on their existing knowledge and identify the consequent learning needs. The students look for evidence to support their ideas and take the responsibility for analysing and presenting the ideas either as part of a group or as an individual supported by others. Applying this learning approach on a wide scale is a radical approach to higher education when compared to the mostly traditional teacher-centred approach.

This innovation engages students as partners in the learning process. It encourages personal research as the students become familiar with the resources at their disposal, and are given the opportunity to support one another in research and explore different avenues of information (Khan & O’Rourke, 2005). They further explain that EBL encourages students to follow up interesting lines of enquiry and allows them to concentrate their efforts where they need to do further work. The innovation is perceived to be an appropriate pedagogy for higher education as it is believed to better prepare graduates for professional practice.

McMaster University’s medical programme is often credited with making the use of the model in higher education a widely known innovation. The school introduced problem-based learning as its main approach to educating and training medical students in the 1960s (Boud, 1985). Many medical schools in North America and Europe followed in adapting this EBL approach. The approach has been employed at varying levels in other courses in many countries. For example, in engineering education (Mohd, Azila et al., 2004) and surveying education (Enemark, 2002a).

This approach to higher education, and in particular professional courses, has been promoted as a more effective approach to professional preparation than traditional educational methods. The philosophical underpinning of EBL is constructivism which views the development of knowledge and learning as an on-going construction that is influenced by a multiplicity of factors and agents (Wilson, 2012). This approach changes the focus from teaching to learning and from behavioural change to competency building.

Biggs and Tang (2011) view pedagogical approaches that engage students as being more effective at narrowing the gap between students who are more academically inclined (traditional university student) and those students with a greater inclination towards more practical work related skills (non-traditional university student). This has contemporary relevance since, as have been shown, university enrolment has diversified significantly.

There has been growing interests in project-based and problem-based learning in higher education. Project based learning has been used extensively in profession-based education (Capraro & Slogh, 2005); and problem-based learning has been identified as a popular alternative to traditional instruction (Lovell, 2010).

As Heitmann (1996) points out, profession-orientation is a key motivating factor in the development and delivery of higher education courses. He identifies project-oriented and project-organised curricula as approaches employed within engineering courses as one way to satisfy industry demands for skills emphasis and a reduction in specialised content orientation. According to Heitmann (1996) these demands 'promote a rapid expansion of problem-centred project work and of active and productive learning.' (p. 121).

Project-based learning, also referred to as project-centred learning (Crostwaite et al 2001), is a predominately task-oriented approach to learning that involve individual or group activity within a specified timeframe, with set parameters and criteria, resulting in a product, presentation, or performance (Savin-Baden, 2003). This instructional approach is widely used in engineering education and in other situations where case study methods provide a useful focus in teaching/learning. In his review of the literature on the nature of projects, Thomas (2000) identifies the following characteristic features of projects:

> Projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative actives; give students the opportunity to work relatively autonomously over extended periods of time; culminate in realistic products or presentations. (p. 1)

Thomas' (2000) definition of projects reflects many of the features of problem-based learning. In fact, project-based learning and problem-based learning are sometimes used interchangeably though researchers have illustrated that the terms are not synonymous (see e.g. Boud, 1985; Donnelly & Fitzmaurice, 2005; Savin Baden, 2003; Boud and Feletti, 1998). Donnelley & Fitzmaurice (2005) explain that both learning approaches have several features in common but have subtle differences. They explain that while PBL is both a curriculum and a process, project-based learning is usually based on an individual or group activity over a specified period, resulting in a product, presentation or performance. Hence, where PBL is used as a curriculum its scope is more extensive than project-based learning which typically has a more narrowly defined target. However, Capraro & Slough (2009) consider project-based learning to be a more extensive approach to learning than PBL . According to them:

> Project-based learning is broader and often composed of several problems students will need to solve. [It] provides the contextualized, authentic experiences necessary for students to scaffold learning and ... requires students to think critically and analytically and enhances higher-order thinking skills. (p. 2)

Researchers of EBL distinguish between problem solving and PBL. Though often associated with projects, problem-solving is not limited to EBL. Savin-Baden (2004) identifies a distinction that is important to make when considering the degree to which a learning approach encourages learner autonomy. She states that:

> Problem solving involves setting the learning problem scenarios within a discrete subject or disciplinary area. The focus then is largely upon acquiring the answers expected by the lecturer, answers that are rooted in the information supplied in some way to the students. Thus the solutions are always linked to a specific curricular content which is viewed as vital for students to cover for them to be competent and effective practitioners. In problem-based learning, the focus is on organizing the curricular content around problem scenarios rather than subjects or disciplines. Students work in groups of teams to resolve or manage these scenarios but they are not expected to acquire a predetermined series of right answers. Instead, they are expected to engage with the complex scenario presented to them and decide what information they need to learn and what skills they need to gain in order to manage the situation effectively (p. 2).

Donnelly & Fitzmaurice (2005) indicate that, in practice, there is a thin line between the two PBLs. The learning method 'begins with an end product or 'artefact' in mind, the production of which requires specific content knowledge or skills and typically raises one or more problems which students must solve together' (Donnelly et al. 2005, p. 89).

As used in electrical engineering (Crosthwaite et al. 2006) and surveying (Enemark et al. 2002a), problem-centred curriculum provides a structured sequence of professional practices (sometimes simulated) as a vehicle for systematic and simultaneous development of technical and generic learner attributes. This is considered to provide realistic and relevant contexts to integrate and develop the graduate attributes that the modern workforce demands (Crosthwaite et al.2006).

PBL is seen as having significant relevance in terms of its capability to develop problem-solving skills relating to professional practice. Skills such as the ability to deconstruct problem situations, work effectively in teams, communicate ideas and solutions, to demonstrate creative and critical thinking in the solution of complex real-world problems. Some of the 'advantages' cited by proponents of PBL are viewed as 'disadvantages' by others. One example is the flexibility of the learning process is viewed as being an advantage as it enables students to decide and prioritise their own learning. However, Kirschner, Sweller, et al. (2006) sees this as a disadvantage as novice and intermediate learners require a more rigid structure to support effective learning.

Research by Boud and Feletti (1998) identified important challenges to PBL. Some of these include issues of appropriate problem selections, group dynamics, resources, intangible outcomes, students' inability to determine content, tutor training, low content coverage, among others. Through her analyses of PBL practices and of users of PBL in various institutions and countries, Savin-Baden (2004) observes that there remain uncertainties concerning various aspects of the innovation.

Within this context it is clear that there remain many unanswered questions about PBL and further research can offer some answers. The International Journal for Engineering Education (IJEE) (2008) has issued a call for research to provide "more evidence to document the impact of PBL on knowledge and skills acquisition. They posed the question: what evidence do we have, for instance, confirming that PBL truly results in deep learning, more complex knowledge and the ability to collaborate across discipline and cultural barriers? The gaps in our understanding of staff and students experiences of PBL Savin-Baden (2003) can only be narrowed by more extensive research in the application of the innovation.

3.6.2 Signature pedagogy

The relevance of educational strategies to particular disciplines is a growing area of interest among academics and educational researchers. Huber et al. (2003) purport that:

> professors in disciplines from anthropology, to zoology are beginning to consult pedagogical literature, look critically at education in their field, inquire into teaching and learning in their own classroom, and use what they are discovering to improve their teaching practice…the scholarship of teaching and learning is taking shape within the extraordinary diversity of disciplinary cultures that constitute postsecondary education (pp.1-2).

According to Shuman, Atman, et al. (2002) ‘teaching and learning strategies are domain specific’ (p. v) in relation to disciplines. This way of perceiving and developing higher education pedagogies offers a new educational approach called signature pedagogies. In this sense educational programmes that more closely capture the special features of a profession may be judged as more relevant to professional preparation. Shulman defines signature pedagogy as:

> …types of teaching that organise the fundamental ways in which future practitioners are educated for their new profession. ….novices are instructed in critical aspects of the three fundamental dimensions of professional work- to think, to perform, and to act with integrity. (Shulman, 2005 : 52)

He believes that professions are more likely to develop distinct signature pedagogies than academic disciplines because ‘their pedagogies must measure up to the standards not just of the academy, but also of the particular professions’ (p. 53). This is important since ‘professional education is not education for understanding alone; it is preparation for accomplished and responsible practice in the service of others’ (Ibid.). Hence, signature pedagogy is a way of teaching more than basic content, but also the understanding and practice of disciplinary ways of thinking or habits of mind. (Gurung, Chick et al., 2008)

It has been acknowledged in a number of disciplinary fields, both academic and professional that there exist some distinctions in forms of thinking and reasoning that are reflected in pedagogical approaches.

Law and engineering are examples from the professions with what have been identified as distinct signature pedagogies. Shulman (2005) describes the signature pedagogy of law as influencing even the arrangement of the classroom which in some cases mimic a courtroom. The pedagogical arrangements within an engineering school he describes as, having a concentration on mathematical modelling of physical processes, done in a typical teacher-led class setting with a low level of interaction between teacher and students and between students. He identifies this approach as generic to a number of disciplines that are mathematically intensive but claims that this does not define their signature pedagogies. It is those aspects of the profession and discipline that is distinct in their activities that define their signature pedagogies. In this instance, engineering's signature pedagogy is better seen in a class that more closely reflect the role of the engineer.

Shulman (2005) identifies three dimensions of signature pedagogies: surface structure, deep structure and implicit structure. The surface structure consists of concrete, operational acts of teaching and learning –showing, demonstrating, questioning, answering, interacting and with-holding, approaching and withdrawing. The deep structure consists of 'a set of assumptions about how best to impart a certain body of knowledge and know-how' (p. 55). An example of this is 'the processes of analytic reasoning characteristic of legal thinking' (Ibid.). The implicit structure is the aspect that concerns the moral dimensions in terms of beliefs about the profession along with attitudes, values and dispositions associated with it. An important aspect of signature pedagogies is that they represent choices taken regarding what is considered appropriate for the teaching and learning for a specified profession. Shulman (2005) notes that making these pedagogical choices 'necessarily highlight and supports certain outcomes while, usually unintentionally, failing to address other important characteristics of professional performance' (p. 55).

This way of looking at professional habits within the classroom is useful for understanding distinctions in pedagogical approaches. It has implications for how pedagogical effectiveness is considered for all professional disciplines.

An early catalyst for this research was my personal belief that some pedagogical approaches may be more appropriate than others, for the teaching and learning of surveying. It was also presumed that this notion would hold true for other professional disciplines. This notion has much resonance with Shulman's (2005) theory. Support for this belief is implicit in May and Perry's (2011) comment that 'the bounded nature of professional knowledge production is variable according to discipline, institutions and macro factors that attribute value to particular activities' (p. 192). However, studies of university teaching and learning have mostly been focused on generic aspects (Neumann, 2001), with only a few considering the impact of disciplinary culture on disciplinary knowledge (e.g. Becher, 1994). Jenkins (1996) purports that most members of academic staff have a primary allegiance to their discipline and those educational developers often fail to recognize the value of disciplinary focus demonstrated by academic staff. He further stated that a disciplinary focus is sometimes viewed as an obstacle to improving the quality of teaching.

Since it is difficult, if at all possible, to separate individuals from their disciplinary cultural orientations, it is worth considering what impact disciplinary culture may have on teaching and learning effectiveness. As Case (2008) cautions, professional models of theory are not necessarily applicable to teaching since teaching is 'a matter of making judgements rather than following rules' (Hammersley, 1997, p.147).

Studies have found that academics identify strongly with their discipline (Neumann, 2001) and that there is a strong interconnection between disciplinary culture and disciplinary knowledge (Becher, 1989). Though it is often accepted that disciplines have their distinctive cultural characteristics, this consideration is largely overlooked in research in higher education (Becher 1994, Kolb 1981). According to Kolb (1981) each discipline has its own language (or dialect), norms and values; there are strong boundaries defining membership and corresponding initiation rites, different patterns of authority, different criteria for attaining status, different norms and values about the nature of truth. He asserts that 'these patterns of variation are not random but have a meaning and integrity for the members' (p. 233). Kolb (1981) believes that it is possible to match learning styles with the learning demands of particular disciplines.

Table 2:Typology of intellectual clusters and disciplinary groupings (Becher, 1994)

Biglan	**Kolb**	**Disciplinary areas**
Hard pure	Abstract reflective	Natural sciences
Soft pure	Concrete reflective	Humanities and social sciences
Hard applied	Abstract active	Science-based professions
Soft applied	Concrete active	Social professions

Table 2 illustrates Biglan (1973) and Kolb's (1981) intellectual clusters and the disciplinary areas they identified with each. According to Becher (1994.), Biglan (1973) was more concerned with the nature of the subject-matter and Kolb the styles of intellectual enquiry. Though it remains debatable what qualifies as distinct disciplines or where exactly in those typologies particular disciplines should fall, the discipline of surveying in its modern state (geomatics) will not wholly fit into any one category in the typologies shown in **Table 2**. **Table 3** is an augmentation of the illustration in **Table 2** showing classifications of knowledge and culture by disciplinary groupings. Based on Becher's (1994.) classifications, it is suggested that traditional surveying with an emphasis on earth measurement and representation would best fit in the technologies group (hard-applied) and aspects of its more social science related roles such as land management and arbitration relating to boundary disputes would best fit in the applied social sciences category (soft-applied). Within this framework of thinking, modern surveying education would be impacted by the forms and traditions associated with these areas.

Table 3: Knowledge and culture by disciplinary grouping (Based on Becher, 1994)

Disciplinary groupings	Nature of knowledge	Nature of disciplinary culture
Pure sciences (e.g. physics): ‘hard- pure’	Cumulative; atomistic (crystalline/tree-like); concerned with universals, quantities, simplification; resulting in discovery/explanation	Competitive, gregarious; politically well-organised; high publication rate; task-oriented.
Humanities (e.g. history) and pure social sciences (e.g. anthropology): ‘soft - pure’	Reiterative; holistic (organic/river-like); concerned with particulars, qualities, complication; resulting in understanding/interpretation.	Individualistic, plurastic; loosely structured; low publication rate; person-oriented.
Technologies (e.g. mechanical engineering: ‘hard- applied’[Surveying]	Purposive; pragmatic (know-how via hard knowledge); concerned with mastery of physical environment; resulting in products/techniques.	Entrepreneurial, cosmopolitan; dominated by professional values; patents substitutable for publications; role oriented.
Applied social sciences (e.g. education): ‘soft-applied’ [land management]	Functional; utilitarian (know-how via soft knowledge); concerned with enhancement of [semi-] professional practice; resulting in protocols/procedures.	Outward-looking; uncertain in status; dominated by intellectual fashions; publication rates reduced by consultancies; power-oriented

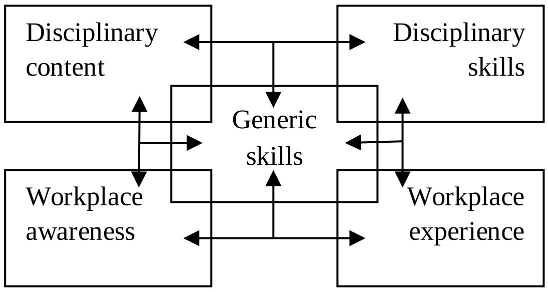
How might these 'disciplinary cultures' impact on university course design and pedagogy? Studies have shown that underlying differences in ontological and epistemological standpoints within academic disciplines do have an impact on the design and delivery of university courses, which in turn influence students’ learning processes (Snow, 1964; Becher & Trowler, 2001; Abrandt Dahlgren, 2008, 2003; Neumann 2001; Abrandt Dahlgren & Dahlgren, 2006; Neumann et al., 2002). Hence, the development of professional education programmes could see real benefit from giving consideration to the socio-cultural contexts of the profession.

3.7 Ways of conceptualising professional education

The ways that professional education courses are conceptualised, or the philosophical principles that underlie their development have much to do with the directions they take. Furthermore, these aspects of an educational system are important to consider if existing systems are to be improved.

The degree to which university curriculum target professional development can be assessed using different criteria. Bennett, Dunne & Carré (2000) propose a five-component model of skills development for higher education and employment (illustrated in **Figure 5**).

Figure 5: Schema for skills development in higher education & employment (Bennett, Dunne and Carré, 2000)



In their Schema for Higher Education, Bennett et al. (2000) portray higher education curriculum as a composite of three domains: disciplinary, workplace and generic. These domains, they explain, are interconnected but no domain is more important than the other. They also explain that within the schema no domain is discrete and there are overlaps between them; the skills of disciplines can be understood as separate from disciplinary content and students' capabilities in each may be separately developed; and generic skills are to be found, or at least can be exemplified and realised in each of the other domains. Barnett and Coate (2005) commented on specific features of the schema: 'the fluidity across the curriculum as a whole; the interconnectedness between the elements; and the sensitivity to the inner complexity of any one major element' (p.56). The degree to which higher education curricula conforms to this schema is varied, as Bennett et al (2000) point out that the emphasis placed on domains are generally not equal and some may even be omitted.

Decisions to innovate educational strategies should never be taken lightly since, as Frand (2000) outlines, innovation is not necessarily synonymous with improvement. He states that :

> there will always be a role for the lecture format, and there are learning situations in which computer use is totally inappropriate. The goal must be to match the appropriate use of technology, with the content, the instructor's personal style and the students' learning style (p. 24).

3.7.1 Transmission, product, process and praxis

The educational approaches employed can say much about where the emphasis is placed within a course. In his analysis, Smith (2000) classifies approaches to education in four ways: as a syllabus to be transmitted; as a means of developing a desired product; as a process; and as praxis. There are various implications for each of these philosophical stances and associated advantages and disadvantages as summarised in **Table 4**.

Table 4 : Comparison of four educational models based on philosophical underpinning (adapted from Smith, 2000)

Model:	**1. Transmission**	**2. Product**	**3. Process**	**4. Praxis**
Model definition	Strong focus on content and the order in which it is presented. Body-of-knowledge oriented.	A technical exercise that seeks to develop a particular product. An objective-oriented approach.	Knowledge seen within frameworks of general principles. Content and pedagogy develop through interactions in the learning process as participants make judgement and meaning.	Builds on the process model but extends the notion of learning as an emancipating process. It aims at bringing about an embodiment of the learning in the learners. 'Transformational learning'.
Perceived Advantages	Protects important body of knowledge considered necessary for the course.	Effective at building measurable competencies.	More participative than instructive. More engaging for learners.	Curriculum in a constant state of development. Reduced risk of misaligning studies with learner interests & work relevance.
Perceived Disadvantages	May pay too little attention to effectiveness of delivery at the expensive of covering content. Highly instructive and takes little advantage of students' prior knowledge	Strong focus on behavioural objectives risks the development of other skills. Very instructive and takes little advantage of students' prior knowledge	More concern with participation of stakeholders than with content. Risk of compromising content.	The focus on individual needs of stakeholders can put at risk sufficient focus on other areas of the curriculum e.g. content.

It has been shown that though models may have leanings towards particular philosophical approach(es), they generally cannot be neatly located in any distinct class. Considerations should be given to whether the course will emphasise the: vocational or academic; inter-disciplinary or specialist content; student-centred or subject-based pedagogy; global perspective or national perspective; and whether it will be a modularised structure or unified programme. Within the emerging knowledge economy with increasing global standards, there is a trend towards interdisciplinary approaches to professional education with greater learner-centeredness and a global outlook. It is believed that curricula designed with this outlook have more purposeful learning experiences which are rich in complexity and mirror the demands of profession (Herrington 2005, Enemark 2005b).

The literature has many accounts of innovations in the delivery of course components. These innovations typically are motivated by a desire to enhance learning and to promote the development of competencies that have professional relevance. Several examples can be found in engineering education (see e.g. Lehmann, Christensen et al., 2008; Lucena, Downey et al., 2008; Kaider and Shi, 2011); in medicine (e.g. Neville, 2009; Doxiadis, 2011) and, fewer in less popular and less researched disciplines such as surveying (Enemark, 2001).

If the curriculum composition draws from a wide liberal field one may assume that the course aims at providing a foundational education for later specialised learning; or it might be that the course is guided by the philosophy that higher education should not confine students to narrow specialisations but rather concentrate on 'providing students with the means to think and act logically' (Ditmore, 2001 p.1) through a more liberal education. This may say something about the education system within a particular country or university but perhaps, more relevant to professional surveying education; it may reflect the degree to which the surveying profession is actively involved in the development of the educational systems within the discipline.

3.7.2 Body-of-knowledge as a framework for professional development

Professional education curricula are usually developed around a 'Body of Knowledge (BoK)' that represents the core competencies and values of the professions they seek to develop. The body of knowledge for a profession-based programme is traditionally derived from academics' affiliation with the profession, developed by research in the field and discussion with other stakeholders, and mediated through the university's course approval and accreditation requirements. In this regard, knowledge in a particular field is usually presented as a bound set of requirements (Reid, Abrandt Dahlgren et al., 2006).

The engineering profession has, for a long time, utilised BoK as a framework for ensuring standards within its educational programmes. Examples of these are the American Association of Civil Engineers BoK (2008) and the SE2004, the software engineering body of knowledge (Joint Task Force on Computing Curricula, 2004). The SE2004 BoK indicates that one of its main purposes is to 'provide guidance to academic institutions and accreditation agencies about what should constitute an undergraduate software engineering education' (p.1).

Within the spatial science disciplines (Surveying and GIS in particular) the development of a BoK is at an early stage. The Geographic Information Science and Technology Body of Knowledge (GISTBoK), for example was established by the University Consortium for Geographic Information Sciences in 1997 and is still being developed (DiBisae, DeMers, et al., 2006). A BoK for surveying education was proposed by Greenfeld and Potts in 2007.

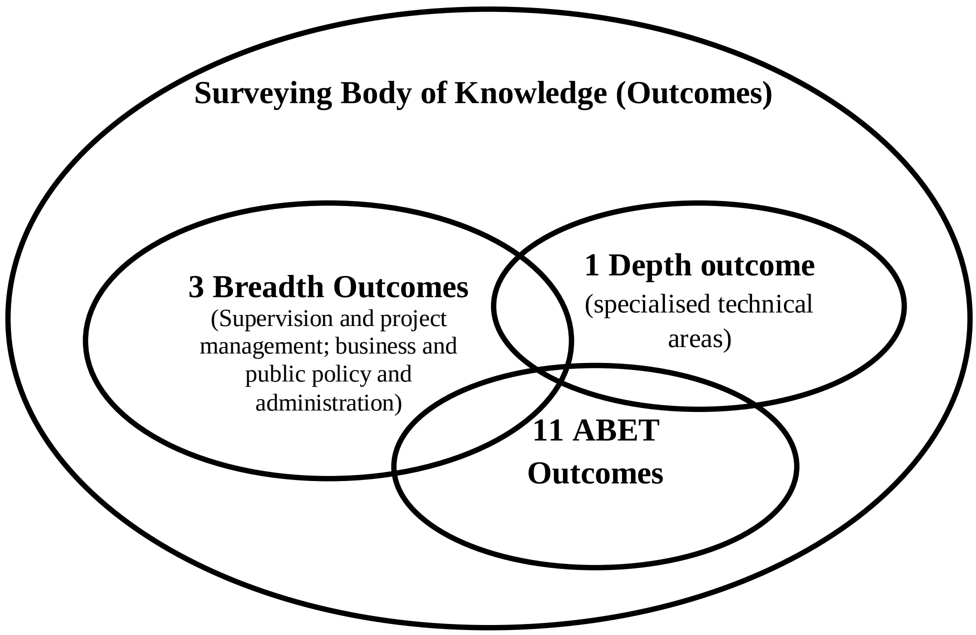


Figure 6: Outcomes of surveying body-of-knowledge (Greenfeld and Potts 2007)

The model by Greenfeld and Potts (2007) specifies broad areas to be incorporated in surveying education. **Figure 6** illustrates the combination of aspects of the ABET (Accreditation Board for Engineering and Technology) criteria for engineering education with what Greenfeld and Potts describe as breath outcomes (more general education areas) and depth outcomes (specialised technical areas). From this proposal the greater proportion of the learning outcomes were derived from the ABET Criteria and include the following:

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments, as well as to analyze and interpret data
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multi-disciplinary teams
- an ability to identify, formulate, and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- a recognition of the need for, and an ability to engage in life-long learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Greenfeld (2011) outlines both macro and micro features for the SBoK based on the FIG definition of the role of the surveyor. The inclusion of five sub-areas, each with its own BoK demonstrates that contemporary surveying education and professional practice, straddles diverse areas. By including general and specialised competencies this BoK seems geared towards developing a fixed and generalized set of competencies while allowing for specialised training in one of the related sub-group areas. While the development of the BoK is important, it is not likely that an evaluation of its effectiveness can be obtained until the system has been implemented and used over an extended period. As it stands, the surveying BoK is still in an infancy stage. Although it can be used as a tool for measuring conformity to a convention, a BoK may best serve if one is developed specific to national or regional contexts.

3.9 Summary discussion

A real and robust demand on contemporary higher education is the need to be aware of the dynamic needs of professions and a willingness to engage the various stakeholders. Hence, developers and delivers of professional courses are expected to be prepared to make adjustments, not only to content, but also to scope of knowledge, methods of knowledge building and ways of encouraging cooperation between the various stakeholders. The literature has shown that educational strategies, used in professional courses, benefit from acknowledging domain specific characteristics. Perhaps, more effective, is the mixing of curricular and pedagogical strategies so that the courses are offered on a flexible basis. This not only increases enrolment, but empirical studies have shown that flexible systems impacts positively on student learning. It has been argued that, if higher education courses were to have relevance to modern societies, they should cater to a variety of needs, some of which are discipline specific and others more generic. It has also been shown that matters of knowledge and skills development should be identified and form part of the learning outcomes. From this complex of factors, several outcomes may be derived based on the emphasis placed on one or more of the components. Hence, educational strategies should have contextual relevance.

Surveying education has not been researched to the degree that other professional disciplines such as medicine and engineering have. Those two specific fields were mentioned several times in the literature review because they are considered to emphasis specialist education as is done in surveying courses. These professional fields all have fundamental theoretical elements and distinct practical components that must be accounted for in educational programmes. The lack of consensus as to what educational model will work best is indicative of distinctive features of the various professions and the relevance of context. The review has highlighted that although studies have been done in higher education curriculum and pedagogies, there remains much to be understood about how particular disciplinary fields navigate professional and educational demands for the best outcomes.

CHAPTER FOUR

RESEARCH METHODOLOGY

4. Introduction

In this chapter, the development of the research methodology employed in the study is explained. Initially, the researcher's ontological and epistemological positions are discussed as factors influencing the research methodology employed. An account is then given of the methodological choices including the research design, the enquiry methods and the theoretical and analytical frameworks used. Additionally, theoretical concepts adapted are explained. The chapter also addresses issues of ethics, research quality and limitations of the study.

4.1 Research paradigm

Having established research objectives (chapter 1), some critical questions needed to be answered. What methodology would effectively facilitate a deep and rich investigation of the phenomena of interest? How should the empirical data be collected and from whom at what locations? Answers to these questions have ontological and epistemological groundings as Fleetwood (2005) asserts:

> The way we think the world is (ontology) influences: what we think can be known about it (epistemology); how we think it can be investigated (methodology and research techniques); the kinds of theories we think can be constructed about it; and … stances we are prepared to take. (p. 197)

I concur with Mack (2010), in seeing the (research) paradigm as the combination of ontological and epistemological assumptions. I believe there is an objective reality in regards to things in the physical world but that social realities are more subjective in nature. However, knowledge of both the physical and social worlds is subject to human interpretations. Hence, there are possibly many interpretations of the same phenomenon. Is one right and another wrong? Can there be some measure of 'truth' in all points of view? My conception is that those things which are absolute do have wrong and right answers. However, there are many things that we claim to know that are essentially human constructions, thus, perceptions may be as varied as there are cultures or even individuals. This means that the perceived 'truth' about many things is subjectively accessed and cannot be understood outside of an understanding of the individual's or group's perspectives. Individual perspectives may themselves be quite complex, since they are influenced by a myriad of things such as upbringing, culture, education, gender, etc. As stated earlier, these elements of human characteristics have some resonance with Bourdieu's concept of habitus.

Even scientific knowledge is transient as evidenced by the recorded changes in what was believed to be true but seen differently in different contexts or seen differently on a general level as a result of 'development' in science and technology. For example, Homer in the 9th century BC thought the earth was a flat disc floating around in an oceanic river (Brown, 1979). In light of modern scientific knowledge, this idea is considered to be absurd. Advances in scientific methods and technology now show that the earth is not as Homer saw it. Now it is widely believed that the earth is a sphere and scientists can determine accurate measurements of its dimensions. Not only does this illustration show that knowledge claims change over time but also that there is a tendency for humans to embrace knowledge that is linked to authoritative figures as Homer was in his days. Considering the rate of knowledge growth in the last few decades, it would not be surprising to see many established 'truths' about the physical world revised through the application of 'more reliable' technologies. I believe that this analogy has parallels to the social world. We come to knowledge based on the 'lenses' through which we look, in other words, based on the context within which we exist and the 'tools' we have available to us to aid our knowledge building. How we perceive the nature and impact of social phenomena, I believe, is a subject of culture and society. Therefore, I believe that we can come to useful understandings of social phenomena, but only through scrupulous consideration of their context facilitated by a process that involves those agents involved in the social systems being explored. Coming to an understanding then of surveying education requires careful consideration of the contexts in which it exists. I believe that context is grounded in history and so giving a historical account is an imperative for exploring social systems.

Like May (2001), I believe that social research is invariably influenced by value judgements, assumptions and limitations. Therefore it is important that any study into social phenomena should employ a well thought out methodology with appropriate enquiry methods, if the findings are to be considered to be reliable and valid. Value judgements are influenced by the researcher's development in the sphere(s) that relate to the nature of the study. My cultural, educational and professional backgrounds (outlined in chapter 1) have informed my world view (ontology) and my perspective on how I can come to an understanding (epistemology) of social phenomena that interest me. Jones, Torres & Arminio (2006) reinforce the importance of understanding my own standpoint and position in relation to the subject of my research. They state that this understanding is important in research, because it guards against:

> hearing, seeing, reading, and presenting results that conform to the researcher's experiences and assumptions about self and others, rather than honouring the participants' voice in the study. A researcher must understand his or her position and power within societal structures in order to attend to his or her potential biases...Without reflection on the influence of social identities in the research process, interpretation and representation become more about telling the researcher's story and less about staying true to the words and stories of participants. (pp.102-103).

Essentially, this speaks of a reflexive process that considers the views of the research subjects in their diverse roles and dispositions as well as that of the researcher. On this basis, I think that coming to an understanding of observed social phenomena is facilitated by interactions with the people involved and the processes and artefacts created through the interactions between the agents within the observed system. Within this framework, reliable knowledge is seen to be achievable through an active process that engages with the phenomena being studied with an appreciation for, and acknowledgment of the ‘power’ of social interactions.

My experiences as a surveying student, surveying practitioner and as a surveying educator have influenced my perceptions of how surveying education ‘works’ at least within the contexts I have studied and worked. I perceive that the knowledge and skills development of surveying students is the product of a partnership between multiple ‘players’. My belief concurs with Allan’s (1995) that ‘the education and training of a specialist group, such as geodetic surveyors, cannot be isolated from the vocational activity it seeks to serve.’ The configuration of the partnership between profession and academia, I believe, will depend on the roles played by the various stakeholders and the context within which they operate.

Educational systems, by their very nature, are multi-dimensional; as such, they are likely to yield varied findings and interpretations. The ‘realities’ within the observed phenomena are personally and socially experienced and are influenced by the culture, norms, values and structures of the society they are derived from and by individual cognition. There will, therefore, always be a level of subjectivity in findings from social research. It follows then, that a clear understanding of aspects of social phenomena may best be obtained by employing a methodology that allows for a broad description of the system but also provides an avenue for deeper meanings of what is observed. It is in this context that I have decided on a two-tiered case study methodology – on one level, a collective case study of multiple programmes in several countries, and on another level, two comparative in-depth case studies.

4.1.1 Case study methodology

The choice of multiple cases (fifteen) from several national contexts (thirteen countries) allowed for a broad view of contemporary surveying education. On the other hand, there was a desire for a deeper and richer understanding of educational strategies employed within the discipline. This deeper analysis was concerned with understanding how educational strategies and issues relate to the current state of surveying practice, and what meanings may be derived in regards to students' preparedness for professional engagement. This was the primary motivation for choosing two in-depth case studies for comparative analysis. The case study methodology offered the avenue to carry out the investigation at both levels.

Case studies are considered to be useful a research method for explorations that not only seeks for the descriptive but also to go deeper in answering 'why' questions (Yin, 2009). Yin further states that when the research focus is on a contemporary phenomenon within real life (as surveying education is), and the researcher has little control over the events, the case study approach is a preferred method. The method allowed for detailed contextual analyses of a limited number of events within selected surveying programmes and the relationships between these various events. Yin (2009) cautions that:

> …the richness of the phenomenon and the extensiveness of the real life context require case study investigators to cope with a technically distinctive situation: there will be many more variables of interest than data points. In response an essential tactic is to use multiple sources of evidence, with data needing to converge in a triangulating fashion. (p. 2)

On this basis, multiple data collection methods were used within the case study (to be discussed in the next sub-section). The convergence or divergence of the data from these multiple sources addresses issues of credibility of the research. The use of multiple data gathering methods, termed 'data triangulation' by Denzin (2009), is considered to have enhanced the reliability and validity of the study. Triangulation is not used simply as a way of searching for convergent findings but more importantly to explore the multiple perspectives of the studied phenomena as a way of enhancing the understanding. For example, divergence of findings from interviews of students when compared to interviews of academic staff on similar pedagogical issues may suggest something about the variations in perceptions from each category of agents. This outcome can be viewed as an enhancement of the understandings of a complex educational system. The complexities of social systems requires that considerations be given not only to what is obtained from the data sources but also what possible impact the data gathering methods may have on the type of data obtained. Whether there is convergence or divergence from the varied data sources, the findings in their complex forms are used to come to some understandings of the studied social phenomenon. It is this approach to social research that Denzin and Lincoln (2005) sees as contributing to the elimination of bias, hence, enhancing validity and reliability, or rather increasing the trustworthiness of propositions about a social phenomenon.

It is sometimes argued that case study researches do not lead to knowledge with wide generalisations. However, this criticism is truer of a critical incident case study or more explorative ones with a small number of cases. While having fifteen cases does provide some scope for generalisation, this is not a main objective of the study. The research is not concerned with coming to wide generalisations but rather with providing some understandings of the nature and impact of surveying education programmes within the identified contexts. What I perceive to be a driving force behind the choice of research methodology is what Flyvbjerg (2004) identified as the context-dependent knowledge about human learning that case study research facilitate in social research.

> First, the case study produces the type of context-dependent knowledge that research on learning shows to be necessary to allow people to develop from rule-based beginners, to virtuoso experts. Second, in the study of human affairs, there appears to exist only context-dependent knowledge (p. 421)

Fyvbjerg (2004) further asserts that in the same sense that individuals develop into experts in narrow fields through intense context-dependent knowledge, the case study approach offers similar benefits to researchers. It is a desire to have this richness offered by context-dependency that contributed to the selection of a case study methodology. The research seeks not merely to describe the teaching and learning activities and processes being investigated, but to provide an understanding of the observed phenomena and the impact they may have on the individuals involved in them and the associated surveying profession within the selected contexts. The use of case studies in coming to context-based understandings of surveying education is even further strengthen by Flyvbjerb (2004) assertion that:

> Social science has not succeeded in producing general, context-independent theory and has thus in the final instance nothing else to offer than concrete, context-dependent knowledge. And the case study is especially well suited to produce this knowledge. (p. 422)

The two in-depth cases were taken to be unique and distinct representations of surveying education. Their analyses followed a similar thematic approach as used in the collective case studies. However, more emphasis was placed on pedagogy as the data from the two in-depth cases afforded more scope for a deeper exploration of this aspect of the educational systems within two distinct contexts.

This methodology offered an effective means of understanding the various cases considered. The interpretations are based on multiple layers of data that draws heavily on context. Stebbins (2001) see this approach as being beneficial to educational research as it allows for the simultaneous investigation of complex issues impacting educational systems. This trend in using the qualitative approach in educational research sprang from a growing unease with the use of more positivist approaches in this field; and at the same time, the increasing awareness that a more naturalistic interpretive approach seeking to understand phenomena in their contextual settings offered deeper and richer understandings. As Patton (2001) puts it, in qualitative research 'the researcher does not attempt to manipulate the phenomenon of interest' but allows it to 'unfold naturally' (p. 29).

Bryman (2008) notes that quantitative and qualitative research paradigms are not merely about different approaches to collecting data, but that they are taken to denote divergent assumptions about the nature and purpose of research in the social sciences. Suffice to say, quantitative research with its use of numeric values and statistical significance has a history within educational research and I believe still has a place in exploring some issues either as part of mixed method studies or as a standalone approach. In regard to underlying assumptions of these paradigms, I believe the treatment of social phenomena as if they were objects that respond in similar ways to measurable changes in stimuli is too extreme a perspective to adopt, since human activities are complex and unpredictable and have groundings in contexts and history that themselves are quite complex. Whereas I believe quantitative methods can be usefully and appropriately applied to some aspects of educational research, I believe much of what we seek to understand about specified educational phenomena are more appropriately derived from a more qualitative look at empirical data. My position on this matter, then, is that a researcher should carefully assess the aims of his/her research in coming to decisions about what method will be a more appropriate fit. Why then have I chosen qualitative research for this study?

Though I have not been involved in numerous research projects, my studies as a surveying student, particularly at the postgraduate level as well as in social sciences, have involved some amount of research. Apart from minute aspects of my previous research in higher education, all my earlier research work was based on quantitative methods. Not only was I taught quantitative research methods during my technical education but also in my studies in social sciences. While the quantitative methods used in my previous social research allowed me to test statistical significance for some of the human behaviour I was studying, I was less able to use the statistic to explore deeper issues behind the research subjects' behaviours and perceptions. It became evident during the face to face administration of questionnaires, that verbal comments made by respondents often provided valuable meanings to their responses that may have been missed without this type of engagement. This observation heightened my interest in looking for deeper meanings when researching social issues, more so than I believe a quantitative approach only allowed. Since the overarching aim of the study was to have a deep and holistic understanding of the nature of contemporary surveying education, I believed that a qualitative approach would be better suited. For this reason, the approach utilized was reflexive as it sought to incorporate the perspectives from different and sometimes divergent sources: the researcher (author), the researched (subject) and the audience. As Serpell (1993) states:

> We can identify three different roles which feature in the communication situation: the subject whose behaviour is to be explained, the author who proposes the explanation and the audience to whom the explanation is addressed. (p. 281)

This interplay of perspectives is illustrated by Serpell's (1993) reflexive *triangle* (**Figure 7**).

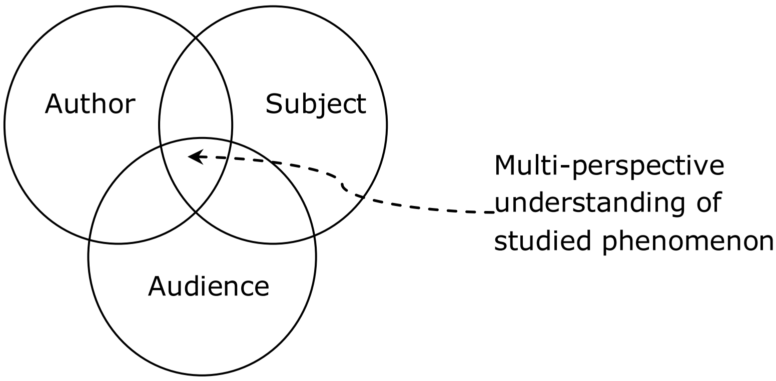


Figure 7: Cultures of interpretation: The reflexive triangle (Serpell, 1993)

Within this framework of thinking, I was interested in coming to an understanding of the research subject through a process that involves all three 'voices' and yielding a multi-perspective understanding of the studied phenomenon. Giving room for the voice of the research subjects was facilitated by seeking responses from academic staff, programme administrators, students, professional surveyors and representatives of accrediting bodies. Acknowledging my membership within the communities of surveying educators and practicing surveyors as well as researcher, is also considered to have important implications for how data collection and data analysis are approached. Additionally, acknowledging the growing community of educational researchers as well as surveying educators who have an interest in research of this kind, also impacted the study in terms of what data is targeted and how the findings are presented. The research process has therefore been a reflexive and iterative one that layered one interpretation upon another in an effort to validate claims and strengthen arguments.

4.2 Theoretical concepts adapted to the study

The study was primarily explorative and largely driven by the empirical data. However, some theoretical concepts were useful as tools for distinguishing between the various educational models used in the different contexts. Two features of surveying education were identified as important to consider for a study within the discipline. Firstly, systems of surveying education have multiple stakeholders; and secondly, surveying courses are intrinsically linked to professional surveying practice. Thus, it was useful to locate a framework within which both layers of analyses could be factored into coming to an understanding of the observed systems in different contexts. The relationship between the related fields can be usefully analysed using Bourdieuian concepts in the sense that it offers an approach for, 'researching in a relational way' (James, 2011, p.1). By this James means:

> the study of the social world should be as much about the relationships between things (or people) as it is about the substance of the things or people themselves. (p. 3)

Thus, concepts from Bourdieu's *Theory of Practice*, in particular *field, agents, habitus* and *capital* offered useful tools with which to examine some important aspects of surveying education. Conceptualising the educational system as a *field* that interacts with the *field* of practice is a useful approach to understanding the dynamics of the relationships between the various *agents* in the *field*. The Bourdieuian concepts used to illuminate this aspect of the study are further explained next.

4.2.1 Concepts from Bourdieu's Theory of Practice

In his *Theory of Practice*, Bourdieu (1984) described a *field* as a system of social positions, a setting in which agents and their social positions are located and are structured internally in terms of power relationships. The position of each agent in the field results from interaction between the specific rules of the *field*, agent's *habitus* and agent's *capital* (Bourdieu, 1984). He describes *habitus* as a set of acquired patterns of thought, behaviour, and taste, which constitute the link between social structures and social action. It constitutes the practices and norms of agents within the social field. This theory presents history as a prominent determinant of agents' habits or *habitus*.

According to Bourdieu (1984), habitus is ‘history turned into nature’ (p. 78). Important to note, *habitus,* according to the theory, determines the positions of the *agents* within the *field* and their relative importance in creating and re-creating *capital*. A feature of this conceptual tool that makes it even more attractive for this study, is the explicit acceptance that the agents’ positions are not seen as static, and their relationships are not seen as linear or following any particular path. Therefore, application of this Bourdieuian concept is useful for exploring how different social influences in different contexts, impact on the field of surveying education.

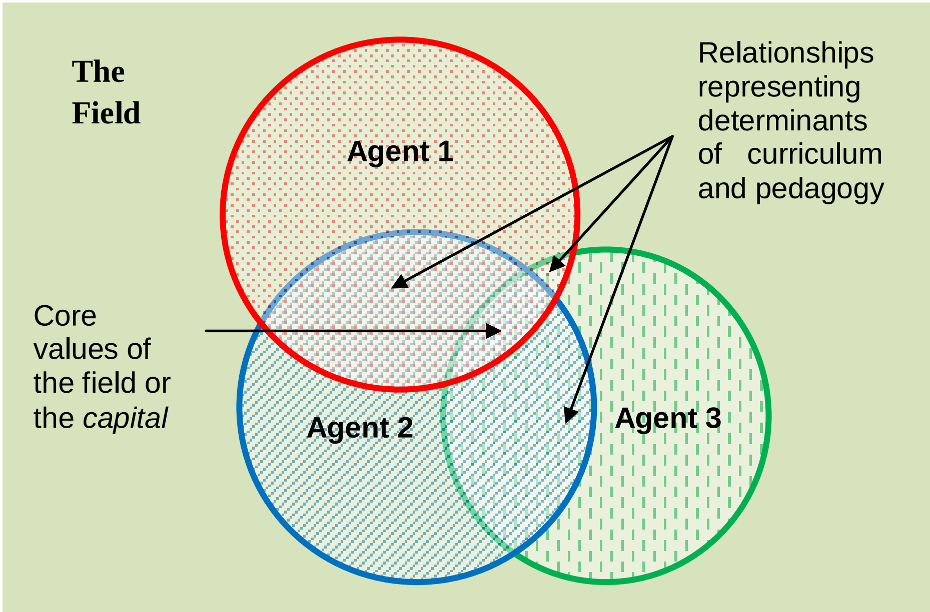
Capital is the currency of the field, that is, the things that are held as values within that social system. Capital can change and do change from time to time. Bourdieu (1984) further explains that capital may be economic, cultural, social or symbolic. Economic capital refers to wealth that may arise from inheritances and income that defines ones monetary assets. Cultural capital may be embodied, objectified or institutionalised, and as James (2011) states, it is primarily refers to products of education such as qualifications or more visible forms such as accent and vocabulary. He saw social capital as ‘resources based on connections and group membership’ They are ‘the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalised relationships of mutual acquaintance and recognition’ (Bourdieu and Wacquant, 1992, p. 119). Symbolic capital ‘is the form that different capitals take once they are perceived and recognised as legitimate. Cultural capital has to be legitimised before it can have symbolic power’ (Ibid.). Bourdieu believed that economic capital is at the root of all other capital.

The theory is considered useful as a framework for exploring how social relationships impact surveying educational systems. For example, the framework will help to show how the capitals of one field impact the other field. Seeing this as a social construction is not to say that the ‘products’ are not real but it recognises that how students and graduates are viewed in the wider surveying community is contingent on the social arrangements that exist within the field of education and the field of professional practice. Furthermore, the relationships between the agents within the field of education and also the interactions between the field of education and the professional field say much about the nature, directional course and impact of educational programmes. The nature of these relationships influences how students/graduates are perceived in regard to readiness for the modern job market. Considerations of these theoretical concepts, in this study, offer a yet to be explored perspective on the nature and impact of the surveying education field.

Bourdieu had an interest in the dynamics involved in power relations in social life. He believed that *capital* results from those values that are held by dominant agents or group of agents within a *field*. When *habitus* is aligned with *field* there is a sense of harmony that Bourdieu (1984) described as *doxa*. According to Bourdieu (1984) *doxa* is 'where the natural and the social world appears as self-evident' (p.164). The relationship between habitus and capital is therefore reciprocal, whereby dominant dispositions tend to form capital. The dominant group within the *field* of surveying education will thus largely determine *capital*. As a theoretical frame, these notions help in looking at the nature and possible impact of the social relationships that exists within the field. In other words, there is an interest in coming to an understanding of the nature of surveying education from different forms of social arrangements (curriculum architecture and pedagogical approaches). Concepts from Field theory offer a framework to consider the *agents* (represented by the range of participants) and their *habitus* (dispositions and roles) in the *field* (surveying education) along with the social *capitals* (educational and professional values) involved.

Since *capital* is inherited from the past (Bourdieu, 1997) the historical perspectives given in Chapter 2 is of relevance to the framework. Furthermore, within field theory, history is seen as a primary determinant of nature. This framework will also help in exploring possible influences of the history of surveying and surveying education on the contemporary systems within the various contexts. ***Figures 8 and 9*** illustrate how the identified theoretical concepts help to map two layers of influence in surveying education systems. The notes below describe the various elements of the framework:

Figure 8 : Illustration of theoretical concepts



Each of the three primary agents represented by a circle within the *field*, has particular dispositions and play particular roles that help to determine the direction and impact of the *field* (educational system). The *habitus* of each of these *agents* will be considered to determine the strength of their influence on the *field* within each case context. A focus on the *habitus* of the academic staff is specifically concerned with coming to an understanding of their roles and functions, the nature of their relationship with students and with the surveying profession, as well as the challenges they perceive themselves to have in the execution of their academic duties. The concept of *habitus* offered one way of looking at the learners' cultural identities and to consider the nature of the impact this has on professional preparation. This concept also helped to frame the discussions of the roles of students within the in-depth case studies. In this regard, learners' general dispositions to learning responsibilities, motivations, fears and other aspects that emerge from the data are looked at. The sections in the diagram where two shaded patterns meet are the overlaps between the *agents' habitus* and represent the relationships between the various *agents* that impact and determine curriculum and pedagogical decisions. These will be considered in defining the nature of the curricular and pedagogical arrangements within the two distinct cases. The intersection of all three circles represents the core of activities within the *field* or the *capital* features that primarily influence the course and direction of the educational system and ultimately determine the nature of the product (graduates). The overlaps of the circles are arranged disproportionately as it is assumed that within the *field* there is predominantly a relationship between the students and the academic staff and to a lesser extent between staff and industry and even less so between industry and students. However, it is expected that these relationships will manifest in different ways for each case, since their curriculum and pedagogical arrangements are different. Furthermore, there are differences related to national, education and professional contexts.

Furthermore, the field concept allows for the simultaneous consideration of views from the field of education and the field of professional practice. Since professional education in any discipline is concerned with how effectively the educational programme prepares individuals for work, considering the interactions between these fields is of significant relevance to the study. Grenfell and James' (1998) use of overlapping concentric circles (representing overlapping fields) allow for this desired simultaneous examination of the related fields. This aspect of the theoretical modelling, together with the first (**Figure 8**) contributed ultimately to the proposed improved educational model for contemporary surveying/geomatics.

Three groups of agents are seen as involved in determining the course of professional surveying education- university, practicing surveyors as employers and accrediting bodies. As an adaptation to Grenfell and James' (1998) use of Bourdieu's theory, I consider the influence of primary agencies/agents in the wider surveying education field by theorising them as overlapping fields with various layers of influence. This framework allows for the analysis of data from the three target groups in coming to understandings of the complex relationships within the studied phenomenon. **Figure 9** illustrates the inter-related fields and the various levels of influence within each field. Furthermore, a level of analysis that considers the pedagogical arrangements within surveying programmes is illustrated in **Figure 10**. This latter layer of analysis examines the dispositions (habitus) of the agents within the field. Such characteristics such as the educational and work experiences of students, the research or teaching focus of the academic staff, and the level of involvement by the profession are considered.

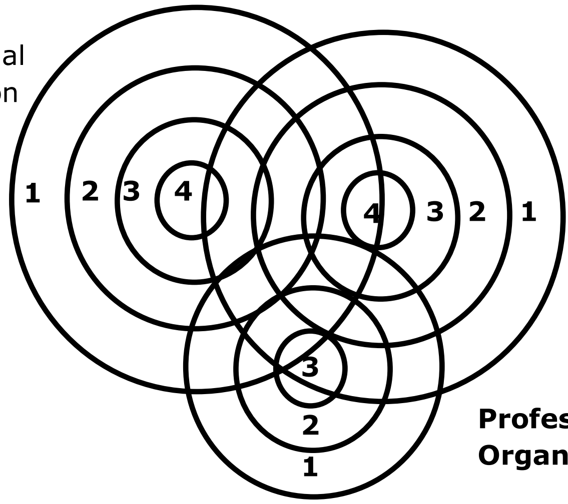
Figure 9: Inter-related fields in surveying education – university & profession (adapted from Grenfell and James, 1998)

Professional Practice

1. Historical Practice
2. Technological Influence
3. Contemporary Practice
4. Professional Projections

University Programme

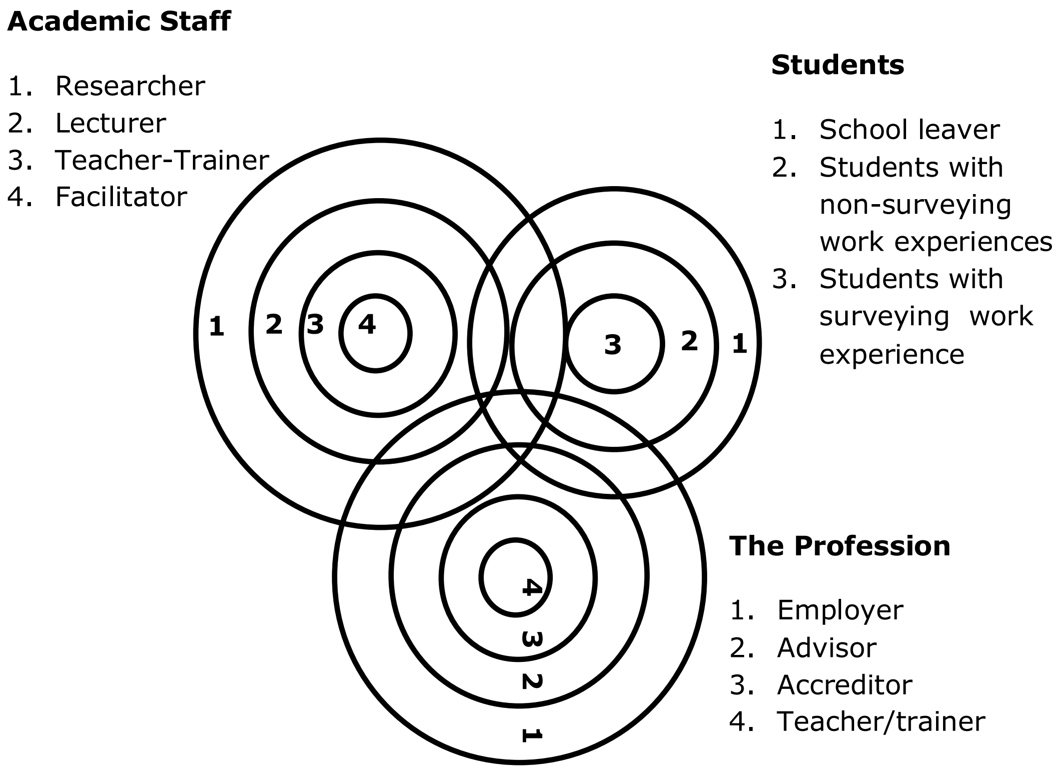
1. University type
2. Curriculum
3. Pedagogy
4. Professional Preparation



Professional Organisations

1. International Professional Groups
2. National Professional Groups
3. Accrediting Bodies

Figure 10: Inter-relating fields in surveying pedagogy



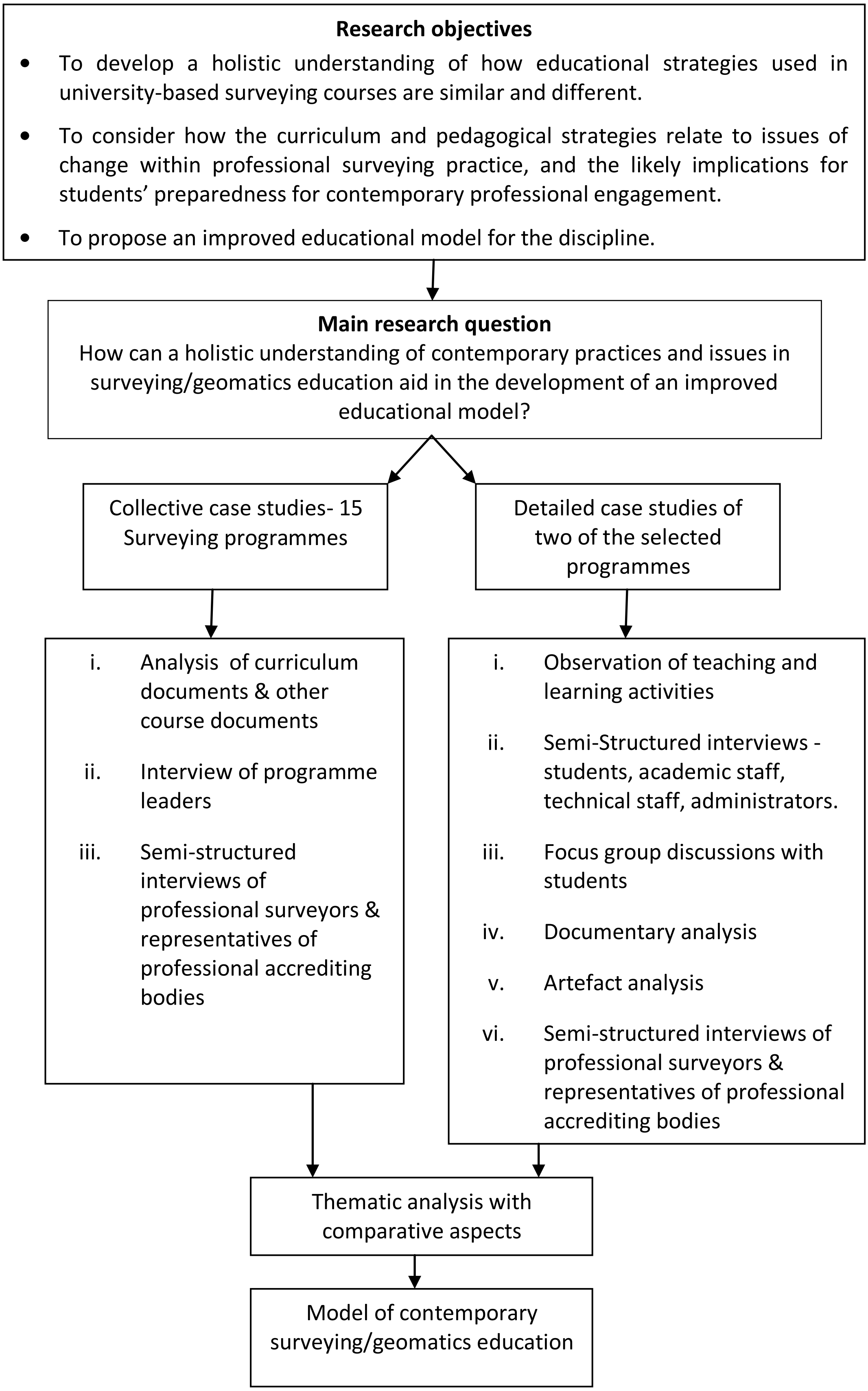
It is critical to point out that the interactions between fields are an important element of the study. Having discussed a theoretical framework for the study, a discussion of the research design follows.

4.3 Research design

An inductive approach was adopted for the study to tap into issues that currently impact surveying education without being constrained by preconceptions arising from personal experiences and opinions, and those suggested by previous researches. It is important to restate the general objective of the study here to help make clearer the connections between objectives and design. The study's objectives were to develop a holistic understanding of the nature of university-based surveying education and to consider how this field is impacted by key issues that emerge from the data. More specifically, the study aimed to: firstly, develop an understanding of how university-surveying courses differ relatively; secondly, consider how differences in curricula and pedagogical approaches used within these courses relate to the issue of change in the profession as well as issues related to student-preparedness for professional engagement; and thirdly, to explore whether a model of contemporary surveying education can be proposed in light of the findings of the study.

With this in mind, two primary methods were employed for the study. Firstly, a relatively extensive multi-case case study of surveying curricula from a wide range of geographical contexts was conducted. This allowed for a general mapping of a fairly extensive group of surveying programmes which facilitated comparisons of particular features which are elaborated on later in this chapter. This provided a breadth of understanding about contemporary practice within surveying education. Secondly, the study utilised two in-depth case studies for investigating deeper curriculum and pedagogical issues within the field. The criteria used for selecting the fifteen curricula for the wider study and the two in-depth case studies are discussed later in this chapter. The overall research design is illustrated in **Figure 11,** flowing from the study's general objective at the first level to the two primary strategies, then unto multiple enquiry methods followed by thematic analyses.

Figure 11: Illustration of research design



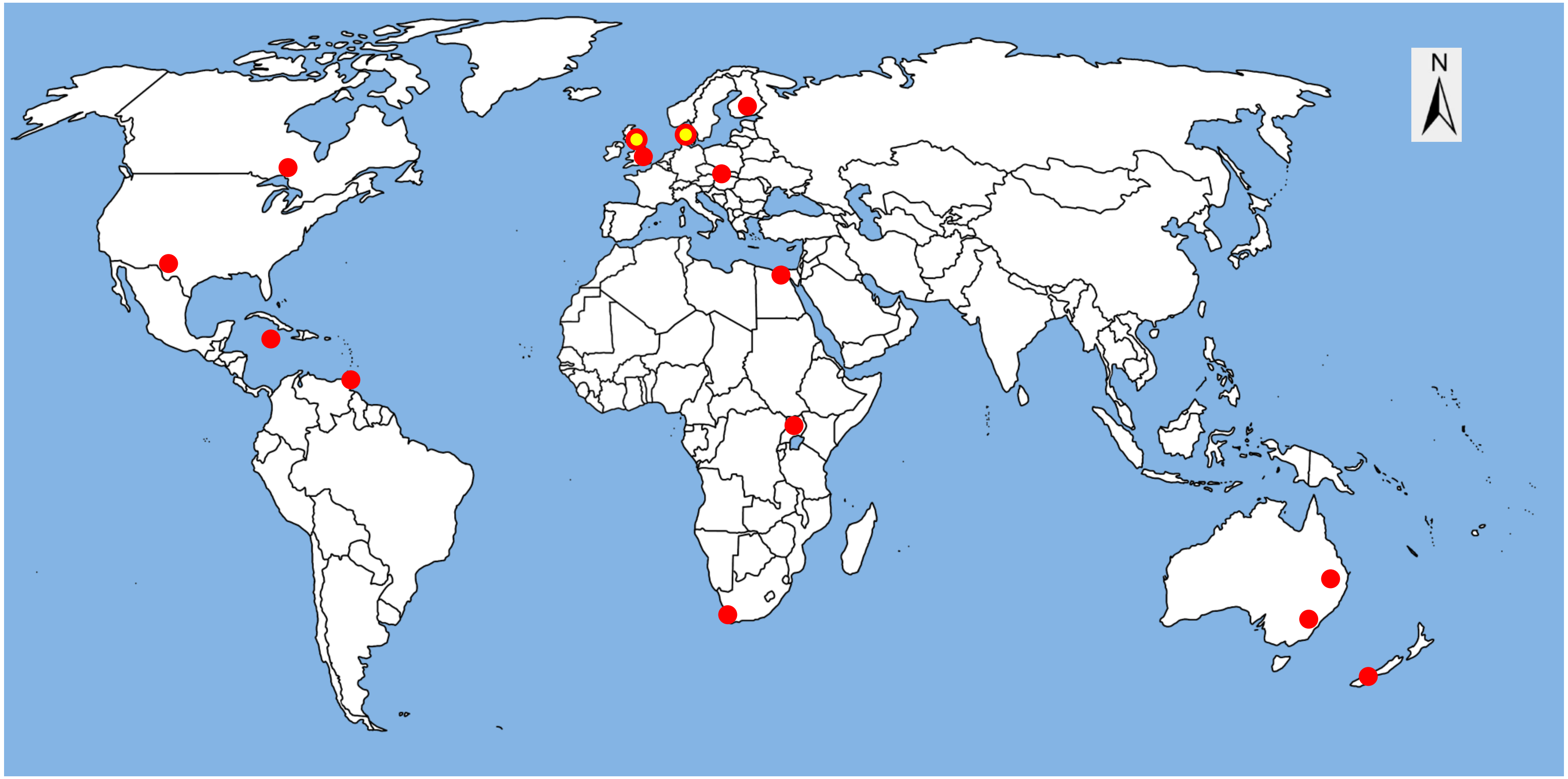
4.4 Rationale for selection of sample programmes

The surveying/geomatics programmes were chosen to represent a diverse mix based on geography, history, student composition, curriculum design and accreditation status. Many of the selections were facilitated through links with the International Federation of Surveyors (FIG) - an organisation with keen interest in the development of the discipline worldwide.

Of the five UN designated continental regions of the world (UN Statistics Division, 2011), four are represented in this study. The fifteen programmes are from thirteen countries (see **Figure 12**) and represent a broad spectrum of features that afford a useful basis on which to explore surveying educational models used within different contexts. **Table 5** illustrates the universities' geographical locations and some reasons considered to be salient to the selection of each programme. With this fairly large dataset, issues of educational strategies and their impact on professional preparation were explored with various layers of analyses.

Initially, online research was carried out to locate surveying programmes that may have some prominence in the countries or regions in which they are based. Prominence, in this regard, was based on the relevance of the programmes to professional requirements within prescribed geographical zones, their links with professional associations such as the FIG, and their scope of influence in terms of student access. The initial information gathered was obtained from printed and online documentation from the universities that outlined the courses offered and other matters pertaining to the programmes and the surveying profession in the respective countries. Of the fifteen surveying programmes in the study, each represents the academic requirement necessary for professional certification. These academic qualifications have relevance to systems of professional qualifications within local or national and some regional jurisdictions.

Figure 12: World map showing geographical locations of sample programmes



MAP NOT TO SCALE

Source: http://vectorya.com/freevectors/art-designs/free-vector-world-map/

KEY

Country location of sample programme

Country location of case study programme

Table 5: Selection of sample programmes

University	Location	Key Reasons for Inclusion in Study
1. University of Aalborg (AAU) *	Europe - Denmark	Curriculum innovation and strong links with the international representation of the profession.
2. University of West Hungary (UWH)	Europe - Hungary	Close links with the international professional body. Traditional European programme influenced by Bologna Agreement.
3. Aalto University (AU)	Europe - Finland	Has features unique to the country based on the nature of the profession there.
4. Newcastle University (NU)*	Europe – England	Largest UK and only RICS accredited programme and ease of access. Represents a good example of a traditional programme.
5. University of East London (UEL)	Europe – England	Only other UK programme and ease of access.
6. New Mexico State University (NMSU)	N. America - USA	Traditional North American programme and key links with FIG Education Commission
7. University of New Brunswick (UNB)	N. America -Canada	Historical role in the development of and use of the term Geomatics. One of the largest and oldest North American Surveying programmes.
8. Otago University (OU)	Oceania - New Zealand	Only surveying programme in New Zealand
9. University of New South Wales (UNSW)	Oceania - Australia	Prior knowledge of progamme. Long established programme with international outreach.
10. University of Southern Queensland (USQ)	Oceania - Australia	Curriculum innovation with distance programme. Has an enrolment emphasis that is different from the others in the sample.
11. University of Technology, Jamaica (UTJ)	Caribbean – Jamaica	Relevance to the researcher's personal experiences and future work.
12. University of the West Indies	Caribbean – Trinidad & Tobago	Provides a balanced perspective on the Caribbean context and also important to researcher's future work.
13. Makerere University (MU)	Africa – Uganda	For large developing country perspective from a large content.
14. Benha University (BU)	Africa – Egypt	To reduce broad generalizations about a large continent and to examine an African perspective from one of its more developed countries.
15. Cape Peninsula University of Technology (CPUT)	Africa South Africa	A Southern Africa perspective having looked at one in the central region and another in the northern.

* in-depth case-study

The programmes' geographical locations and their scope of influence (significance within their country or region) are diverse and provided a useful foreground for discussing the themes that emerged from the data.

4.4.1 Geographical locations & implications for surveying education

The locations of the fifteen sample programmes are shown on the thematic world map (**Figure 12**). Of the 15 programmes two were based in England, three in mainland Europe, two in the Caribbean, two in North America, three in Africa and three in Oceania. **Table 5** identifies the specific universities used as sample programmes for the study and the countries in which they exist.

Language was one factor that was considered in determining the sample for the study. It was not taken for granted that communicating with participants from non-English speaking countries would be unproblematic. This is not to say that communicating with individuals with English as their first language would be without challenges, since obtaining data from human subjects can yield multiple layers of perceptions that can be difficult to decipher. Hence, for all interviewees, the interviewing process involved respondents' verification of my interpretation of their responses. It was against this premise, that it was considered important to take this reflexive approach during the interviews since I recognised that:

> interviews are social encounters and not simply passive means of gaining information. Clarification is not only a practical, but also an ethical and theoretical consideration' (May, 2001, pp. 128-129).

Language is one way of exploring connections between programmes. All but four of the programmes are in countries where the official language is English and the courses are delivered in English. The other three programmes are delivered in the official languages of their countries, Danish, Finnish, Hungarian and Arabic (Denmark, Finland, Hungary and Egypt respectively). Some links have been identified between former British colonies and Britain; even so, it is also important to consider the impact of that historic link and the nature of the social relationships that may still exist. Europe is represented in the study by four programmes and three languages. The literature has shown that Western European countries have investigated possibilities of harmonising the education and practice of surveyors (Allan, 1995). Within this geographical space, language is identified as only one of several diversities which render harmonisation of surveying education and practice a problematic venture.

Three countries and two languages represent the African content: Egypt in the North, Uganda in the central regions and South African in the south. The historical account has shown that surveying practice and education have diverse expressions in Africa as they do in Europe. From the perspective of Egypt's prominent role in ancient surveying, it was interesting to explore contemporary surveying education in that country as well as others on the African Continent. With their surveying programme starting in 1990 (Musinguzi, 2009), the University of Makerere in Uganda is the youngest surveying programme in the study. Cape Peninsula University in South Africa is the only university in the study that does not offer the highest qualification for surveyors in its country. It does, however, offer a degree that qualifies graduates as a specified type of professional surveyor. This will be further discussed later but is mentioned here to show the diverse representation of surveying education in Africa.

The Americas are represented by one university in Canada, one in the USA, and two in the Caribbean. Canada and the USA are vast countries relative to the Caribbean islands represented (Jamaica, and Trinidad and Tobago). Not only is the practice of surveying diverse amongst these countries, they are also diverse within the larger countries. Considering the fifty states of the USA, the study includes only a small representation of the diversity in surveying education in that country. The same is true for Canada but to a lesser extent since Canada has less political jurisdictions than the USA. Of significant importance is the consideration of political jurisdictions, since surveys, particularly cadastral, typically have stringent legal frameworks which are a dominant influence on surveying courses. The two Caribbean programmes included in the study are the only surveying degree programmes currently being offered in the Anglophone Caribbean. Thus, this region has a strong representation in this study.

Oceania is represented by two universities in its two largest countries, Australia and New Zealand. Having these countries in the study extends the reach of the study from the far North to the far South. The programmes in the study from the Oceania region include the only degree level surveying course offered in New Zealand but only a percentage of those offered in Australia. The countries, however, have reciprocal arrangements regarding qualification for surveyors (Coutts, 2011). This means that academic qualification in surveying in one country is acceptable for professional engagement in the other.

Though not all parts of the world are included in the study, the geographical reach in regards to surveying education is extensive. The diversity in this regard afforded a rich field for exploring contemporary surveying education.

4.4.2 Scope of influence of surveying programmes

Scope of influence refers to the reach of the surveying/geomatics programme in regards to numbers of students enrolled as well as students' geographical origins. Of equal importance is where students find employment after graduation. Looking at scope in these senses helps in coming to a clearer understanding of the impact these programmes have on the profession within their national contexts.

In England, surveying/geomatics education at the undergraduate level is offered in two universities and both are included in this study. This offers good scope for England but extends even further, as both programmes recruit students from other countries. , The University of East London, in particular, has attracted a large proportion of international students since its early days as the North East London Polytechnic (Allan, Haugh et al., 2008). Allan et al., (Ibid) note that from as far back as 1971 the institution had students from thirty two countries. Five of the listed countries are represented in this study (Australia, Jamaica, New Zealand, Trinidad & Tobago and Uganda). UEL's programme document asserts that the programme continues to attract students from other countries, which suggests that its scope of influence still extends beyond England.

The importation of UEL-styled surveying education is one possible outcome of having a significant proportion of surveying academics within a country receiving their education at UEL. As an example, four of the current seven fulltime lecturers at the University of Technology, Jamaica were educated at North East London Polytechnic, now UEL (UTJ SGIS Self Study, 2009). Many of the teaching and learning activities observed on a visit to UEL were reminiscent of methods employed by my UTJ UEL-educated lecturers during my tenure as a student at UTJ. This resonates with research findings that university lecturers tend to teach the way they were taught (e.g. Dutton, Cheong et al., 2004) and from my own experience, also what they were taught. This practice can contribute to the transferring of *capital* (values and cultural practices) not just in teaching methods but also in knowledge and skills emphases. This transfer of values has some resonance with what has been described as a Eurocentric dominance in higher education (for example, Selvaratnam, 1988). In the UEL-UTJ example, the social influence extends even further. The College of Arts, Science and Technology (now UTJ), has traditionally attracted a large proportion of students from other Caribbean countries (UTJ, 2009). The UEL surveying education *culture*, therefore, not only impacts Jamaican surveying students but also students from other Caribbean countries on this secondary level. Since knowledge exchange occurs through social interactions of shared norms and values (Nahapiet & Ghoshal, 1998), the knowledge exchange process also involves the transfer of values.

Of the 2500 international students enrolled in Newcastle University in 2010 (ceg.ncl.ac.uk/info/), the Geomatics programme had only a small number of European students and generally does not attract a wider diversity of international students (NU Geomatics Programme Leader)as does UEL. However, in regard to local students, NU's surveying programme may have greater strength in the *cultural capital* of RICS accreditation. However, there is at least one similarity in regards to professional accreditation as a feature of *capital*. Both universities' programmes are accredited by the Institute of Civil Engineering Surveyors. The student numbers in both universities are comparable with a current total population of between 120 and 125 students in each programme. Both English universities perceive that graduates from surveying/geomatics programmes have skills that are sought after in the public and private sectors; thus, the development of marketable skills is presented as a prominent value (UEL and NU programme documents, 2009).

The University of Western Hungary (UWH) is one of two universities offering surveying courses in Hungary (Programme Leader, 2009). The UWH programme leader explains that surveying remains a popular option; which can be seen in the over 200 students that are enrolled in their surveying programme. This university targets students for education in the more practical aspects of surveying to fill a range of jobs in the public and private sectors. The University's official website (http://www.uniwest.hu) notes that its Faculty of Geoniformatics enjoys good relations with public and private sector organisations involved in a wide range of operations relating to surveying.

The Aalto University's official website (www.aalto.fi/en/) claims that its surveying programme provides the highest level of education for surveying Sciences in Finland. Lower level institutions, called universities of applied sciences, offer training for surveying technicians. AU's programme documents state that it is the only comprehensive university unit for surveying in that country. The department offers degrees in Geomatics and Real Estate Economics at both the undergraduate and postgraduate levels, and coordinates a national graduate school on Real Estate, Building and Design, a joint school for five Finnish universities (AU, 2010). The surveying programme has an annual intake of between 70 and 90 students (Vitikainen, 2007). Vitikainen (2007) states that interest in surveying has declined over the years and the University, along with the profession, have embarked on a marketing venture to improve the situation. The National Land Survey of Finland employs the majority of the graduates from the surveying programmes (Vitikainen, 2007). With over 340 municipalities and a National Land Surveys Department with a staff of over 2000, Aalto graduates have good job prospects in the public sector (AU website). It is important to note that this university has an external reach as at the time of the research 60 overseas students were enrolled (Aalto academic, 2011).

The three universities in Africa service a wide cross-section of the surveying and construction industries in each country. Senior academics within the surveying programmes at each of these universities provided the accounts related here. Benha University is not the only university offering surveying degree courses in Egypt. The university typically has between 100 and 150 students graduating from the undergraduate surveying programme annually. Graduates typically find employment in public and private surveying and construction related firms in Egypt and other countries in the Arabian region. Makerere University is one of three universities offering a degree in surveying in Uganda. Student-intake at Makerere has experienced growth in recent years and is currently at 60 students annually. Many of the graduates from the programme work with private surveyors doing cadastral work; but in recent years, they have mostly found jobs with engineering projects.

Cape Peninsula University of Technology (CPUT) in South Africa offers a three-year diploma programme in surveying that is upgradable to a Bachelor of Technology degree (BTech) with one additional year of study. Three other universities in that country offer similar BTech degrees. Graduates from the CPUT degree programme may obtain registration for certain specified surveying functions, but not as professional land surveyors who are certified to do cadastral surveys (legal boundary surveys). A surveying degree programme with a different focus offered by two other South African universities is required to qualify for certification as cadastral surveyors. The CPUT programme document (CPUT, 2010) states that its programmes prepare graduates to fill positions in public departments and private sector surveying firms as surveying technicians (diploma graduates) and as topographical and engineering surveyors (BTech graduates). The programme currently enrols 40 students annually, which according to its programme document (CPUT, 2010), represents a 100% increase in enrolment compared to five years earlier.

The Australian and New Zealand programmes in this study represent a significant proportion of the surveying education landscape in the Oceania region. Otago University holds a unique position as it is the only university in New Zealand that offers degree courses in surveying. This fact may be one of the reasons that Otago University enjoys a consistent flow of relatively large number of students into its surveying programme (Hannah, 2006). Hannah also mentions the contrasting trend of general diminishing numbers entering the surveying programmes in Australia. To mitigate this trend, UNSW has sought to increase student enrolment in its surveying and spatial information sciences (SSIS) courses to fill diverse positions in the land, building and construction industries and emerging industries that deal with spatial information (UNSW SSIS programme director). University of Southern Queensland's (USQ) surveying programme is unique in the sense that it has a focus on distance education targeting persons already employed to the surveying industry. The majority of these distance students require educational upgrade to qualify for professional certification in Australia (USQ academic).

The discussion has shown that geographical locations of programmes, enrolment patterns and links with the surveying industry were factors considered for selecting the fifteen programmes in the study. Two of these programmes were selected for more in-depth case studies. The reason for the case studies and the criteria for their selection are next outlined.

4.5.1 Criteria for case study selections

The selections of the case studies were given much consideration because, as Yin (2009) maintains, the greatest understandings of the critical phenomena being studied depends on choosing the case(s) well. The preliminary review of surveying curricula (mentioned earlier), presented some evidence of significant content changes within surveying courses and a variety of curriculum patterns in various universities around the world. There were also interesting variations in specializations ranging from highly specialised single majors to surveying/geomatics mixed with more liberal education. Most of the programmes appeared to use traditional pedagogical approaches with limited innovations in certain subject areas. The level of pedagogical and curriculum innovations was therefore one criteria used in the process of selecting cases; the prominence of the programme in local and international contexts was another; and also the geographical location of the programme (for reason of practicality).

The geomatics programme at Newcastle University and the chartered surveying programme at Aalborg University were selected for in-depth case studies. These were considered to be distinct in their curriculum and pedagogical designs and so offered good contrasts in those respects. There were other features that distinguished these courses from each other and contributed to their selection for the case studies. Further details supporting the selection of NU and AAU are provided at the end of Chapter 5 as an introduction to the in-depth case analyses in Chapters 6 and 7.

The data collection methods used within each of the two research approaches will be discussed in the following section.

4.6 Data collection methods

The methods employed for data collection were based on a desire to arrive at a clear understanding of the cases in the multi-case study. Using multiple data collection methods enabled data triangulation and facilitated rich interpretations. They included written and published documents, internet published information, interview responses from a range of stakeholders and at the deeper level observations of teaching and learning activities. Since there were some differences in how the two layers of investigation were approached for data collection, they will be discussed separately.

4.6.1 Data collection for collective cases

Data regarding the design of the courses were primarily obtained from curriculum documents and supporting course documents. In most cases official hardcopy documents were obtained from the universities. In some cases very detailed course information was available online from the universities official websites. It was not taken for granted that the textual information obtained from these documents fully or accurately represented the architectures of the programmes being studied. Furthermore, it was not assumed that the researcher's interpretations of documents would be reliable representations of the authors' intentions or the actual nature of the social structures being investigated. May (2001) cautions that if we read the accounts of a document, separate from the methods we employ to achieve this; we may suggest that social facts exist independently of interpretation. In the use of data from documents, I was always conscious that there were particular intentions present with the authors of the documents that may not be immediately evident to me. These data were, therefore, treated as secondary, thus warranting verification through data triangulation.

The initial analyses of the curriculum documents were, therefore, followed up by interviews (30-60 minutes) of programme directors or other senior academics within each programme. A few interviews were done face to face but the majority were done using Skype. The semi-structured interviews served two main roles: (1) to verify the researcher's interpretations of the studied documents; and (2) to explore underlying, perhaps hidden, reasons for the decisions taken regarding the surveying programmes. A schedule was used as a guiding frame for the semi-structured interviews. Having a common schedule allowed for consistency in the interviews for all fifteen programmes. The semi-structured nature of the interview questions conformed to broad issues and facilitated flexibility in the line of questioning. This flexibility gave the respondents room to dwell on those issues that they knew to be important to an understanding of their programme. The interview schedule was a framework within which a wide range of questions could be entertained with a level of control that ensured that the issues explored bore some similarities and so could be legitimately compared. The main issues in the interview scheduled were:

- The nature of the surveying profession in the country or region in which the programme is located. This sought for a description of role of surveyors and the impact of change in the discipline within the various country and regional contexts.

- The nature of surveying education in the country of selected programme with particular focus on curriculum design and content and pedagogical approaches employed.

- The relationship between the University and the surveying profession.

- The perceived future of the surveying/geomatics profession and the role of university-based education in this.

A sample of the interview schedule is included in Appendix A

Since the courses being investigated are profession-based, it was considered important to include the perspectives of representatives of professional accrediting bodies. In this case, there are two international bodies that offer some recognition to surveying programmes – the RICS and the FIG. As with the programme directors, the interviews of representatives of the RICS and the FIG were done using a semi-structured interview schedule (See Appendix B). Documentation from both organisations was also used to provide data regarding the role and functions of these organisations in relations to the surveying programmes studied.

4.6.2 Enquiry methods for in-depth case studies

For deeper and richer accounts of surveying courses, multiple enquiry methods were employed within the two in-depth case studies. Specifically, the enquiry methods sought to understand how the students and academic staff negotiate the complex mix of generic and transferable skills development along with the technical and vocational components required of surveying graduates. Data were, therefore, obtained through observation of teaching and learning activities as well as interviews of staff and students, as well as focus group discussions with students. Since surveying courses are profession-based, the study was also interested in understanding the nature of the influence the profession has on the educational programmes and vice versa. The views of representatives of the surveying profession in each case study site were, therefore, sought through semi-structured interviews. The interviews explored their perspectives on the impact and the relevance of educational programmes to the surveying profession. These interviews also allowed for an exploration of how members of the profession perceive the development of the profession during this period of change.

For the in-depth case studies, specific areas were investigated using the following approaches:

- The roles of the learner and the instructor were explored through observations of teaching and learning activities and semi-structured interviews of academics, students and programme administrators. This was also considered from a design perspective as presented in the official curriculum documentation with supporting information from an interview with the programme leader.
- The role of the surveying profession in curriculum development is explored through semi-structured interviews of F.I.G. and R.I.C.S. representatives and professional surveyors in each of the two countries represented.
- The role of the institution (university) was also considered in terms of institutional policy and aspects of the educational and professional culture. This was seen as important for contextualizing the findings. This also provided a basis to explore how change in the educational programme has been managed.
- Finally, other tangible evidence was sought out that could help in coming to understandings of the quality of student learning. Student-produced artefacts, such as terrain models, survey data analyses, maps and technical reports, were viewed and questions asked about them. Intangible evidence such as critical thinking and spatial management skills was investigated through the triangulation of data from interviews of students, instructors and employers of the graduates.

4.6.2.1 Case study protocol

Establishing a protocol for the case study component of the research was important, for ensuring consistency in the approach used within the two sites and to enhance the reliability of the case study aspect of the research (Yin, 2009). The importance of this was further reinforced by the decision to do a comparative analysis of the findings from both case studies. This meant that it was particularly important that there were similar approaches in how the investigation was conducted at both case study sites. The case study protocol gave detailed consideration to the procedure to be followed, general rules, instruments to be used, list of participants, activities to be observed and the questions that guided the enquiry within the case studies. The protocol followed for both in-depth case studies is included in Appendix D. As is typical of qualitative research, the data collection experience is unlikely to turnout exactly as planned (Stebbins, 2001). Appendices E & F outline the actual observed data which show an inconsistent number of interviews with the various stakeholders within each site. However, there were respondents representing all the categories of interest, excepting in the AAU case where students in their ninth semester were unavailable, as they were all away from the campus on their internship attachment. As shown in the tables (appendices E & F), a large amount of data was collected that allowed for a holistic interpretation of each case study. Though the protocol provided a framework for similarity in the data collection, there were still some variations in the number of interviews and number of focus group discussions. The differences were primarily due to the differences in the pedagogical approaches employed within each case study site. The predominance of learner-led small group activities within the AAU programme dictated closer investigation into the nature of that aspect of the pedagogy. Within NU's more conventional pedagogical setting, a greater amount of the teaching and learning activities observed were more lecturer-centred. These distinctions between the two case studies are further elaborated in the case reports, particularly in Chapter 7 which takes a more comparative approach.

The case study investigations were guided by questions related to the research aims. The sample of questions shown here represents the essence of the line on enquiry:

1. How is the course designed?
2. What is the underlying philosophy of the educational model?
3. What are the roles of the students, academic staff, administrators and the profession in the educational model?
4. How do students, academic staff, senior administrators and the profession perceive the impact of the educational model on learners and the implications for the surveying profession?
5. What pedagogical approaches are used and how are they perceived by the mentioned stakeholders?
6. What are the goals of the curriculum and how do the pedagogies reflect these goals?

The questions were used as a guiding frame; but in most cases, were not asked directly to avoid coercing respondents into focusing on areas that interest the researcher rather than those that they perceive to be most important about their courses. While there were areas of particular interest relating to both curriculum and pedagogy, there was an awareness that the study is primarily explorative and that room should to be given to 'surprises'. That is, respondents were asked questions such as: *What would you say are the significant elements of this programme and why do you say they are significant? If you could change anything about this course, what would it be and why?* Responses to questions, such as these, shed much light on issues and tensions that may have been missed if a more structured line of questioning were followed.

4.6.3 Pilot study- testing & developing enquiry techniques

Since the primary research data were collected by the researcher, it was considered necessary to test the planned data collection techniques before embarking on the actual field study. It was, therefore, decided that a pilot study would be helpful for the following reasons: to assess the appropriateness of the data collection methods (interviews, observations and focus groups) selected for the study; to develop confidence in regards to interacting with participants; and to identify areas of weakness and strength in the techniques used. The strategy adopted was to critically reflect on each interview before moving on to the next. This reflection included transcribing the interview, listening several times to the audio tape and getting feedback from the interviewee for their impressions of the effectiveness of the interview; all of which were critical components that aided me in meeting my objectives. This process facilitated the improvement of questioning and gate-keeping techniques that kept the discussion within the bounds of the research interest without overly constraining the participants from expressing what they perceived to be most relevant in a study of this nature. I identified, as an area of strength that I was able to draw on my experience as an academic in my interactions with other academics. This created what appeared to me to be a relaxed atmosphere that allowed the participants to freely disclose perceptions and opinions without fear of reprisals. The academics who were interviewed in this pilot were all experienced researchers some of whom have conducted research that adopted research strategies I employed. My preoccupation with covering issues that I presumed to be important was identified as a potential weakness, as it could limit the participant in focussing on issues they considered most relevant to the broad area outlined by me. From this type of feedback, I was able to make useful adjustments to the semi-structured questions I took into interviews and had an enhanced ability to provide guidelines for discussion while listening for key and relevant issues raised during the interview.

The pilot involved half-hour interviews of university academic and administrative staff and students. The academics interviewed included two surveying academics from the University of Nottingham (UoN), one surveying academic from Newcastle University (one of the case study sites); three UoN senior academics involved in both research and administration in civil engineering, economics and general academic programmes in the university. It also involved observations of teaching and learning activities in civil engineering surveying lecturers and field work as well as the application of problem-based learning (PBL) by students at two levels in UoN's graduate entry medical programme. The observations of the PBL sessions were followed up by focus group discussions with the students and interviews with the PBL facilitators.

Additionally, two students from the observed surveying classes in civil engineering were interviewed after their lecture.

Even though my experience as a surveying lecturer has allowed me many opportunities to observe students in both classroom and field settings, I perceived that my current research interest required different observational skills than that of a teacher. With this in mind, I was able to assess and develop my observational skills during a one week field surveying course that I attended during the first year of my study.

The pilot exercises reinforced my perspective as it relates to how profession-oriented education is organised and developed. This process has helped to show that within academic specialisations, there is a range of influencing factors. An understanding of how the education programme functions and the impact it has on the profession, is seen to be most effectively done by understanding who the key stakeholders are. Also of importance is giving consideration to the roles played by these stakeholders within a professional education programme.

The pilot study was an important component of the study that helped to create a reliable structure within which the study could be conducted. As discussed, it provided valuable information that was useful in enhancing the rigour of the data collection. Another important aspects of the study were the ethical considerations given to protect the research subjects. This is discussed in the following section.

4.7 Ethical considerations

Important to social research is the acknowledgement that the research subjects are real people involved in authentic social systems and should be protected from harm (Bogdan and Biklen, 1992) that may result from the study. The important issues of informed consent, confidentiality and consequences as outlined by Kvale (1996) were carefully considered in the design of this study.

The human participants in this study included university students and staff (academic and administrative), and representatives of the surveying profession. The views of students and staff were solicited regarding the nature and impact of the educational system within their universities. Surveying professionals were asked to state their opinions about the impact of the universities' programmes in the preparation of students for the profession. Hence, consideration was given to the likely effect participants' responses may have on stakeholders of the universities and the profession.

To ensure that all ethical procedures were followed the study plan was submitted to the Research Ethics Committee (REC) in the School of Education, the University of Nottingham and after review, approval was granted to proceed with the study within the guidelines indicated in the plan. The REC operates in accordance with the Research Ethics Framework (ESRC) and BERA's Revised Ethical Guidelines for Ethical Research (2004) principles. Data collection only proceeded after careful consideration of potential harm to participants and other stakeholders as a result of the study. Being satisfied with the plan to guard against such potential harm, the REC granted ethical approval. The participating universities agreed to the terms as outlined by Nottingham University's REC through the informed consent of the representatives of those institutions.

To ensure that the principle of informed consent operated throughout the project, information sheets (Appendix C) were provided to all who participated in the study. It was made clear that: transcripts of recordings would be used for research purposes only; the identities of the participants would remain anonymous unless agreement is obtained from the interviewed person that authorises the use of either the names of the persons, their position held in the institution or the name of the institution; and confidentiality in the publication of findings by the researcher would be maintained as far as possible. It was acknowledged that dissemination may involve some risk of identification; which was clearly explained to participants. All data were stored securely with names of students, lecturers and university changed. Subsequent to data collection, it was considered useful to include the names of the universities to increase readability and coherency in the writing. Permission was obtained from all representatives of universities mentioned to publish their names in this thesis.

In an effort to reduce the perception of threat to the reputation of the universities being used in the in-depth case studies, I sought to obtain an understanding of the general culture in Denmark and the United Kingdom. Through a pilot study, I obtained some exposure to techniques for interviewing individuals within cultures that were broadly unfamiliar to me. It was important to show respect to the participants, and in so doing, mitigate the likely defensive stance of the staff and students who may desire to protect the image of their institution. My aims and methods were made transparent through the holding of briefing sessions with the participants. In these sessions, I reinforced the fact that my study was more about coming to an understanding of the educational processes rather than making a critical assessment. This was supported by inviting the universities and the profession to request access to the data and findings that referred specifically to their programmes and to the final thesis document upon completion of the study programme. Only two of the programme representatives indicated an interest in reviewing the aspects of the thesis that make direct mention of their programmes. Plus, respondent verifications were provided where required. During the analysis phase, it was decided to use alphanumeric codes to represent the quotations from programme representatives to maintain some amount of anonymity since there was no perceived benefit to disclosing full information. The codes 'PD#' or 'PR#' were used. Specific numbers were assigned to particular programme directors (PDs) or other programme representatives (PRs). These numbers helped to differentiate between respondents without revealing their institutions. In a few places it was considered helpful to specify the actual source (e.g. president of FIG) where it was believed to offer some strength to the argument. Moreover, permission was granted from all individuals who were identified.

Though described in a fairly linear pattern, the research process did not logically flow from research design to ethical considerations to data collection to data analyses. Rather, it was a reflexive process that moved between the various facets in numerous criss-crossing layers. Having discussed data collection strategies and ethical considerations, the next section will discuss the analytical framework used in the study.

4.8 Analytical framework - qualitative data analysis

The research findings resulted from a mix of data consisting of documents, interviews, observations and artefacts. As is typical of case study research, a substantial dataset was obtained from the multi-data sources within each case (Yin, 2009). During data collection, there was no desire to reduce the dataset since each new layer of enquiry provided a deeper pool of data from which to do the final selection. To make the analysis possible, there needed to be a systematic approach towards sifting through the voluminous data and targeting those aspects that would best lead to some useful findings. Since the study had a primarily explorative approach, there needed to be room for 'the data to speak' (Ospina, Dodge, et. al., 2008). That is, there needed to be allowance for surprises to emerge as well as room for the data to confirm what may already be known or assumed. There was a desire to find some way of describing the systems of surveying education in the various contexts with some emphasis on the relationships between the key 'players in this field' (using Bourdieu's metaphor).

Hence, I decided on an analytical approach that, like the data collection strategy, was multi-layered and that drew on information known to me as a practitioner, documentary evidence about each programme in the study and from interactions with individuals and groups of individuals who represented various aspects of the studied phenomenon. This complex processing of data involved moving in and out of analysing data from the various data source. This was deliberate as it provided for me a greater sense that I was drawing from the various sources for a more holistic outcome. This is an approach with features of what Denzin (2009) describes as interpretive interactionism in the sense that it weaves ideas from different sources to create a coherent interpretation of something complex. Furthermore, this analytical approach allowed for a simultaneous consideration of practice and theory.

In a real sense the analysis of the data was on-going throughout the research. This 'analytic induction' (Goetz and LeCompte, 1984, p. 179) meant that as data were collected, there was on-going speculation about what was being observed and reported. This led to further investigations and new questions in interviews.

Using key elements of interpretive interactionism allowed for careful and systematic analysis of the data, resulting in complex layers of meaning and interpretations of the findings beyond the superficial. This provided the basis upon which an illuminative and substantive account could be given of the studied phenomena. Notably, this analytical approach allowed for the exploration of themes, in order to interpret meaning and to generate rich depictions of the research settings (Cousin, 2008).

4.8.1 Thematic analysis

Close examination of the transcripts from the interviews of the fifteen programme representatives, along with examination of the curriculum documents from all the programmes indicated recurring issues that could usefully be represented under four major themes. These issues were used to guide a thematic analysis of the findings. As explained earlier, some Bourdieuian concepts were used to illustrate the relationship between various agents in the surveying education field. This helped to make distinctions that are primarily context-dependent.

The curriculum and other documents were carefully studied before interviews with the programme representatives. Some curriculum documents provided very detailed information that described the structure, aims and objectives of the courses. Some even provided information on pedagogical approaches used, assessment methods and other information associated with student and graduate experiences and opportunities. The less detailed documents offered lists of subjects within the courses and brief backgrounds to the programmes. Hence, the interviews with academics representing the latter group, involved more detailed questioning and probing concerning the curriculum structure and the pedagogical approaches adopted. The programme representatives, from the programmes with greater documented information, were interviewed on similar issues. However, with these interviewees, I was able to more quickly delve into deeper underlying issues that motivate or drive curriculum and pedagogical decisions. This meant that follow up interviews were less common with representatives from this group.

4.8.2 Extracting themes

A matrix of selected features from the programmes was constructed using seventeen fields initially. These included: Course Title(s), Qualification Pathways, Administrative Location, Duration of Course(s), Year Programme Started, Name Change (from-to), Basis for Professional Qualification, Matriculation Requirements, Core Modules, General Modules, Total Credits, Practical Component, Policy (Government) Influence, Lecturer Qualifications, Accreditation Status & Professional Affiliations. Some features were subsumed in others to enhance management of the data and this resulted in seven fields: Programme Offerings & Duration, Enrolment, History of Programme, Curriculum Type & Pedagogical Approaches, Resources (material and human), and Employment and Industry Links. See **Appendix G** for an extract of the matrix.

The curriculum documents provided most of the information needed to populate the fields in the matrix. Some issues of interest such as the impact of government policy on the surveying programmes were difficult to determine because the information was presented in different ways in the documents and omitted in others. Where policy was inferred, I did not make a decision on how to describe it until the interviews of programme leaders were conducted. The matrix, even with a few cells unpopulated, provided an effective way of looking at related features of the fifteen curricula together. This helped to show patterns of similarities and areas of wide variation.

In addition to the identified features of interests from the matrix, I was able to reflect on the interviews as a collective, since they all explored similar issues of curriculum and pedagogy, along with how these are perceived to relate to work in the modern surveying/geomatics industry. Particular questions sparked impassioned and detailed responses from many of the programme leaders and academics. The issues raised were flagged as possible themes for discussions. Questions in this category related to: (1) the structure of surveying curricula; (2) the relevance of surveying education to work; (3) pedagogical practices & innovations used in surveying programmes; (4) the issue of the geomatics paradigm and its implication for surveying work and education; and (5) conformity of educational strategies with others outside of indigenous cultures. From the above mentioned, four major themes emerged:

- **i.** Curriculum Architecture
- **ii.** Pedagogy
- **iii.** Geomatics Paradigm
- **iv.** Academic-Vocation Dichotomy

4.7.3 Approaches to analysing curriculum-related data

In analysing differences between the fifteen curricula, the architecture of the curricula in terms of the content composition was first discussed. These were initially explored based on the information from the curriculum documents, module outlines and syllabi. The findings were verified using data from the interview transcripts. This verification was important since similar module titles do not necessarily represent similar content composition nor do they necessarily have the same emphases. Also, modules may have different titles but represent the same content. Where syllabi and instructional plans were available it was fairly simple to judge the degree to which modules of similar titles were similar in content and focus. These were available for most programmes and so some degree of analysis was done on this basis. To illustrate how module titles can be deceptive, two quotations from the interview transcripts are included. Both quotations were made in response to a question about the specialisation focus of the curriculum relative to more generic subjects, and represent part of a wider investigation of the curriculum.

> *Mathematics has changed in the programmes to reduce the amount of perhaps the broader based mathematical theory to increase the emphasis on the mathematics on particular applied areas of surveying mathematics. Surveying mathematics is taught by a surveying lecturer.* [PD5]

> *We actually call it [the mathematics taught to surveying students] survey mathematics but all the students in the Faculty of Technology use the same engineering math book so they basically do the same Math. It really is not mathematics specific to surveying students.* [PR13]

These responses related to how mathematics is positioned within the surveying curricula. It was a strategic question, given that surveying is sometimes described as applied mathematics and that a good background in pre-university mathematics is desirable for entry into all the surveying programmes studied. Furthermore, the responses demonstrated the potential risk in making judgements about a curriculum based only on module titles and abbreviated module descriptions. Whereas one university's 'surveying mathematics' refers to specialised applied mathematics, taught by a surveying academic, the other used a similar title to represent a more generic mathematics.

The analysis of the architecture of the curricula in the two in-depth case studies was based on a framework derived from Hawkins and Graham (1994), who proposed that, if curriculum were to be the working out of a quality plan, then:

> …attention must be paid to its architecture, or the ordered arrangement of the parts of the system. The parts of the plan must include how teachers are deployed, what content will be called for, through what process, to which groups of students, for how long, and where they are in congruence with the values held in high esteem by the planners. (p. 44).

Within this aspect of the analysis, the curriculum content composition and process are firstly considered. Secondly, the analysis examines programme durations, followed by considerations of the implications of these aspects of the analysis for curriculum. The roles, responsibilities and dispositions (habitus) of the academic staff and students are explored under the separate, but related theme of pedagogy. For consistency with Hawkins and Graham's concept of curriculum architecture, consideration is also given to the degree to which the examined features are in congruence with the values of those held in high esteem by curriculum decision makers.

4.9 Summative statements

This chapter explained the connection between the various aspects of the study. Importantly, the relationship between the researcher's ontological stance and the chosen research methodology was established. This laid the foundation for explaining the enquiry methods and the analytical tools adopted. Data triangulation and the reflexive approach to managing the data and analyses are both considered to have enhanced the study's reliability. This is particularly so since data were obtained from multiple sources within each case, reinforced by a multi-layered analysis. The first level of analysis follows with a focus on the findings from the fifteen studied surveying courses.

CHAPTER FIVE
COLLECTIVE CASE STUDIES:
FIFTEEN SURVEYING/GEOMATICS PROGRAMMES

5.1 Introduction

In this chapter, the findings from the collective case study of fifteen surveying/geomatics programmes are presented in a thematic analysis using the four major themes described in the previous chapter. The presentation of the findings portrays issues that are impacting contemporary surveying education as presented by the empirical data. Furthermore, the findings are aimed at modelling the various approaches to education within the discipline (see chapter 8). Through this process, underlying principles are explored in coming to a deeper understanding of the critical elements that are later considered in proposing an improved model of surveying/geomatics education.

The chapter offers some breadth in understanding the wider field of contemporary surveying/geomatics education. This broad account forms a useful background for the in-depth case studies that will provide a richer account of the educational strategies used in two of the programmes identified as employing distinct strategies. The breadth that this chapter offers refers to a wide view of what incorporates surveying/geomatics education in the context of the university courses selected for the study. While there cannot be a legitimate claim of a universal picture of the field of study, a fairly extensive mapping of contemporary practice in the field is derived from the breadth of programmes included in this collective case study.

The findings in this chapter are based on documentation from the fifteen programmes, transcripts from the interviews of programme representatives and representatives of the surveying profession.

5.2 Theme I: Curriculum architecture

Under this theme, various aspects of the fifteen studied curricula are presented. An understanding of the design, structure and functions of the curricula studied provides some answers to the question: How can the educational strategies used in surveying/geomatics courses be distinguished? Firstly, three aspects of curriculum architecture are considered, as they have particular relevance to this study based on the empirical data. These include three of the features of curriculum architecture as described by Boyd and Dunlop, et al. (2007): structure, course duration, and curriculum change drivers.

5.2.1 Curriculum content structure

The historical account of surveying education (Chapter 2) demonstrated its evolution in many countries, from an apprenticeship system to formalised university-based professional courses. This shift in approach to educating professional surveyors has been well established for many years in all the countries represented (see **Table 5**). A look at the structure of their curricula will demonstrate areas of similarities and some distinguishing features in how the curriculum content is structured.

Interestingly, large components of the programme documents and the programme representatives' interview responses related to curriculum content structure. Distinctions in curriculum structure were made based on subject composition, length of programme and the emphases given to specialised subjects versus general education subjects. From these, curriculum models of existing surveying/geomatics programmes will be derived and further analysed in the discussions in chapter 8. This layer of analysis is an important element of the systematic development of a proposed improved educational model.

A large majority of the fifteen courses had relatively little, if any at all, emphases on general education. Conversely, a significantly greater emphasis on discipline-specific subjects was evident. This specialist emphasis was assessed at two levels: (1) by comparing general education elements with surveying/geomatics specific elements; and (2) by comparing intra-geomatics integration.

Core surveying vs. general education elements

The curriculum documents, supported by programme representatives' interviews, represented content compositions within the programmes as either 'highly specialised' or 'specialised with integrative elements'. These categorisations relate to the makeup of core, generic and elective elements and are illustrated in **Table 6.** Also induced in the table is also an indication of where each programme is considered to be appropriately placed based on its content composition and emphasis. Additionally, two examples are included to elaborate the distinctions made between the two categories (highly specialised and specialised with integrative aspects).

Table 6 : Curriculum categorisation based on content specialisation emphasis

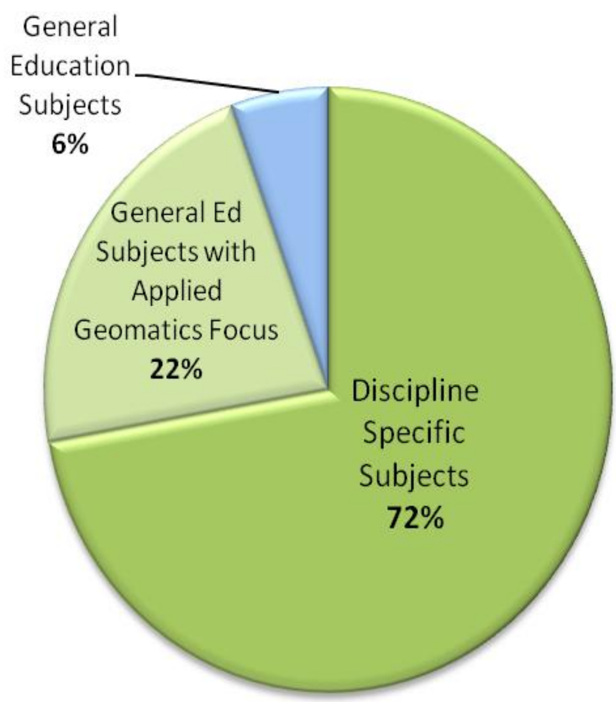
Highly Specialised	**Specialised with Integrative Aspects**
NU, OU,UEL, UNB, USQ	AAU, AU, BU, MU, NMSU, UWH, UNSW, UTJ, UWI, CPUT
• High proportion of specialised modules.	• Fairly high proportion of specialised modules
• Cross-disciplinary & more generic modules are slanted towards surveying/geomatics applications	• Generic and/or cross-disciplinary subject included without applied surveying/geomatics requirement
Example	**Example**
UEL: of 7 level 1 modules 6 are clearly specialised and one a more generic Quantitative Methods but taught with a specialised application emphasis. Of 10 level 2 modules, 8 are clearly specialised and 2 more general but with surveying application emphases.	UTJ: of 8 first year modules 4 are specialised and 4 general education (sociology, communication, mathematics, and information technology). Of the 8 second year modules six are specialised and 1 general education (mathematics) and 1 cross-disciplinary (elective)
Most modules are taught by surveying lecturers including 'surveying mathematics'.	Only specialised modules are taught by surveying lecturers

'Highly specialised' composition is assigned where a high proportion of the curriculum is made up of modules that are surveying/geomatics specific or general education subject such as mathematics and management with specialised application focus. One such programme composition is illustrated by **Figure 13** which shows over ninety percentage dedicated to surveying/geomatics specific subjects.

Using the stated criteria, the UEL programme is an example of programmes categorised as highly specialised. Correspondingly, the information provided in the curriculum documents, corroborated by the programme director interview, showed that of 18 modules, 12 to 14 are discipline specific, one is general education and the remaining 3-5 are from non-surveying specific subject areas but have clearly stated applications to surveying/geomatics e.g. ‘management studies in geomatics’ and ‘legal framework for geomatics’ (UEL Student Handbook, 2009). In the UEL case, the high specialist focus was further strengthened by having some less specialised modules such as ‘management studies’, taught by surveying lecturers as their programme representative stated:

> *Management studies and mathematics are taught by surveying lecturers. For us, these modules are specially geared for our students. [PR]*

Figure 13: Chart showing distribution of programme content in regards to discipline-specific subjects and general education subjects (UEL)

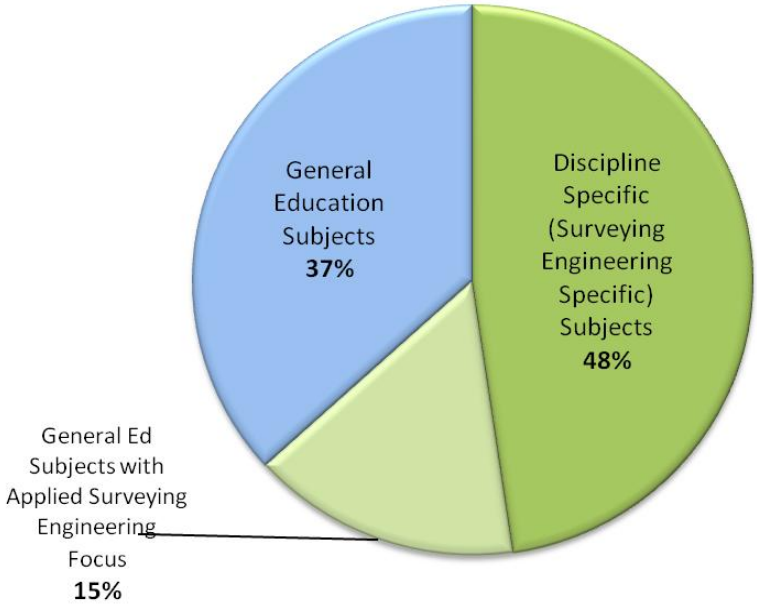


Although the module compositions in the fifteen programmes differed in some respects, five of the programmes were categorised as highly specialised. The OU and UNB models are also used to illustrate high specialisation. While the OU curriculum showed a predominance of specialised subject focus, two differences are noted relative to UEL. At the lowest level in this programme, there was greater opportunity for cross-disciplinary studies through a system of electives (OU programme representative). As such, these modules may be selected from other disciplinary areas that interest the students. Also, relative to the UEL model, OU’s offers more general education even though it maintains major emphasis on specialised surveying subjects beyond the first year.

Another contrasting model is UNB's curriculum which has two core categories: a core of basic engineering subjects and a core of more discipline specific subjects amongst which mathematics, computer science and general science are listed along with geomatics engineering subjects. A small component (10%) is dedicated to what the programme document described as 'technical electives', which are highly specialised areas such as 'oceanography for hydrographic surveyors'. A similar amount is then reserved for what the document described as 'relevant practical experience approved by the department' (UNB Course document, 2010). With subjects such as mechanics and a few that include major design components; the programme, unlike most in the study, has an engineering 'flavour' which justifies its title -'Geomatics Engineering'.

In spite of the high specialist concentration found in surveying programmes, the data showed that the majority of programmes offer a limited amount of non-surveying modules without explicitly stated surveying applications. The UTJ example shown in **Table 6** is a typical example of the programmes listed in this category. Interestingly, the NMSU curriculum, which is accredited as an engineering programme, stands out as having the largest proportion of its curricula dedicated to general education. Similarly, Figure **14** shows a relatively large proportion of the NMSU programme dedicated to general education and a smaller proportion to surveying engineering specific education. This represents a more liberal approach relative to the other programmes in the study.

Figure 14: Chart showing distribution of programme credits in regards to discipline-specific subjects relative to general education subjects (NMSU)



It is acknowledged that the labelling of subjects/modules as 'specialist' may overshadow underlying non-discipline-specific knowledge and skills development as are often referred to as 'generic'. Comments from the programme representatives suggest that even within robust disciplinary focussed curricula, more generic skills are embedded.

> *Within several of our modules we have what we call enabling skills. At level one these include elements of research and academic integrity. At the higher levels these include research skills and employability skills. [PD5]*

> *We don't specifically teach generic skills but the nature of the course does mean that students build those skills anyway. [PR8]*

As have been stated in the literature, activities such as group work and active learning as done in practical exercises (evident in all fifteen programmes) are likely to build generic work-related skill. However, outside of observing teaching and learning activities, there are limited data to explore generic skills development beyond what is explicitly stated in the documents consulted. The degree to which generic knowledge and skills are embedded in the teaching and learning of discipline specific modules will be further explored in the more in-depth case studies (Chapters 6 & 7). This is considered more appropriate for this deeper layer of the analysis since those case studies involved observations of pedagogical activities as well as interviews of students and lecturers.

Comprehensively, when the number of specialised modules is compared to the number of modules described as general education; this suggests a high proportion of specialisation across both categories shown in **Table 6.** That is, the disciplinary focus in both the highly specialised and integrative content compositions represents an overall high concentration of discipline-specific content in most of the studied courses. This suggests that disciplinary specialisation is a major *capital* within the *field* of surveying education.

To address another aim of the study, *the impact of the geomatics paradigm*, the nature of the disciplinary focus is further explored in relation to the level of integration between the various facets of geomatics. The wider impact of the 'geomatics paradigm' will be explored later under a separate theme.

Intra-geomatics integration

Having already established that general education subjects represent a minimal component of most of the programmes in the study, the analysis moves to another level to dissect the discipline-specific components of the curricula. As discussed in chapter 1, intra-geomatics integration refers to the content composition of traditional surveying knowledge and skills and the newer technology-induced elements such as GNSS, GIS, and Remote Sensing. This composition is examined using similar classifications as in the preceding discussion: 'Highly Specialised', 'Integrated' and 'Mixed Approach' as a hybrid of the first two classifications.

The category described as 'highly specialised' comprises those programmes with a relatively limited exposure to the wide range of subjects that fall under the geomatics umbrella. Students in this model, after the first year in the programmes typically move into distinct specialist areas such as Measurement Science (MS), GIS and Land Management. The transition into the specialist fields would ordinarily mean that the other areas are either dropped or have significantly reduced focus so that very narrow specialised competencies are developed in the selected area.

Based on the stated criteria, high specialisation was evident in five of the surveying/geomatics programmes (see **Table 7**). Responses from representatives of the surveying profession, compared to responses from programme representatives within this classification, showed important differences in the perceptions from both groups. Whereas, representatives of large geomatics organisations indicated interests in graduates with highly specialised education, smaller firms that engage in wide geomatics activities showed less interest in graduates who have been educated in a highly specialised manner. Two comments demonstrate a clear distinction in expected graduate skills from the two types of surveying/geomatics organisations:

> *We often look for graduates who are very good at specific areas such as LIDAR or Remote Sensing or GIS but we often get people who can do a little of everything and that does not work best for us. [Partner in large European geomatics organisation]*

> *We look for well-rounded people. What we would not be terribly interested in, are people who are very specialist in any particular aspect of geomatics. We would prefer people joining our business who have a broad, rather than a narrow knowledge base. The people we are producing in the universities in this country in geomatics are too narrow. [Principal, Small UK surveying firm]*

Comparatively, a large proportion of programme representatives supported a broader geomatics education without stating considerations for target markets. The following two comments illustrate this finding:

> *I try and dissuade students from looking at geomatics as narrowing option. I show them the syllabus and say here it is you are doing everything from land law to geophysics. You are doing a wide range of stuff. [PD1]*

> *Industry has narrow ambitions just to meet their specific and sometimes transitory needs but we are educators and we must look beyond those narrow requirements and strive to provide a sound education for our students. [PD4]*

Notwithstanding these popular views, one PD's comment demonstrates how course emphases are determined through a collaborative process between industry and academia.

> *From the feedback we are getting from them (industry), they would like us to stay concentrated on those aspects of boundary surveying with knowledge of LIS and GIS but not trying to concentrate on those areas. We have to show that our students are capable of doing what the industry demands. [PD6]*

Notably, the relationship between these two agents emerged as a major theme. Thus, it is further discussed later, in this chapter, under the theme *vocation-education dichotomy*.

However, before moving on, it is important to discuss the categorisation of courses employed. Categorising a programme as highly specialised is not as simplistic a distinction to make as may be suggested. For example, the specialist field of MS often includes the application of a number of techniques such as GNSS, Photogrammetry and Remote Sensing, which individually, are classified as specialisations in their own right in some contexts. Thus, it may be possible to specialise in MS and still be exposed to other components of the wider geomatics spectrum. NU's programme is considered to be highly specialised because the MS and GIS groups have specialised arrangements for the last two years of the programmes. In spite of this, the programme document shows that NU's students may earn a MS or a GIS specialised degree but yet have been exposed to a broad range of knowledge and skills in the other specialisation.

The UNSW case illustrates how perceptions about market demands and market trends along with students aligning themselves with these perceptions can be determinants of the level of intra-geomatics integration. As UNSW's PD stated, prior to 2010, the university offered a Bachelor's Degree in Surveying and Spatial Information Science that integrated traditional surveying with elements of GIS. The decision to change from an integrated programme to two distinct specialisations was grounded in a desire to cater to market demands and to students' interests which relate to their career ambitions. This point was elaborated by the PD:

> *… we did not have the flexibility to say this is a core requirement for the surveying programme, you have to do survey camp, you have to do a number of basic surveying courses just like everybody else will do the basic GIS courses, the basic remote sensing course, …. And there are a few electives in the latter year if you want to do an extra course here or there. But fundamentally the core education had to be from the surveying perspective and the various tools that are now part of the modern surveyor...we believe we have lost students who did not want to do a degree specialising in surveying with a few options. There was some logic in separating these two degrees because there was a separate market. In our marketing we will be emphasising the differences between the two, one being tied to civil engineering, infrastructure and in the land and land development and the other would be geoIT.*

As a result, UNSW now offers two distinct specialisations with a mostly common first year and a significantly more specialist concentration in the remaining three years. However, labelling the UNSW programmes as highly specialised is problematic since the students may make their education less specialised and more intra-geomatics by choosing electives from other areas. This was explained by the programme director who offered an alternative way of looking at surveying specialisation. Rather than specifying distinct areas, he suggested that it may be more useful to specify **emphasis**.

> *There is a significant overlap even though we believe there are different markets. About 70% of the courses appear in both programmes either as core or electives. This reflects the fact that the modern surveying practice cannot divorce itself from the new tools of geoinformation and remote sensing etc. It is more a question of emphasis rather than distinctiveness. [PD]*

This illustrates that specialisation or emphasis is viewed in different ways. To further demonstrate differences in specialist focus, the USQ module is looked at. USQ offers two specialisations for its 4-year full time programmes (surveying and GIS). It is categorised as highly specialised because of a large number of modules that are specific to each major after the first year. Based on the module listings in the Student Handbook (University of Southerland Queensland, 2010), in the first year, seven of eight modules are common to both specialisations. However, the commonality is significantly reduced in the second and third years with each having only two common modules of nine. The fourth year shows five of seven modules common. However, some of the modules that share module titles such as 'Professional Practice 1 & 2' and 'Research Project 1 & 2' may be specific to the major focus and so could be listed as specialised also. If that were done, the commonality would be reduced to two of seven modules. On this basis, the USQ programmes are considered categorised as highly specialised. The programme representative stated that the high level of student interest in both specialisations is the primary reason for keeping the courses distinct.

> *Because we have enough students for subjects to stand on their own, we have had less pressure to sort of blur between what people would think of as Surveying and what people would think of as GIS and Remote Sensing and other generalised spatial things. [PR]*

This comment implies that maintaining narrow specialisation is more desirable than integrative curricula within the USQ context. This capital also has some resonance within the UNSW context as suggested by its programme leader's comment (quoted earlier), and shows a commonality that may be due to historical linkages within that common regional context as alluded to in Chapter 2.

As a second category, an Integrated Model defines a curriculum in which various aspects of geomatics are taught within the programme at all levels without offering highly defined specialisations as previously described. This basically, describes the type of structure that existed at the UNSW as mentioned earlier in this section. It does not mean that the emphases on all areas are equal but rather that the elements of the newer aspects are taught as required subjects although typically, the surveying aspects may be dominant.

Table 7 illustrates the five programmes that are considered best categorised as integrated. UTJ, for example, teaches traditional surveying at all four levels of its BSc. programme and integrates more modern aspects either within the traditional subjects or add more modern subjects like remote sensing and GIS at various points in the programme. This was also found to be true of UWI geomatics programme and to a lesser extent, the MU, NMSU and CPUT programmes. Relative to the other programmes in this category, these latter three have a narrower range of subject offerings. NMSU's programme director explained that their programme emphasis is primarily influenced by industry demands:

> *We mostly concentrate on boundary survey. We have what we call Land Information System (LIS) in the programme and we have a required lower level course and an elective as an upper level course. Our outside advisory group would like us to stay concentrating on boundary surveying with knowledge of LIS and GIS but not trying to concentrate on those areas.*

The third classification is described as the mixed approach and represents the curricula that offer a period of generalised geomatics studies and an almost equal period of specialised studies in a sub-field of geomatics. The OU 4-year BSc surveying programmes is considered best placed in this category. It covers basic surveying in the first year along with general education subjects. The second year offers a range of traditional surveying modules along with introduction to GIS. The third year offers some higher level surveying modules and allows for the beginning of specialisation through a limited number of electives. The 4th year offers a greater number of electives for strengthened concentration on specialisation.

In contrast to the other contexts in the study, a Master's degree is the requirement for the professional surveyor in Denmark and Finland. Hence, the AAU and AU programmes are considered in this study as five-year education models. Within this framework, the 3-year BSc component represents exposure to the wide geomatics field, followed by two years of narrow specialisations in the MSc component. Thus these programmes are classified as having a mixed specialisation focus.

Another interesting arrangement is seen in the BU programme; the first year is generic across the Engineering Faculty which includes electrical, mechanical, architectural, civil and surveying engineering. The specialisations for these five disciplinary areas start at the second year and continue for 4 years. According to the programme representative, surveying students at BU do a single degree covering a wide range of geomatics sub-fields:

> *The preparatory year is a must before they [students] specialise. In surveying we expose our students to all the directions so there are no specialists at this stage. They can dedicate their studies in a specific field like Geodesy or Photogrammetry at the Master's level. [PR]*

Based on the module listings from the BU curriculum document, from the second to the fourth year of the surveying engineering specialisation, a wide base of geomatics is included along with engineering modules similar to those seen in the UNB and NMSU courses. **Table 7** summaries the elements of these models and illustrate where each programme is considered to be best placed based on the stated criteria.

Table 7: Classifications of surveying/geomatics curricula

Model title	**Highly Specialised** (NU, UEL, UNB, UNSW, UWH, USQ)	**Integrated** (CPUT, MU, NMSU, UTJ, UWI)	**Mixed Approach** (AAU, AU, BU,OU, UEL (major-minor or joint options))
Model description	Students are given limited exposure to the wider geomatics field but after the 1st year chose between specialisations and focus on that narrow area for the majority of the course.	Several aspects of geomatics (e.g. surveying, remote sensing, photogrammetry, GIS/LIS, hydrography, planning, land law, land administration) are integrated in the entire programme. The specialist areas are not done at all levels of the programmes but none is optional.	A longer period is dedicated to a generalist focus with options for specialisations (single or combined) in the senior year(s) of the programme. This optional element in some programmes is facilitated through a system of elective subjects.
Most cited advantage	Develops strong specialists	Develops generalist competencies	Develops both generalist and specialists competencies
Most cited disadvantage	Graduates not able to link knowledge to related areas	Risk of not being able to go in depth with any area because of the diverse content.	Varied approaches to integration make it difficult to determine what combinations may work best.

The AAU's innovative curriculum (to be discussed in more details as one of the in-depth case studies) emerged as the most radical in regards to how the distribution of general education and specialised education is undertaken. A senior academic from this programme suggested that the problem-based approach to educating students facilitate holistic preparation of students for the surveying profession. He identified a shift from the technical focus to a more managerial focus as an important element within their educational system.

> *This swing I am always talking about – from measurement to management, is all about education. There is a need to include the more managerial aspect of the surveying discipline into the programmes. So in a sense this means leaving the very engineering approach to surveying ...to include more of the administrative, managerial sides of our discipline related to the social sciences. [PR1]*

This comment represented an unpopular perspective among the interviewed programme representatives. A reduction in the technical focus was generally seen as a threat to an education that is relevant to surveying practice. The majority of the respondents shared the view that surveying education should rightly have a disciplinary emphasis if it is to adequately and effectively prepare students for work.

> *We are a professional school, so we put ourselves on par with lawyers, dentists, pharmacists, doctors and so on. We don't teach particular generic skills but the nature of the course does mean that they build those skills anyway. [PR8]*

> *We are a professional programme and so we cannot get away from having a narrow focus. [PD4]*

The empirical evidence demonstrates wide support for maintaining surveying programmes heavily weighted towards specialists surveying content. Notwithstanding this evidence, a more liberal approach to educating surveyors, as suggested by the AAU representative, appears to be having some influence on contemporary course development. That is, the subject composition in many of the studied courses, as reported by programme representatives, has changed over the years with more space given to less discipline specific content. The reason for this, as suggested by a number of programme representatives, is not based on efforts to liberalise surveying education for the sake of making the courses more general education. Rather, this is a strategy to mitigate dwindling enrolment numbers in surveying programmes and also to meet the changed and changing needs of the geospatial industry as alluded to by several individuals in the literature (e.g. Psarianos, 2001; Witte et al., 2002, Strobl, 2009; Ossko, 2008). The comments from the following programme representatives demonstrate this shifting towards a more liberal focus. They also highlight the claim that the course focus is influenced by enrolment challenges:

> *We now offer cross-disciplinary degrees in which surveying can be mixed with several other disciplines. This is a strategy to attract more students to the discipline and to prepare our students for what is happening in the geomatics industry [PD9].*

> *... because surveying is such a small discipline relative to others within the university, we could not remain viable as a single major. We were forced to open our doors to a more liberal mix of subjects. [PD 4]*

> *In lots of other surveying programmes within the country as the numbers have fallen, the pressure comes on to the faculty to have more, as it were, cooperate courses that have subjects that are common to a lot of programmes. We were*

under that sort of pressure when our numbers were not as healthy as they are now. [PR 10]

A number of our students do a dual degree in surveying and civil engineering. [PD6]

The inclusion of general education subjects in surveying curricula also reflects institutional (university) requirements for degree programmes as well as what the literature describes as a trend in liberalising professional higher education (e.g. Paisey & Paisey, 2004). The following comments from two PDs illustrate these claims:

The university has some compulsory requirements for all its degree programmes. This includes some general education elements. [PD11]

Our subject composition is to some degree influenced by international trends in higher education. It is more and more widely accepted that professional courses should offer some generic areas to develop graduates with a broader education. [PD4]

For now, the majority of the programmes remain right of centre of the liberalisation-specialisation trajectory. Even though they show some evidence of change, they are heavily weighted towards disciplinary specialisations.

5.2.2 Course duration

Whereas the majority of the programmes in the study was assessed as having a high disciplinary focus, greater diversity was evident in the durations of study. The data showed that surveying course durations ranged from three years to five years of full time studies. Of the fifteen programmes, two had five-year durations and three had three-year durations. The remaining ten programmes were for four-year durations. It was, therefore, no surprise that the examination of the curricula showed that module count in the longer programmes exceeded those in three-year programmes. This demonstrated that the longer term programmes are not merely a matter of spreading similar content composition over a longer period, but rather that the longer programmes do include greater knowledge content. The documentation also suggested that that the longer programmes include more extensive theoretical and practical content. The data also showed that some of the longer programmes include some elements of work-based learning and more assessment exercises relative to the programmes of shorter duration. Additionally, the data showed that shorter programmes are more specialised than longer ones. It is understandable that the longer periods allow for greater integration of general education within the otherwise discipline-specific programmes.

A comparison of course duration of necessity demands a consideration of entry level of students in the programmes and post-graduation professional qualifying requirements. Though understandably, entry requirements vary according to country and according to university, all universities in the study require passes in higher secondary school qualifications which the interviewed academics generally believed to be equivalent to the British A'level standard. 'Good' performance in mathematics and a science subject (particularly physics) is generally regarded as important entry requirements for surveying/geomatics programmes.

The mobility of students between countries is another way to compare entry standards. Students from the Caribbean, for example, can use Caribbean Advanced Proficiency Examination qualifications for entry into English universities. Some African students still sit English-based university-qualifying examinations. However some of the African countries in the study have, like the Caribbean, developed their own qualifying examinations that they consider to be equivalent to the British Examinations they replace. Between European countries the Bologna agreement has been a common criterion for all the universities from that region included in the study. On these bases, entry requirements are considered to be equivalent for all the programmes in the study unless otherwise stated.

All universities in the study offer full time programmes in surveying/geomatics. A few also offer part time studies in surveying courses. The Danish and Finnish universities have a unique feature in that five years of study is required for professional surveying qualification. With the Bologna agreement, this translates into a Master's degree. This higher level education has a historical link to surveying practice and education in Denmark and Finland as outlined in Chapter 2. The desire to unify surveying educational and professional standards in Western Europe (Allan, 1995) appears to have little relevance to this educational arrangement at this time.

The English and Hungarian universities in the study are the only ones offering only three-year undergraduate professional surveying programmes. CPUT, OU and USQ along with their four-year professional surveying degree programmes, also offer three-year professional education for specified sub-disciplinary areas such as mining surveying (OU and USQ) and engineering surveying (CPUT and USQ). In those contexts, the four-year programmes are the academic requirements for certification as cadastral surveyor.

Generally, professional surveying education does not place a high value on postgraduate education. Rather, the work-based learning achieved after formal studies is seen as a more appropriate ‘education’ for individuals interested in professional certification. In most national contexts, postgraduate qualifications neither offer status nor improved remuneration, as indicated by one programme representative.

> *Post-graduate education does not improve the earning potential or status as surveyors. [PR10]*

He described the professional activities of surveyors in that particular region of the country as primarily associated with the large mining industry along with on-going civil construction projects. The role of mining and engineering surveyors in that region is considered to be relatively secure, so it is considered justifiable that traditional measurement science at the undergraduate level remains the focus of the education programme for surveyors. This shows that in this context, the nature of the local job market is a major determinant of curriculum content.

The variation in course duration, however, does not necessarily mean that graduates from the three-year programmes are less prepared for surveying work than those from the longer programmes. Indeed, if high specialisation is valued above more general education, then a shorter concentrated period of high specialisation may be seen as more attractive for those in the industry. Furthermore, responses from professional surveyors and international surveying associations indicated some amount of dissatisfaction with graduates from all the surveying/geomatics programmes in the study, regardless of duration of study. Some of these comments are included:

> *I know my view is one shared by a number of other persons I speak to about how successfully universities prepare students for work in the surveying industry. We believe that universities concentrate too much on teaching people*

measurement if you like and not enough on teaching them business skills. Geomatics needs to raise its game. We need to be producing graduates who have developed the other skills that are necessary beyond the core geomatics/surveying skills. [UK chartered surveyor]

Among the current generation of university graduates, a lot of them are not prepared for work. [Director, international surveying accrediting body]

I know that the universities are very good at teaching the theory and the detail but not in the business side of things, and the reality of being in a business situation where you have to apply your knowledge and understanding of the subject, in a project setting where there is real money involved and you can't go off on a tangent, you hat to stick within the requirements of that project. [Senior Partner, European-based International Geo-services Company]

If you go back 25 to 30 years ago, when students left university they could perform as a surveyor immediately. Nowadays when they finish the master level they still need a lot of the technical skills. [Danish Professional Surveyor]

The comments show an overall expectation that university courses should prepare students for work. They perceived preparation for work to include the theoretical and practical surveying knowledge and competencies and also more generic work-related competencies. The data suggest that postgraduate education is not broadly considered to be relevant for professional surveying work. Instead, an undergraduate degree that provides an education in the fundamental surveying principles and methods is generally the academic requirement for professional accreditation. Beyond this qualification, proof of professional competence is achieved through organised post-university supervised work and professional examinations.

It is asserted that, if these two aspects of professional surveying qualification are seen to work together in a complimentary relationship, it is likely that the education will be perceived to have greater relevance to work. Course duration would be less of an issue if university, the profession and its governing bodies, can together develop the framework that defines the functions of each aspect of professional surveying qualification. For example, it can be specified what is expected from 3-year or 4-year and 5-year academic programmes and on that basis decisions can be made regarding what additional work-based knowledge and skills are expected to be developed in the post-university engagement for each category of graduates. Where there appear to be shortfalls in one area it can be determined whether the responsibility is better placed within the university or within the industry. It is to be noted that conflicting views from industry and university about the effectiveness of surveying education suggest an underlying misalignment of expected outcomes.

5.2.3 Change drivers in surveying/geomatics education

In considering what underlying factors influence or drive surveying curriculum decisions, four factors emerged as primary: market demands, student demands, academic staff demands and university administrator demands. Whereas student demands appear to be related to career aspirations and perceptions of market requirements, the market demands are perceived to be directly related to overall economic activities within a local, regional or national area (see **Table 8**). These findings are based on responses from programme representatives. However, the case studies in the two following chapters provide analyses of this issue using perspectives from a broader group of surveying lecturers, students and professional surveyors within those contexts.

Table 8: Indicators of factors that influence curriculum decisions

Market demands	**Student demands**
There is quite a close relationship between the school and the profession. We have a reasonably good view of what their expectations are. That follows what the industry is wanting and we develop our curriculum based on this. [PR 8]	*Because we have had enough students for subjects to stand on their own, we have had less pressure to sort of blur between what people would think of as Surveying and as GIS, Remote Sensing and other generalised spatial things. [PR 8]*
Our Advisory Committee includes members of the profession. They advise the department of the industry's requirements- what they would like our graduates to do. They also give input in our subject contents, how to develop our courses, where to put emphasis. We use them extensively to develop our programme. The reason for this is to ensure that our students are educated in a way that industry wants. Without industry involvement we don't have our graduates well trained for industry. [PD15]	*We may have lost students who did not want to do a BEng specialising in Surveying with a few options. [PD9]*
From the feedback we get from our professional advisory group, they would like us to stay concentrated on those aspects of boundary surveying with knowledge of LIS but not trying to concentrate on those areas. [PD6]	*The vast majority of our students regard the degree course as vocational- as a passport into the industry. [PD4]*

Comments from many of the programme representatives interviewed, in relation to the subject composition within their courses and the emphases placed on particular areas, suggested that the desire of the surveying/geomatics industry was a key variable. The involvement of professional surveyors on advisory boards or some similar body suggests a direct link between the educational field and the professional field. The management of this relationship is important to avoid domination of the interest of one group and the suppression of the other. One programme leader articulated how professional accrediting bodies are sometimes prescriptive in how the programmes are to be structured and maintained.

> *In a sense we feel like we are almost beholden to the professional accreditation bodies. Accrediting bodies have varying levels of input into curriculum design. The Institution of Civil Engineers, for example, has a very prescriptive view of what constitute a valid corpus of engineering knowledge. [PD4]*

The professional body is clearly an active agent within surveying education and this impacts curriculum content and emphasis.

Additionally, students' desires were identified as a factor that determines curriculum content and emphasis. From the programme representatives' interviews, references were made to curriculum changes based on students' expressed interests or lack of interest in particular areas. It was shown that students have questioned subject composition and emphasis and in some instances asked for a greater freedom of choice in regards to the subject compositions. As one programme director explained:

> *Our programme was changed to offer greater specialisations for those students who had interests in one specialist field over another while at the same time allowing for integration for those students with that preference [PD]*

These findings show that students' desires are recognised and also served to influence curriculum development.

Another group of agent found to have influence in this area are the academic staff. The data corroborated what the literature has identified as the privilege that higher education teachers have in determining curriculum emphases and the teaching of values that may not be explicitly mentioned in syllabi. Surveying/geomatics academics largely determine the particular emphasis placed on the subjects they teach. This was alluded to by several of the programme representatives interviewed. The less explicit aspects of a curriculum referred to as the hidden curriculum in the literature includes, for example, the emphasis placed on particular sections of a module. The following comments demonstrate that these features are highly lecturer-dependent:

> *What we teach is to a large degree determined by the expertise and research work of our academic staff. [PD 4]*

> *As lecturer I look at the syllabus and if it's not up to scratch and I would teach what I perceive to be more relevant. The syllabus outline would not change but the delivery would be different. [PR13]*

> *One of our professors is retiring soon and we are not sure if we will be able to find anyone with his expertise. We may have to do some adjustment to the module depending on the expertise of the person who fills this position. [PD1]*

It was also shown that the administrative location of geomatics programmes strongly influence the 'flavour' of the programme. Surveying programmes located in Civil

Engineering faculties (e.g. at NMSU) tend to have more engineering focussed modules than do those located, for example, within faculties of Computing and Technology (UEL) or Built Environment (UTJ). Though some exist as distinct entities, such as UNB's Geomatics Engineering and Geodesy Department, they all had roots in Civil Engineering. The administrative influence is also seen in relation to institutional regulations. An example is the case of NMSU which specifies the percentage of the degree to be dedicated to general education, math and science education and more discipline-specific subjects.

Based on several comments from interview respondents, the decision regarding the pattern to which the programmes conform is influenced by how the market demands are perceived by those with the greatest influence on surveying/geomatics curricula. The preceding discussions have shown that Surveying curricula are largely structured around what industry requires and changes in geomatics related technologies. Furthermore, management of these changes is a common feature of all the Surveying programmes in the study. With some, significant changes in the curriculum structure and the specialisation offerings have already been made; while in others, plans were in place to change aspects of the programmes.

> *We have put in an application to change the title to geomatics. This is to cater for the inclusion of GIS and Remote Sensing in the delivery of the course. [PR13]*

Table 9 illustrates some of the data that suggest which factors drive change in the field of surveying education. The change driver that each set of comments are associated with are listed in the right column of the table.

Table 9: Change drivers for surveying education

Interview responses	**Identified change driver**
Our programme has struggled over the years to enrol qualified students who have an interest in Surveying. [PD] *We have had to consider new ways of promoting and delivering our courses in an effort to improve student enrolment. [PD]*	Improving student recruitment
I have been teaching Surveying for 15 years and there are very few things that have not changed due to the influence of technology. [Lecturer] *Though many of the fundamental principles of Surveying remain unchanged, many of our methods have changed due to technological advances. [PD]*	Keeping pace with relevant technologies
We educate our students to be able to find gainful employment in a very dynamic geomatics industry. We need to keep a close eye on what is happening in industry and make adjustments where necessary. [PD] *Our curriculum reflects what is happening in industry. If industry is dissatisfied with our graduates then we need to look at our programme. [PD]*	Improving industry satisfaction with graduates

Having examined differences in how surveying/geomatics curricula are organised, the data were further interrogated to examine pedagogical approaches.

5.3 Theme II – Pedagogical approaches

As seen in the literature review, higher education pedagogy has seen increased attention in recent years. Therefore, it was surprising to see evidence of open resistance to the idea of evaluating pedagogical effectiveness in surveying education. Though the interviews of programme representatives showed some amount of interest in pedagogical development, they also showed strong perceptions about the irrelevance of concentrating efforts on teaching and learning strategies. Pedagogical approaches to some programme representatives were of secondary importance relative to curriculum content. Many surveying academics seem to give priority to teaching fundamental principles without much thought about the relationship between pedagogical approaches and learning. Two comments reflect an extreme position on the issue:

We are not into dictating to academics how they teach. Pedagogical approaches are not the most important thing for educating the students, more important are the teaching of the principles that will form functional surveyors. [PD9]

This is a university after all; we don't have competency teaching, it's really left up to the staff which has its positives and negatives. You can't make a big deal out of it. [PD]

In spite of what the PD9 comment suggests, the matter of effective pedagogical approaches in the teaching of surveying is not about mandating how surveying lecturers ought to teach. Instead, it is more about encouraging academics to explore what is known about teaching and learning and seeking to find effective means of promoting the type of learning in students that will strategically position them for contemporary professional engagements. This implies a well thought out set of expected learning outcomes that considers student characteristics and desires, potential employers' needs and expectations, the surveying profession's ethical principles and practicing framework, surveying academics and the university administrative framework.

In spite of the extreme view by a small representation of the sample of programme representatives, there appears to be some level of interest and activity in developing effective pedagogies for surveying/geomatics.

We typically put our best lecturers in the first two years because it helps to get the foundations right. These staff, I believe are our best teachers, they do try different things, they experiment, they make videos, employ Power Point on the webs, some use Vista but this is very much driven by the individual not by any conscious policy on the part of the school or the faculty. [PD4]

We have a system in place by which lecturers are encouraged; in fact newer lecturers are required to enrol in a formal programme of higher education where they are educated in issues of pedagogy. [PD5]

One programme leader also identified disciplinary culture as a factor that influences pedagogy. His view resonates with the concepts of signature pedagogy (Shulman, 2005) and disciplinary cultures in knowledge and skills (Becher, 1994).

…there is an element of the culture of the course as well as of the staff members that come through. Subjects like Geodesy that is more mathematical, students might perceive to be more difficult. Subjects like Remote Sensing or

environmental subjects tend to be a bit more 'coloured pencil' type subjects. So you have this extra layer which is on top of the individual staff members being encouraged to continue upgrading their materials and their methods. The bases of the courses influence the way they are taught. [PD9]

This comment demonstrates that there is some recognition of 'cultural impartation' in the teaching of surveying/geomatics subjects. Consequently, the degree to which a 'signature pedagogy' for surveying can be identified, will be further explored in the case studies. The observation of teaching and learning activities will likely shed more light on how values and habits associated with the profession are conveyed through pedagogical approaches.

With few exceptions, the programme documents and programme representatives interview responses showed that the programmes studied, employed mainly traditional didactic teaching approaches. However, it was evident that lecturers were not restricted in the use of personally chosen aids and instructional methods. Many of those interviewed used the actual term 'traditional' or 'classical' to describe the pedagogical approaches employed by themselves and lecturers within their programmes.

It's real traditional. I teach using the typical lecture style. [PR13]

Our approach is the classical lecture with practical exercise. So we deliver lecturers - the students typically get two hours of lecture per week and then a 3-hour practicum or lab. They are also given take-home assignments to solve problems or do research. Towards the beginning we probably teach using more focus-driven exercises and tasks so that they know how to do this part of it. The senior classes, they have to take all these parts and we given them larger projects and then they will have to put them together as if they were doing a survey in the real world. [PD6]

We are basically traditional in how we teach. However, our lecturers are at liberty to try new things, and some do. A few of our lecturers are keen to explore instructional methods and their effects on student learning and to some extent the university encourages this. [PD4]

The data showed that a number of pedagogical innovations are practised on small scales. Examples of these are the application of mobile phones in the teaching of surveying instrument use at UEL (Brown, Lakin et al., 2010), the virtual surveying field-course at UN and the involvement of professional surveyors in the UTJ

Surveying Practicum (Young, Smith et al, 2010). These examples are by no means unique but the data showed that they represent only minute components of surveying programmes, and are generally instigated by lecturers with a keen interest in pedagogical effectiveness. There appears to be very little effort in making strategic decisions for the evaluation of pedagogical effectiveness in surveying programmes, and for developing wide scale innovations as a way of supporting student learning.

Only two of the fifteen programmes were found to employ wide-scale pedagogical innovations. The USQ distance programme and the AAU model are the two that employ pedagogical approaches distinctly different from the others in the study. The AAU which employs a project-oriented, problem-based model is explored in some details in Chapter 7. The distance education pedagogical arrangement in the USQ model was described by its programme representative:

> *Each enrolled external student gets a study book - about 250 pages of selected readings. We have a web interface with discussion groups. The facility put up recorded lectures or power point presentations with narration. The students do most work away from the University, but they visit the campus for classes six weeks over the 8-year period of the course.*

The distance education used within the USQ surveying programmes is an example of a non-traditional pedagogical form applied in this field. The USQ programme representative stated that this pedagogical strategy was adopted in response to contextual demands related to the wide geographical spread of potential students and significant interest in a non-residential course for employed individuals who desired academic qualification:

> *The large majority of our students are not in a position to study in a full-time, on-campus course. Many of them already have jobs in the surveying industry. Also in this region of the country the population distribution is vast and many people would find it difficult to access on-campus education. [PR]*

It is important to note that, the use of distance education carries with it enormous implications for pedagogical strategies. This reality was endorsed by the USQ programme representative whose comments suggested that, along with the distance programme documents are supporting online and on-campus elements. His comments about making adjustments based on student responses, underscores the importance of student feedback in making pedagogical decisions that will enhance student engagement and learning:

> *The online discussion groups give us important feedback on the content provided online and in the course documents. A lecture may sound fine live. But when distance students watch it, they may hit the fast forward (button) or get bored with it. You have to be much more direct when you are recording a lecture for the external guys to use. We only get feedback when we have that contact with them.' Because you really had very little idea of feedback, of what they understand and what they don't as much as you can get when you are standing in front of someone. So you may labour some points more than you would have to if you are teaching a group in front of you. [PR]*

The comment from the USQ academic aligns with the idea that effective distance education involves more than just employing distance education tools such as online recorded lectures, but perhaps more importantly, it also involves thinking about how students engage with the methods used and making adjustments where necessary. Of relevance here is Keegan's (1994) assertion that, though this mode of educational delivery has inherent problems, they can be mitigated against when appropriate pedagogical strategies are employed. These observations underscore the need for traditional and innovative pedagogies in surveying education, to be systematically and regularly evaluated, in order to determine their effectiveness at fostering learning that is aligned to expected outcomes.

As indicated earlier, these innovations do not represent the pedagogical approaches used predominantly in surveying programmes. In fact, the data showed great commonality in the use of what surveying programme representatives described as traditional pedagogical approaches. The curriculum documents generally showed subjects arranged in modular format and taught over specified periods (typically, semesters). Several of the respondents confirmed that lectures were used predominantly for conveying theoretical concepts and principles and practical sessions (field and laboratory) intersperse the lectures providing opportunities for the practical applications of theoretical knowledge. They generally described the practical sessions as small, lecturer-plan and supervised surveying field and lab projects. Several of the programme representatives explained that students in the earlier years are often given greater direct supervision from staff during these practical exercises. There was generally an indication of gradual increase in student autonomy in the execution of practical exercises. It was also stated that the delivery methods are adjusted to account for increased student-centred learning as students progress in the programme. Two comments demonstrate these points:

> *We use a combination of theory principles together with practicals. In most of the courses we teach we would do the theory first and then apply the practical and explain the practical application and do that in a practical environment with student exercises, lab work etc. So the emphasis is on the application of theory. [PD15]*

> *We use mostly traditional methods in teaching. There is an almost equal mix of theory and practical sessions for some subjects and for others like GIS the practical sessions are greater. We tend to provide greater supervision of first year students but as they move up into the senior years we expect greater input from the students. We expect them to not need as much supervision as they get more experience with both the theoretical and practical aspects. [PD4]*

Another pedagogical feature identified was the inclusion of members of the profession in learning activities within some of the studied programmes. The comment from one PD is representative of comments from other programme representatives:

> *We have guest lecturers for subjects such as Land Economics and Land Development. These are not taught by academics but by practicing surveyors and they would have different teaching styles as they would not be educated in teaching methods. We do this to deliberately draw on industry practice. [PD9]*

This practice is seen as a way of making the education relevant to industry requirements and is also seen as conveying professional values (capitals) to the students, through their interaction with professional surveyors. This practice has implications for student habitus as their dispositions towards professional practice will, in part, be informed by their interaction with these professionals.

Another way professional surveyors are included in the pedagogical arrangements was seen in the organisation of UTJ Field Courses. UTJ, in an effort to improve students' awareness of professional surveying expectations, invite members of the profession to participate in the oral assessment of students' practicum exercises (field courses). This is similar to what AAU does for the assessment of student projects as will be elaborated in Chapter 7. The UTJ model uses a panel of 5 – 8 assessors consisting mostly of professional surveyors. AAU uses one external examiner and one internal examiner to assess students' projects. In both cases, students get feedback based on both university criteria and industry standards. In the UTJ context, students in the later years do cadastral surveys for real clients and the plans produced are actually submitted for approval by the national lands department. The skills developed are considered to be authentically industry relevant.

These findings show that professional orientation is not only evident in the curriculum content but also in the pedagogical approaches employed within surveying programmes. However, the data suggested that much more attention is paid to curriculum structure and content relative to pedagogy within the majority of the programmes. It is argued here that a meticulously structured curriculum, achieves little, if its delivery strategies are not deliberately and strategically planned. Furthermore, if surveying academics continue to use teaching methods as if they are a given unchanging tools, their effectiveness may be compromised given the reality of changed and changing learning and working environments. Hence, pedagogical approaches should facilitate the meeting of the learning objectives and the expectations of the stakeholders (students, accrediting bodies and the geospatial industry). Additionally, if we acknowledge that the nature of the discipline has changed and continues to change, then it is risky to assume that old pedagogical strategies will work as well in new contexts. If considerations for pedagogy are viewed as irrelevant to effective surveying education, by surveying academics, there are crucial implications for learning, and a likely mismatch between graduate competencies and professional practice. It is strongly believed that pedagogy is an important contributor to students' dispositions towards both learning and the profession they are being educated for. Hence, the relationship between pedagogical emphases and students dispositions will be explored further in the two case studies (Chapters 6 & 7).

5.4 Theme III: Geomatics paradigm

Perceptions of the Geomatics Paradigm

While the use of the term 'geomatics' as a replacement for 'surveying' appears to be gaining popularity within universities, the data showed a degree of unease associated with its use. In some contexts, the use of the new term represents a philosophical shift in how the surveying discipline is perceived by academics, course administrators and representatives of the profession. This is demonstrated by selected comments from programme representatives and information from course documents:

> *Geomatics became part of our new name to reflect the department's expanding interests. This new term has also been adopted by governments and private industry across Canada and is becoming accepted world-wide. ...the term "Surveying" no longer accurately expressed the work we do and the knowledge we teach, we have updated our name to Geodesy and Geomatics Engineering. [PD7]*

> *Geomatics Engineering is a modern, rapidly developing field of study which integrates the acquisition, modelling, analysis and management of spatially referenced data. [UWI Handbook]*

> *In the last 12 years, our Department really has outgrown its previous name... Our Department's new name represents the expanded scope of our academic offerings... [PD12]*

These definitions represent geomatics as a new discipline that has evolved from traditional surveying, mainly due to technology-induced changes. One expressed view was that the economic benefits offered by an expanded geospatial market is what underlie the rebranding of the discipline. Thus, it is a pragmatic move for the survival of the surveying profession within a modern labour market that has opened up spatial data handling to a much wider field of professionals.

> *The name change reflects a deliberate effort to make our graduates more relevant to current industry requirements [PD12]*

In some contexts, the use of the term 'geomatics', appears to represent a strategic move to generate greater interest in the discipline. Some data from programme documents and course representative interviews, demonstrate the range of perceptions about the meaning of 'geomatics'. These are provided in **Table 10** and **Table 11.** In these tables, key concepts in the definitions are identified to highlight differences in the use of the concept. Together they demonstrate lack of agreement about the meaning and appropriate use of the concept 'geomatics'.

Table 10: Definition of geomatics as per programme documents

How programme documents define geomatics (samples)	Key concepts
Geomatics comprises the science, engineering, and art involved in collecting and managing geographically-referenced information... Geomatics became part of our new name to reflect the Department's expanding interests. This new term has also been adopted by governments and private industry across Canada and is becoming accepted world-wide. ...the term "Surveying" no longer accurately expressed the work we do and the knowledge we teach, we have updated our name to Geodesy and Geomatics Engineering. (UNB programme information)	Expanding interests. Better describes modern 'surveying' work and its contemporary knowledge field.
Geomatics is an exciting subject that combines the principles of geography and mathematics with state-of-the-art technology to help us manage, analyse, design and understand the world around us. Geomatics is employed extensively in civil engineering to make decisions about the best places to locate roads, bridges, buildings and offshore oilrigs. It is also used to measure and analyse changes to our world caused by climate change and natural disasters... Geomatics surveyors and engineers are in increasing demand… (UN, Programme Handbook, 2009-10)	Marrying of two disciplinary fields with technology. Has wide specialised applications
***Geomatics** is a cluster of several sciences built around spatial data and its measurement and visualization. Geomatics know-how is in demand in all parts of society, from spatial planning to mapping the rain forests, from personal navigation to building virtual models.* [AU website]	Combination of several sciences. Has general applications

Table 11: Programme representatives' definitions of geomatics

How programme representatives define geomatics (samples)	Key concepts
We want to change the title to Geomatics. This is to cater for the inclusion of GIS and Remote Sensing in the course. Given the trends, the department felt that our course should reflect that change. I guess that there is also pressure from the fact that in the region this change is occurring [PR13]	Expansion in course content. Trend in other jurisdictions
The traditional profession is Surveying. They [professionals] never liked the word geomatics. That is why it was never accepted and as for registration it is the 'land surveyor' not the 'land surveyor and spatial information specialist', that's too much of a mouth full. The Board of Surveyors has expanded their name to be called the Board of Surveying and Spatial Information. So Australia is getting to at least recognize the twin –surveying and something called spatial information and spatial science. Not geospatial, not geoinformation, not geomatics but spatial. [PD9]	Term rejected though expansion in discipline is recognised. Doubling 'Surveying' with 'Spatial Information' an alternative to using 'Geomatics'
… spatial science is something that for someone not overly engaged has a bit more meaning than the word geomatics. I think part of the resistance to the word geomatics from a marketing point of view is that people know what surveyors do; they think they know what surveyors do. And the word's got a meaning if someone is looking for a career at age fifteen or so. Whereas the word geomatics or geomatician probably does not have that marketing focus. Wider than just a name to what's in a course can be that generalised as 'spatial' with GIS, remote sensing and traditional surveying. [PR10]	Resistance to meaning from Australia standpoint. 'Spatial' used in place of 'Geomatics'
To me geomatics is the science of geospatial data handling. That includes geographic data, however it is manipulated or processed in computer based systems, which is what GIS is. Geomatics is a very broadening subject, you learn everything from plate tectonics to land law. It is quite wide in terms of that discipline and you shouldn't regard it as narrow. [PD4]	A widening concept that incorporates many sub-disciplinary areas.
In the last 12 years, our Department really has outgrown its previous name... Our Department's new name represents the expanded scope of our academic offerings... The name change reflects a deliberate effort to make our graduates more relevant to current industry requirements… [PD12]	Expansion in academic offering. Relevance to contemporary industry requirements.
Most academic institutions and practitioners have embarked into GIS. However, only one university in South Africa has changed the name of their programme to geomatics, all the others are still Surveying. [PD15]	Combining GIS with Surveying. Not widely used in South Africa

Furthermore, even the titles of the programmes reflected the perceived change in the professional and academic fields. In fact, very few of the programmes used 'surveying' as the sole label in their title. Also, at least one programme representative indicated a desire to change their existing course label to 'a more modern title'. Some examples of course tittles are 'Surveying and GIS' (UTJ), and 'Surveying and Spatial Information Systems' (UNSW). Others used the more modern, for example: 'Geomatics Engineering' (UWI) and 'Geoinformatics' (UWH). The interview data suggested that programme titles not only reflect content but also trends:

> *Many countries within our region have been using the term geomatics to account for the changed nature of the profession. In one country they are now called geomaticians but we are not yet sure what surveyors will be called in our country once we have changed our programme to geomatics. [PR13]*

Though several of the programme representatives expressed support for the use of the more modern terms, one PD expressed a dissenting view. He intimated that the use of more modern terms may not accurately reflect what their course offers:

> *Even though we talk about spatial information, at the end of the day most people see them as being surveying courses. You can dress it up anyway you like but at the end of the day, students see it as using a total station and CAD software and surveying software. It's difficult to convince them that when they graduate they don't have to actually practice surveying but that they can actually go into a GIS role. The reality is that they could, but the perception is that it is too overloaded with core surveying, hard measurement and adjustment courses. [PD]*

It was shown that the nature of the local surveying industries was a key factor in determining the appropriateness of adopting the new label. In fact, in some contexts such as the state of New Mexico, USA, the term surveyor is still considered to more appropriately describe the professional. In the Caribbean, though one university has changed its programme title to Geomatics Engineering, the professionals in this region are still referred to as surveyors and are not largely viewed as engineers, even though they are sometimes involved in engineering projects.

This scenario points to another distinguishing feature of the courses, which is the designation of some as engineering programmes and others as not. Of the three African universities represented, only BU uses the label 'engineering' in its description of its surveying course. According to a senior academic from that university, *'graduates from the programme generally obtain certification as engineers who can carry out surveying functions.'* In this context, there is no unique certification for professional surveyors. To further show the variations in how this issue is perceived, one Australian university reversed its decision to name its programme *Geomatics Engineering* and reverted to its earlier title of *Surveying* coupled with *Spatial Information Systems*. Its PD, however, insisted that one of the specialisations offered in their programme is indeed *'an engineering course as it has close ties to civil engineering, infrastructure and land development.'* The decision to revert to the old course title was partly due to rejection of the new terminology by industry. The PD asserted that:

> *the FIG definition of the surveyor being much broader than the measurement specialist but including land development, land economics, land valuation and so on. That has never been embraced in this country. The profession here for the most part is very conservative. The registration of the cadastral surveyor has nothing to do with, GIS, Remote Sensing and GNSS and so on. So the traditional profession is surveying and that is still is. They never liked the term geomatics or geomatics engineer. That is why it was never accepted.*

By examining the responses from the programme representatives, it became evident that there is widespread uncertainty about how to position surveying/geomatics programmes since they are not viable on their own in most universities in the study. Some of the universities have sought to offer joint degrees with surveying/geomatics paired with other areas such as economics, business management (e.g. UNSW) and some more closely related areas of geography (e.g. UN) and civil engineering (e.g. UEL). Surveying in some of the universities was formerly only a supportive unit for other areas such as Civil Engineering, Architecture and Archaeology. Now many are faced with the challenge of enrolling enough students each year to meet university quotas.

Thus, it seems that the decision concerning where to administratively place a geomatics/surveying programme within a university has been primarily motivated by economics. Notwithstanding, it was found that its impact is more than economic. It is asserted that this issue of the geomatics paradigm is also an issue of positioning surveying courses to make them more attractive to potential students. Also, it needs to be recognised that the associations forged within these programmes impact on the dispositions of surveying staff and students. The findings suggested that the impact is likely to have a negative effect as it may coerce conformance to the dominant doxa which is more likely to be generated and sustained by the larger programmes within the administrative unit as suggested by one PD:

> *We are with the Civil Engineers and they are a much larger group with well-established and popular courses which are oversubscribed every year. That field is much larger than ours and this even means that they have far less challenges in finding academic staff with appropriate qualifications. We have very few postgraduate students. Our discipline is just not as popular or known. [PD4]*

Whereas a few of the programmes enjoy a steady flow of applicants who are easily absorbed into industry at graduation, as indicated by the representatives from UWH, AU and OU, the majority of the other programmes strive to diversify their offerings not only to attract students but to expand their graduates' employment scope.

> *We want to open up opportunities for our graduates so we allow students to choose other disciplinary areas from a wide field to study along with our course. We believe this will enhance enrolment as well as improve the graduates work prospects. [PD9]*

Administrative linkages & inter-disciplinarity

The geomatics paradigm is related to issues of administrative linkages and inter-disciplinarity. While many of the universities have located their surveying programmes within engineering units, most of the programme representatives did not consider surveying to be an engineering course. An exception is NMSU surveying engineering programme. Its PD explained that their programme recently obtained engineering accreditation status and so is legitimately an engineering course. This change is reflected in the course title which before the engineering accreditation was labelled 'BSc. Surveying'. This change, according to the programme director, '*was considered necessary as a means of better positioning the graduates in industry*.' He further explained that the graduates from an engineering accredited programme, within this North American state, qualify for certification as engineers and that this offered both cultural and economic capital since it is seen as enhancing recognition in the wider engineering industry and improved remuneration.

The PD added that efforts to acquire engineering credentials dictated changes to the curriculum to include more design criteria. This, he stated, was a requirement of the professional accrediting body which in this context appeared to have a significant impact on the *field*.

> *Engineering Design was added in the senior year and some of the existing modules were revised to increase the design aspects to satisfy engineering accreditation requirements. [PD]*

It is asserted that the administrative location of surveying courses, and by extension the associations, forged with other academic units within the universities, convey particular *capitals* on the *field* of surveying/geomatics education. The associations are quite diverse among the studied programmes. To demonstrate the variations- UEL's surveying programme is located within a School of Computing, Information Technology and Engineering while UN's geomatics programme is within the School of Civil Engineering and Geosciences. The programme director of UEL stated that this arrangement is only for reason of efficiency in administration.

> *A surveying qualification is not considered to be an engineering qualification. It is qualification in its own right. Our surveying programme is a Bachelor of Science, the Civil Engineering programme is a Bachelor of Engineering. Them being together is really only due to an internal administrative grouping.*

UN's geomatics programme director stated that the administrative location is based on economic expediency. He explained that the surveying programme had been situated in a Department of Sciences in earlier years and for a short period operated as an independent academic unit. The PD stated that this arrangement could not be economically sustained due to its relative small size. Though not overtly acknowledged by the PD, links made with other academic departments can enhance interdisciplinary within surveying courses through arrangements such as shared classes with students from different disciplinary groups and the introduction of subjects from one disciplinary area into another disciplinary area within the same administrative unit (as demonstrated by the UTJ School of Building and Land Management course outlines). However, this reality also appears to impact negatively on the dispositions of surveying staff which may also impact student habitus. This was mentioned earlier as an imposition of the *doxa* of the dominant group where accepted norms and practices may be based on other disciplinary fields. This will be further explored in the analyses of the case studies.

Geomatics as an image booster

Amongst programme representatives, there was a popular view expressed that surveying was constrained by its smallness relative to other professions in both educational programmes and practice. The constraints that it is believed to put on surveying is an inability to determine its directional course as an autonomous unit or to confidently promote new functions in the new paradigm. Both professional surveyors and programme representatives indicated that within societies there are limited understandings and low perceptions of the functions of the modern surveyor.

> *The learned people in rural towns used to be the local minister of religion, school headmaster and land surveyor. Currently, the number of surveyors in the population is so small that it is a rather unknown profession. (PR15)*

> *There is something about the mentality of surveyors. They do the chartered surveying course and they do what they are asked to do by the client but they are not good at really promoting their capabilities and their role in society. This means that society does not have a full understanding of our full competencies. (FIG President)*

The FIG president's comment identified a particular disposition of surveyors that impact negatively on how they carryout out their functions. It is believed that this influences how the profession is viewed by society. The earlier comment by PR15 reflected on the cultural capital held by surveyors in the past. Thus, there is a sense that the surveyor has lost his/her former elevated status and is now faced with the need to elevate the image of the profession. It is asserted that this scenario negatively impacts not only the habitus of professional surveyors but also of those agents within the field of surveying education who are aware of the state of the field. As indicated by another programme representative, it is believed that the rebranding of surveying to geomatics will help to improve the image of the profession.

So much of what surveyors used to do is now being done using high tech instrumentation and machinery. I perceive that surveyors will become more involved in project management and spatial data management. Geomatics may be a way to help us and others see that we are a changed profession. [PR8]

5.5 Theme IV: Academic-vocation dichotomy

A major factor that emerged as impacting surveying education, is the degree to which the courses 'emphasise technical competence versus academic. The emphases, as inferred in the course documents, in some instances targeted more vocational/professional knowledge and skills. While in others, the objectives appeared to be less focussed on vocational readiness; but more so on development of disciplinary knowledge with a more theoretical focus.

The expressed dissatisfaction, of the profession in many of the contexts, is two-fold. On the one hand industry/employers indicated dissatisfaction with the level of technical readiness of the graduates:

The graduates are not as they were in the past. They are not technically ready to take on many of the tasks we do in industry. Perhaps the universities are too theoretical in their approach. [PR]

On the other hand there is an expressed dissatisfaction with the graduates' capability to ascend from one level to a higher one within industry:

The graduates are employable but not promotable. [Industry Representative]

These popular perceptions of surveying graduates demonstrate the need for an education model that develops technical skills while it conveys theory and promote dispositions that set students on a path to continuing professional development.

In an effort to understand the vocational-academic tensions, some interview responses are analysed. For several of the representatives of professional surveying organisations, practical competencies for work were posited as critical course objectives.

Surveying/land surveying/geomatics is a vocational area of practice. We need practical people who are able to bring a broad-base education into practice. [RICS representative]

Programme representatives also expressed support for the vocational emphasis of the courses. One senior academic commented that '*it is folly to consider a course in surveying as primarily an academic discipline'*. He and others agreed that surveying education should be primarily industry sensitive and that their successes can only be measured against how well they prepare students for work.

Many of the programme documents indicated that the courses seek to develop scientific and technical competencies which are demonstrated in students' ability to relate theoretical concepts to practical work. To ensure that the skills learned within a course have relevance to professional practice, there needs to be some mechanisms in place to develop those competencies. Programme documents and interview responses from programme representatives suggested that there existed a range of arrangements with regard to theoretical and practical content and emphases.

However, though there appears to be agreement in what academics and professionals see as critical course objectives, there are underlying differences in what each group values as a sound professional education.

Some of the universities included in this study employ field courses (residential field camps for a week or two) as an approach to consolidating and amplifying the instruction given in classrooms and through smaller on- or near-campus field exercises linked directly to the lectures. These field courses offer the students extended field surveying exposure in more authentic settings than may be available on campus. In these contexts students are required to put surveying techniques into practice in simulated or real surveying problem settings. Representatives from the programmes that have field courses, highly value the learning that the field courses offer. As put by one programme representative '*it is during these field courses that many students make a useful link between theory and practice as it relates to use of equipment and software in solving relatively large scale surveying problems.'* Some programme representative indicated that due to economic constraints, field courses have either been reduced or discontinued. The limitations on filed exposure within courses have led to some pedagogical innovations. One such example is NU's e-learning tools for field techniques.

Some programme representatives agreed that even courses involving intense practical exposure have limitations, since as one expressed, '*authentic learning can only occur in real work settings'*, which offer experiences that cannot be fully planned for in a simulated setting. However, the experiences gained in field courses do have value and can be counted as an important step in developing the technical competencies surveying students will need for professional work. Several programme representatives also stated that field courses help in the development of more generic skills such as teamwork and resource management. The social interactions with clients, surveyors and other professionals on real jobs and all that comes in these settings can be obtained through work-based learning. Internship or work-based course elements are part of only few of the curricula in the study. Several PDs expressed that though work-based learning is *desirable for preparing students for work*, this arrangement was not a practical option. One programme representative indicated that their inability to include work-based learning within the course was '*due to resource constraints. So we have to find creative ways to teach some of those work-based competencies [PR].*

While practical competence is seen as an important learning objective for surveying courses, there also emerged a concern with another dimension of education. The comment from one programme representative identifies a desire to not only prepare students with practical competencies for a vocation but more importantly to educate:

> *Surely surveying at this level has a vocational focus. But we are not merely teaching we are educating. We are not teaching instrument skills, we are teaching engineering design principles of problem solving skills that can be applied to novel circumstances. We use industry examples…the whole issue is the principles that govern what we do. So yes, there is some skill formation and there are instrument skills that are picked up but they are not different from instrument skills that one expects from mechanical engineers or civil engineers. The understanding is that they will be educated to solve problems, educated to lead the project teams, to lead the field parties and to be able to think on their feet. Surveying is taught within engineering framework which is rooted in industry, rooted in vocation but nevertheless is built on the understanding that every problem is slightly different therefore demanding flexibility. (PD9).*

Some programme representatives attempted to make a distinction between vocational preparation and professional education, but the distinction was not clear. The varied comments on the matter, point to an underlying tension in resolving this issue. While both elements of education are important, there is a need, within surveying courses, to find a fit between both aspects that satisfies university requirements without compromising professional standards and expectations. Where should the focus be, and how might we arrive at an effective balance that optimises students learning opportunities in a way that effectively prepares students for professional surveying/geomatics work?

Summary of findings

The curricula are analysed not merely to explore their differences and similarities, but more importantly, to consider what may be underlying factors influencing curriculum choices. It is also believed that a clearer understanding of the nature of the relationship between the agents in the field will enhance the development of an improved educational model.

The preceding findings have highlighted disciplinary focus and profession-orientation as highly valued capitals within the field of surveying education. The data suggested that most of the surveying curricula studied have highly specialised disciplinary foci. It was clear that some programmes incorporated elements of general education while fewer offer scope for cross-disciplinary options, but the data strongly suggested that high specialisation is a prominent *capital* within the *field*. This finding is particularly revealing in light of what the literature identifies as a general trend towards more broad-based learning in professional higher education (Vaatstra & De Vries, 2007). The reality in surveying education does not manifest a noticeable shift from discipline-specific knowledge and competencies to more generic knowledge and skills. However, the literature also challenges the relevance of increased generic elements in highly specialised disciplines such as medicine and engineering (see e.g. Harwood, 2010). This latter view seems more relevant to the research findings since surveying, even within its wider geomatics context, is presented by the data as a field that prepares individuals for the profession in very specific ways. The following comment by a programme representative expressed this view:

> *In the context that we are a School of Surveying and we are a professional school, we put ourselves on par with lawyers, dentists, pharmacists, doctors*

and so on. We are particularly training the students, providing an education for the students for a particular market. [PR 8]

Furthermore, the knowledge content may range from high specialisations to wider geomatics exposure, and may include some elements of related fields such as civil engineering and estate management depending on the career focus of the students and the nature of the profession in particular countries. Outside of these areas, most surveying/geomatics curricula in the study offer very little else in terms of more generic knowledge and skills content. The structures, as expected, showed conformance to university expectations in terms of credit distribution and the progression of module levels in the programme. The number of general education subjects such as mathematics and communication, elective subjects and the options to do majors and minors are all institution-related arrangements. What appears to be of great relevance to surveying/geomatics education is the constitution of intra-geomatics features within the curricula. While some programmes maintain traditional surveying as the dominant element, the data point to a trend in offering wider options within the geomatics spectrum. When viewed together, the structure of the programmes showed variations in the how content focus is distributed over the periods of the programmes. Within this realm, it is argued that in countries where the profession has a dominant influence on the education system, the programmes are more industry sensitive and more highly specialised.

The five-year model is described by those programme representatives within those programmes as providing a more broad-based education at the undergraduate level, allowing students to learn the expansive array of geomatics related knowledge and skills without significant concentration on any one area. Specialisation they believe is better fostered with students who have had this broad-based education. The specialisations are therefore offered at the postgraduate level within this model. This approach has some resonance with how Smits, Veebeek, et al. (2002) described an approach to medical education in the sense that they see undergraduate studies as concerning increasing knowledge and skills and postgraduate studies as improving physician competence and performance in practice. One AAU academic and FIG officer expressed that, within the Danish context and perhaps wider, a three-year full-time education is inadequate to educate students for professional engagement in the surveying industry.

The European programme was traditionally 5 years for a Master's. It is now split in a 3-year Bachelor and then a 2-year Master, within kind of one programme. Some programmes can do it but it does not suit Surveying. Within the Bachelor you will never get to the precision you like. It will take at least 4 or 5 years to produce graduates with the required profile. [Senior academic, AAU]

The examination of the fifteen curricula together, showed that surveying education involves a broad and extensive knowledge base, much of which is covered in undergraduate studies. Programme representatives responses suggested that primary objectives of the courses are to widen the disciplinary knowledge-base of students and develop work related competencies. This latter area is not specific to graduate studies excepting perhaps with the AAU and AU programmes.

The findings have shown that surveying courses generally have a strong emphasis on knowledge and skills application to practical problem with a primary technical focus. This makes surveying a purposive and pragmatic discipline. These can be viewed within the frames of Becher's (1994) groupings of disciplinary knowledge and culture. Within this framework, the more technical and traditional aspects of surveying are best categorised as a hard-applied discipline. Furthermore, since surveying is shown, in some contexts, to incorporate aspects such as land management and GIS, describing it solely as a hard-applied discipline would be inaccurate. This is particularly true in this modern context of widening functions of the surveyor which has been described in Chapter 1. Where the surveying practice and education incorporate applied social sciences such as land management in a large proportion relative to the technical aspects, it is more accurate to describe the discipline as a combination of hard-applied with soft-applied cultures (Becher, Ibid.). **Table 12** illustrates the nature of surveying/geomatics knowledge and culture using concepts adopted from Becher (1994).

Table 12: Surveying knowledge & culture grouping (based on Becher, 1994)

Disciplinary grouping	Nature of knowledge	Nature of disciplinary culture
Technologies: 'hard-applied' • Measurement Science • Cartography	Purposive; pragmatic (know-how via hard knowledge); concerned with mastery of physical environment; resulting in products/techniques.	Entrepreneurial, cosmopolitan; dominated by professional values;
Applied social sciences: 'soft-applied' • GIS/LIS • Land Management • Land Administration • Estate Management	Functional; utilitarian (know-how via soft knowledge); concerned with enhancement of [semi-] professional practice; resulting in protocols/procedures.	Outward-looking; uncertain in status; dominated by intellectual fashions; publication rates reduced by consultancies; power-oriented

The study has shown that measurement science aspect of geomatics has a strong cosmopolitan feature as alluded to by a RICS representative.

> *The general course curriculum in the geomatics context is very similar in different countries. Geodesy is the same all over the world and I think as an area of practice we are quite lucky like that. It's fully global and international. So you could work here on site right now on a topographic survey. I could go to Kenya and carryout a topographical survey. There may be differences in the legal context if we are going into cadastral surveying but really the concepts are global. [RICS Geomatics Director]*

Soft-applied aspects such as those shown in Table 6 are less certain in their approaches and possible outcomes. This, it is argued, is one likely reason for greater variations between programmes in terms of how these aspects are organised within the curricula and taught. Land management, for example, has a legal element that is specific to countries, and in some cases, to states within a country. These represent at least one element of differences among geomatics programmes.

There is strong evidence that within surveying/geomatics programmes, real consideration is given to providing employment related outcomes and not merely knowledge acquisition as identified by Atkins et al (1993) and Barrett (1994) and others.

Introduction to case studies

Having explored differences between fifteen surveying programmes, some key factors were identified. These included:

- Surveying programmes, though of varying durations tend to have highly discipline specific emphases with limited elements of general or more generic education.

- The field was found to have heavily guarded borders. Surveying academics were identified as one of the primary agents in border control. The academic staff appeared to be guided by strong symbolic capital that is associated with maintaining an academic image while, largely unsuccessfully (in the view of the profession), trying to promote the cultural and economic capital of offering a degree that has relevance to professional development.

- The surveying profession was found to play an important influencing rule in determining programme direction though to a lesser degree than the academic staff. It was demonstrated that the symbolic capital associated with academic qualification is less important to professional surveyors than the cultural capital of professional readiness. This in essence, describes the existing dichotomous relationship between the profession and the academy.

- The geomatics paradigm is a reality in the sense that it does influence the development of some of the programmes in the study. The philosophical basis for change in some of the programmes appears to be that surveying practice has changed and that education needs to prepare students for new professional roles.
- Another factor found to impact on programme development is the long standing challenge of attracting applicants to surveying courses. This was found to have impacted programme structure and subject compositions. The idea of liberalising surveying curriculum by offering a variety of intra-disciplinary courses appears to be more influenced by economics rather than the perceived paradigm associated with geomatics. Therefore, for some programmes the use of the term geomatics is more of a symbolic capital (an interest in enhancing the image of the programme) rather than a cultural capital (the desire to make the course more relevant to change in the profession).

This broad understanding of surveying education forms a useful foundation for exploring deeper issues that relate to both curriculum and pedagogical arrangements within surveying courses. As stated in Chapter 3, two programmes with distinct curriculum and pedagogical approaches were selected for in-depth case studies. The AAU surveying programme emerged as employing the most radical educational approach relative to the other programmes in the study. Within this programme, an educational model based on project-organized and problem-based learning has been used since the programme's inception (Enemark, 2004). The model is considered to have the capacity to adapt readily to changes that invariably take place within the surveying profession (Enemark, 2004).

The AAU surveying programme holds a conspicuous position within the surveying profession internationally, as it has been widely referred to as an example of innovation within the discipline (Enemark, 2002c). The former FIG president and former head of the AAU surveying programme, has published widely on the new direction that surveying education needs to take and exemplifies the surveying programme at AAU as an effective approach to preparing students to meet the growing demands of a changed and changing profession. Additionally, with on-going research into PBL taking place within the wider Alborg University, it offers an avenue to explore what has been found about the teaching and learning innovation and then to consider how these findings have been applied to surveying education within this context.

The University of Newcastle upon Tyne (NU) based on its location, offered non-problematic access as a case study. More importantly however, it represented a more conventional educational model, which was a good contrast to the AAU programme. NU's programme is one of two university-based surveying/geomatics programmes in the UK and the only one accredited by both the RICS and the Chartered Institution of Civil Engineering Surveyors (ICES). These accreditation statuses are seen as having a positive impact on how graduates from the programme are perceived within the profession.

The selected cases offer distinctly different approaches to curriculum architecture with interesting variations in the pedagogical approaches used. The cases were selected, not as representative samples of the wider community, but as a means of showing the diversities that exist and how the complex issues involved in preparing students for the surveying profession are negotiated in these distinct contexts.

The NU case will first be presented (Chapter 6) followed by the AAU case study (Chapter 7).

CHAPTER SIX

FIRST IN-DEPTH CASE STUDY – Newcastle University's Geomatics Programme

6.1 Introduction

Newcastle University (NU) is one of two institutions in England offering undergraduate degrees in surveying/geomatics. NU's programme document states that, the current range of taught courses was preceded by the joint degrees in science, which incorporated a (land) surveying element from 1964, and subsequent single honours programmes in surveying science (from 1976) and mapping information science (from 1992). Currently NU offers two single Bachelor's honours degree courses in geomatics with specialisations in surveying and mapping science (SMS) and geographic information science (GIS). The University promotes each specialisation in distinct ways. The programme document describes the SMS programme as having 'a bias towards the measurement methods used to collect land related data, although it also incorporates techniques of map production and map use in areas such as navigation, environmental monitoring and thematic mapping.' (NU, 2010) The document further describes the course as a rigorous engineering-based education. It further adds that graduates are sought after by commercial and public organisations involved in land, air and offshore mapping.

According to the documentation, the GIS degree concentrates more on the management of map and map-related data and the presentation of this to map users who include, for example, persons interested in property, engineering, planning, utilities and the environment. This course utilises available map data, how they are manipulated by computers, their structure and accuracy, the programming techniques which can be applied to them, and methods for managing and updating them. GIS is referred to in the document as a rapidly developing area and a wide range of career opportunities is said to be available to graduates in organisations ranging from public utility companies to suppliers of computer-based mapping technology. The programme documents also stated that SMS and GIS, may also be studied as part of a joint honours degree in science. However, at the time of the study, this joint option had its final cohort as it is being phased out (UN Programme Director).

Both single honours degree programmes are accredited by the Royal Institution of Chartered Surveyors (RICS) and the Chartered Institution of Civil Engineering Surveyors (ICES) (UN Programme Document, 2010). The programme director explained that the geomatics programmes have a total intake of 35 students each year which are divided between the two specialisations. The programme documentation showed that SMS has a larger student cohort than the GIS specialisation in all three years of the programmes. This comparison is in contrast with what was found in other universities in the study where the SMS specialisation had become the less popular specialisation option among students. NU's programme director stated that the programme has ten full-time academic staff and a staff/student ratio of 1:10. He added that there is further support from a full-time technician and a small cohort of postgraduate students.

6.2 NU's Curriculum architecture - Empirical findings

In the previous chapter NU's geomatics curriculum was described as highly discipline specific with minimal elements of general education, and with some scope for integration between the two specialisations offered. The description was based on criteria used to evaluate all fifteen curricula in the study. The criteria were based on analyses of interviews programme representatives and the programme documents. It considered the make-up of the curricula in terms of module types (discipline specific or general education) and the level of integration between traditional surveying and more modern aspects of geomatics. In this chapter, a deeper understanding of NU's curriculum architecture is explored. This will mainly be done through analysing the observations and interviews conducted within this in-depth case study. As outlined in the analytical framework (Chapter 4) the facets of curriculum architecture as proposed by Hawkins and Graham (1994), will be explored under four headings, two of which will be done under the 'curriculum architecture' theme and two under the related theme 'pedagogy'. Under the first theme, curriculum content and process, and programme duration will be analysed. .

6.2.1 Curriculum content composition & process

As demonstrated in chapter 5, the content composition of NU's programme relative to others in the study, was classified as highly structured and predominantly discipline-centred. Describing the programme as highly structured is based on the observation that the subject compositions and the order of subject delivery are mostly fixed. The following comments from the PD, a lecturer and a student illustrate wide agreement concerning this claim:

> *All the 120 credits in the first year are compulsory for SMS & GIS students. In stage 2 there is very little choice. The menu is fixed. It is not a matter of cherry picking modules and accumulating credits. There is a definite diet that they have to take. [PD]*
>
> *The curriculum takes a very pragmatic approach to the profession. In technical terms, I think the programme is very well structured. [Lecturer]*
>
> *There're only a couple modules to choose but I chose the degree for the modules that were there and I quite like the structure of it. I like the fact that all the modules are sort of related. [3rd year SMS student]*
>
> *In GIS we have more choices than they have in surveying but possibly a wider degree of modules available and more specialisations would be useful. [2nd year GIS student]*

The first comment demonstrates the PD's claim of a rigid programme structure with minimal subject choices. The second and third quotations show students' acknowledgement of the rigidity of the structure. Importantly, the responses from many students also showed a general high level of support for the rigid and discipline-focussed curriculum. However, some students were of the view that a less rigid curriculum would offer added benefits (fourth quotation is an example).

Unlike programmes such as UTJ and OU's the geomatics curriculum at NU does not include general education subjects such as Communication. Though comments from lecturers suggested that communication skills are embedded in some of the specialised modules, there was an indication that students could benefit from including some general education modules as a separate subject:

> *We have thought about incorporating Communication as a separate module. A number of students struggle with their written communication, even home students. The students actually do quite a bit of communication exercises throughout the different modules. Some of our classes have seminars, tutorials and so on where students have to give presentations or they have to do written exercises. But they don't get formally assessed in their ability to do that other than through those mechanisms. [Lecturer]*

Another feature of NU geomatics curriculum architecture, brought out in the analysis of staff and student interview, was the incremental and systematic approach to building knowledge and skills. Comments particularly from the PD and lecturers, spoke of a deliberate and systematic progression from basic knowledge and skills to more complex concepts and tasks.

> *At Stage 1, the curriculum focuses on teaching the basic knowledge and building the basic skills. At the field course things really begin to jell in terms of adapting to teamwork and the need to address longer term problems and longer term tasks. After that we do have a greater expectation of the students in terms of their own personal input in the education. [PD]*

> *Our senior students would have covered all the basic knowledge and competencies in the early year of the programme. We expect that they would be able to show more complex skills in the senior years and we demand that of them in the level of work they produce for assessment. (Lecturer)*

Whereas staff broadly agreed that the demands on individual students are increased incrementally as they progress in the programmes, some students expressed the opinion that the 3rd year is the least demanding year.

> *The second year is the hardest year with some difficult modules and many lectures with coursework. The final year is much easier, we do not have as many classes as we are expected to be working on our major paper. (3rd year student)*

This student's evaluation was based on the degree of freedom from scheduled lectures and written assessments. In contrast, comments from the PD and lecturers placed a greater value on increased student self-direction and the resultant reduced demand on lecturer guidance in the acquisition of knowledge and skills, and the production of assessment related artefacts. This demonstrates an orientation of the students largely informed by assessment. This is further developed later in this chapter. At this point, it is useful to state that this is an issue that impacts students' work-readiness. It is argued that where an increase in learner self-direction is perceived to be the same as a drop in learning demands, something is to be said about the learners' lack of awareness of the values associated with taking increasing responsibility for one's own learning. This latter position is seen as most appropriate for work in the geomatics industry which is described as unpredictable and ever changing (Enemark, 2004 etc.).

6.2.2 Programme duration

In looking at the variation in course duration amongst the fifteen programmes (chapter 5), NU's geomatics programme was identified as one of three with the shortest duration (three years). The PD suggested that there is a direct relationship between the course duration and the work functions the graduates are expected to engage in. This he made in direct reference to England, identifying that other countries require a longer time for their surveying courses because of the wider range of functions carried out by surveyors in those jurisdictions.

> *We have 3 years intensive study – 1000 days for the students in university and after that they are out in the world of work. Whereas, in countries like Denmark and Germany, where they have 5 year programmes for surveying, their students can be exposed to a wider area of geomatics. For some of these countries, surveying is much wider than here in the UK so their curricula have many more things in them. [PD]*

This variation in course duration has implications for mobility of students who, for example, desire to do aspects of their courses in a university outside of their country. Schemes such as the European Community Action Scheme for the Mobility of University Students (ERASMUS) have facilitated the movement of students from other European countries coming to study at NU. However, as the PD explained, NU's programme structure does not lend itself to student exchange in a way that benefits NU students:

> *We have had a large number of students from Germany. But it's harder for us to get our students to go over there to take time out of their 3 years progressive studies with lots of prerequisites and a pathway that build on previous work. For them to go off for a semester, outside NU if they came back they would be missing out on stuff that are fairly fundamental to what they are going on to do. And there are issues in sending students across there from an accreditation point of view.*

There is growing interest in establishing international guidelines for surveying practice and education (Goodhead, 2011). However, variability of course duration could undermine such development. It seems that, as far as professional mobility is concerned, there is a question of parity of qualification for NU geomatics graduates. This is a particularly relevant concern in light of the practice of a 5-year programme to Master's level in some European countries as discussed in chapter 5.

6.3 Pedagogy and the impact of academic staff and student habitus

The analysis of pedagogy is justified by the numerous instances in which teaching and learning strategies were mentioned in the staff and student interviews and the many insights garnered from observing pedagogical activities. Particularly, the analysis of the staff interviews showed an overwhelming perception amongst staff that their education culture was ‘traditional’. As seen in the comments from the PD and a lecturer, this characterisation relates specifically to the pedagogical approaches employed. They explained that delivery of the course content was largely lecture-based supported by practical classes (labs and field exercises) that reinforce the theoretical concepts.

> *The teaching methods and the way the curriculum has developed; the methods of assessments and the way in which we engage with the students, are fairly traditional. I have been at this university for more than 30 years and really there are some things particularly in how we teach, that have not changed at all and there are others things that have changed only slightly. [PD]*

> *Our teaching methods are quite traditional; we stand in front of the class and talk. But we do make use of the technologies; and we have the virtual learning environment which is used throughout the university. So there are some tools that we do use that have some effect on the teaching methods but we are still traditional. [PD]*

> *We serve up information through Blackboard online system. A member of staff has done some work on Virtual Field Course. So we try to bring those in to support the student learning. Rather than replace what they are doing it is there as support, not really revolutionising what we are doing. [Lecturer]*

The comments suggest that though lecturers use modern teaching tools to varying degrees, there remains a general traditional approach to teaching and learning at NU. The approaches used appear to lean heavily towards knowledge transmission and guided skills development driven by assessment. This latter finding is further discussed later in this section.

Students generally provided positive feedback on the pedagogical approaches used. Judging from their comments, they valued the structured lecturers with pre-stated learning objectives and the written materials issued to them by lecturers. Additionally, the majority of the students stated that they found the practical sessions most important for learning geomatics. There was an expressed expectation for close staff supervision in the learning activities. These findings are demonstrated in the following student comments:

> *The lectures are good, they are well structured and they have defined goals that I find useful. They are always sort of leading on. I quite like the fact that there are practicals on virtually every module. So whatever skills you do learn you can relate them. They are well tailored for learning what we are about. [2nd year student]*

> *I did not really understand what was the full concept of what was being taught in the lectures till I had done the practical and after the practical I got a better understanding of what was going on. [3rd year SMS student]*

> *A lot of our practical exercises are supervised to put you in the right direction but after the practical we sometimes carryout independent work. Going off on our own probably happens more at Stage 3. [3rd year student]*

6.3.1 Pedagogical implications for disciplinary differences

Comments from the PD and some lecturers suggested that there was a recognised relationship between how geomatics subjects are taught and the nature of the particular subject area. As has been identified in the literature, disciplinary cultures have an impact on pedagogy and are an important aspect of higher education pedagogy (e.g. Shulman, 2005). Within NU geomatics programme, disciplinary differences are seen as a factor that influences pedagogy. Some of the comments from the lecturers alluded to differences in how physical geography students learn relative to geomatics students:

> *We have a joint degree with physical geography. A lot of the geography modules they do is based on theory. They have the lectures and then they write an essay. It doesn't work like that obviously in geomatics. It's a more hands-on- it's a lot more practical. The lecturer has to be prepared to spend more time on it than just preparing a lecture and getting student to write essays. [Lecturer]*

> *The geography students can write well, having been taught to write a good essay from the age of 16, whereas, geomatics students have been doing science subjects in A'levels with not a lot of essays to write. And if you are able to write well in a subject like geography, you are unlikely to fail. The way you have been taught from the age of 16 – you have the structure, a narrative piece of text, then it's very difficult to fail that. Because someone who is marking a geography project will not say – you are completely off track here, you have completely the wrong idea. Because there isn't really a correct answer.*

\Somewhere in the 10000 words, even a poor geography student will be able to put in some good ideas. Whereas a geomatics student may go completely off track. He may do an experiment, a task, a measurement exercise in the wrong way and be completely out of sorts when it comes to the way in which the data is handled and processed and analysed. They may get the complete wrong interpretation of the results. Therefore, it is quite easy to fail when it comes to a more technical form of exercise. [PD]

The comments do not so much identify differences between geomatics and geography as fields of study, but more so the perceived differences between the students who access each programme. It is important to note that there is recognition that pedagogical approaches are more effective, if consideration is given to the dispositions and abilities of the students. In this context, a link is made between students' entry standards and school experiences, and the pedagogical approaches that may work best at promoting learning. This consideration highlights the need to understand the dispositions of the students. These are explored in the following sub-section using some understandings of the concept of habitus as presented by Bourdieu (1984).

6.3.2 Student habitus & pedagogical implications

A look at the habitus of the geomatics students is a consideration of their dispositions towards knowledge and skills acquisition and an explanation of how they engage with the geomatics education field and the agents within it. This is explored as an important component to understanding the pedagogical arrangements within the programme. The sub-headings utilised in the following sections represent what were found to be characteristic features of students within NU's geomatics education field based on the data.

Disciplinary Novices

According to the PD, 'the majority of students in the geomatics programme are school-leavers' with minimal or no work experience. As is typical of universities in England, these students are selected through a central organisation through which applications are processed for entry to higher education. The PD also noted that 'there is an increasing interest from students coming from [other] European countries'. Of the over twenty students individually interviewed there were three students from other European countries, two of whom stated that they started their current course immediately after leaving school with no work experience. A small cohort of thirty-five students is targeted each year for the geomatics courses:

> *We set at target of 125 students per year for this school and 35 of those are for geomatics and 90 for civil engineering. [PD]*

NU's geomatics students are, therefore, mostly school leavers with no work experiences and so are novices in regard to the subject area. A comment by a lecturer shows that specific pedagogical strategies are adopted to scaffold the learning of students who are new to geomatics:

> *We do need to walk these students almost step by step in the early stage as they come to us with very little relative to what we expect them to become by the end of the programme. [Lecturer]*

However, it was shown that even students who have prior knowledge of geomatics may need a different type of scaffolding since, as the PD stated, 'they may be accepted onto the programme as mature students who do not necessarily satisfy the traditional requirements that we expect from new school leavers.' Mature entrants, it was said, may need special support particularly in mathematics. Be that as it may, these students are perceived to have the potential to enhance the learning experiences for the majority of the students who do not have work experiences. From the analyses of students and lecturers' interviews it is seen that prior learning is recognised to be an advantage not only to the students with work experience but also to their fellow students. As the two comments below show, having these students in the programme is seen as enriching the learning experience in three ways: firstly, such a student is able to bring work-based practice to bear on his/her own knowledge and skills development in the university context; secondly, the lecturers can draw on the experiences of those students for illustrations of application of theory into real life situations; and thirdly, students without experience can learn from observing the work and attitude of more experienced students.

> *I have worked with a big civil engineering company doing survey work… I think it was very important to my education… At stage 2 we had a group assignment to carry out a survey on a building. I found that the knowledge I had; the methods and the reality of the survey world I could bring into my studies. I find that really pretty useful. (3rd year student with work experience)*

> *One of the members of the group I was working with had gone and worked for a survey company. I think the difference was in the approach to how he went*

about work. We all had the same knowledge but his approach to work was different. He was able to think not just about what we were doing but why we were doing it. (3rd year student without work experience)

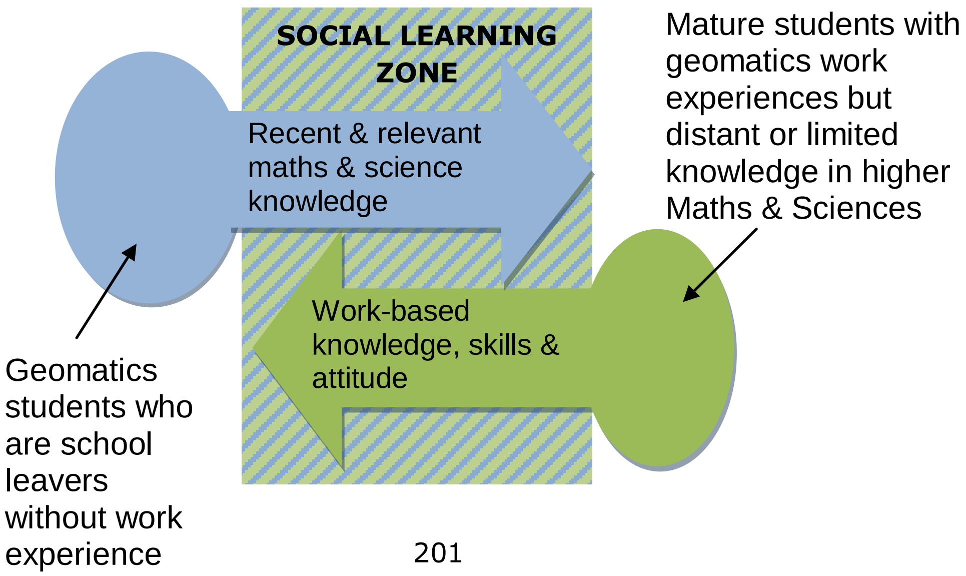
A few of our students have worked in the geomatics industry and bring those experiences into the education programme. These can be very useful in helping other students to have some understandings of how the theory they learn can be applied in work. (Lecturer)

Equally, the mature students are seen to benefit from the shared learning experiences and the interchange that this affords. This was identified as particularly useful in supporting mature students who the PD identified as ‘more likely to have under-developed knowledge in mathematics and sciences’ relative to those who are recent school leavers. The comment from one mature student supports the PD’s claim:

We learn a lot from each other. I share a lot with the younger students about my experiences from doing actual surveying work and there is much that I have learned from some recent school-leavers who have done far more maths than I did many years ago in school. [3rd year student]

This highlights that there is an important social aspect of learning within the geomatics programme at NU. This learning enhancement relationship is illustrated in **Figure 15** in which the ‘social learning zone’ is shown as an important element within the geomatics education field. The diagram illustrates the input from each group of students that contribute to the social learning environment. Later in the thesis, this social learning concept is further developed in regard to its relationship with other features within the developing model of surveying/geomatics education.

Figure 15: Illustration of social learning in geomatics



Diverse Career Goals

Markedly, the student interviews suggested that NU's geomatics students have diverse career aspirations. Although some students indicated a decided interest in working within the geomatics industry after graduation, others indicated uncertainties about career aspirations as well as interest in areas typically not associated with geomatics.

> *I am looking to go into GIS. [3rd year student]*
>
> *I dropped out of another university programme to start this one because it is quite a vocational course that we are taught. I will have the skills and knowledge to work in the Geomatics industry after graduation. [3rd year student]*
>
> *I find the practicals for Remote Sensing are quite good at teaching what you would actually have to do if you went into that type of work. I am planning to go into Remote Sensing. [3rd year student]*

These three comments show clear interests in geomatics work, but others indicated much more diverse interests:

> *I would like to be a RAF pilot. This course will help me to achieve this goal. (2nd year student)*
>
> *I may find work related to my degree when I am finished but I wouldn't mind working in the academic world. [2nd year student]*
>
> *I have been offered a job by the firm I worked with, but I want to continue academically. I think NU is set up for that since late modules probably have very little significance for going into land surveying. I think it covers it sort of professionally if you are going directly into a job; it opens up a real broad range of jobs like surveying and many other aspects so you can diversify if you choose. If you choose to go into land surveying then some of the modules may not be appropriate. I think having a board range of exposure is more appropriate because people do change over the 3 years. [3rd year student]*
>
> *I haven't decided yet. My aspiration is to proceed to further studies, to PhD probably. [3rd year SMS student]*

These latter comments do not speak of a disinterest in surveying but rather a perception that geomatics opens up a wide spectrum of opportunities to students that may include surveying or GIS related work, further academic studies or work in non-traditional areas. This student perception reflects one PD's comment:

I see Geomatics as a very broadening subject. I would be happy to hear that Geomatics graduates are working in non-traditional areas. Maybe as a teacher, or a store manager, or join the other 70% of graduates who are not getting jobs that are discipline specific. They are on the milk round and are seen as management material. [PD]

In spite of the PD's perception he admits:

the vast majority of students regard the degree course as vocational, as a passport into industry. We do not say this to them, rather we tell them that they will possess a degree that will allow them to do a large number of things in different areas and it will not necessarily be restricting in term of what they can do. So the vocational element is almost by accident.

The findings from the student interviews, however, show wide disagreement with the PD's belief that the majority of students see their degree as a passport into industry. Three of the comments from students (previous page) showed interest in higher geomatics education. Another student comment offered one possible reason for students' interest in further education.

When I came I thought I was definitely coming to do a degree to get a good job in some sort of survey or engineering department. And I think my drive was for that. I went to work for a company for two summers worked with the survey department. They have offered me a job afterwards but I think the degree for me has changed me as I want to continue academically. I think probably in Newcastle it is more set up for that, the late module probably have very little significance for going into land surveying. I think it covers it sort of professionally if you are going directly into a job – it opens up a real broad range of jobs like survey and in many other aspects so you can diversity if you chose. [3rd year student]

This comment suggests that the nature of NU's Geomatics programme may be a deterrent to students' interest in industry-based work and a stimulus for post-graduate studies. This notion is further discussed under the theme 'academic-vocation dichotomy'. The student comment also indicated that surveying work experience may also be a deterrent to work in the geomatics industry. This was corroborated by another student who said:

After working a couple summers with a surveyor in a range of projects I have decided that I don't want to work as an actual surveyor. I may not have been able to decide that if I had not gone to work. It is really good experience and I *really learned from it but I think I have now decided that I can do more with my degree than go and work in industry.[3rd year student]*

The data support the conclusion that NU's geomatics students see themselves as having a skill and the knowledge base for vocation, yet not limited to a narrow field. It is surprising that a programme with such a strong vocational ethos can, at the same time, engender this perception of choice and breadth.

Image-related Insecurities

Consideration of how students perceive their programme relative to other university courses can also provide insights into students' dispositions within the field. It is also relevant given the challenge of student recruitment as demonstrated in chapter 5. One of the implications is that entry requirements for geomatics programmes are lower than those for more popular programmes. The PD explained how entry requirements vary in the University depending on demand for particular courses:

> *Comparatively our offer is amongst the lowest of the University for the Entry Courses. Physical Geography is BBB, Geomatics is BBC. Agriculture you can probably get in with CCC but many other places – medicine and law you need AAA. So we start on average with quite a relatively low level for our students. [PD]*

The entry level of students has implications for curricula and pedagogy. The PD explained how this has impacted the curriculum:

> *We have had to introduce two maths modules for students who come in with a low grade in A'level maths. Students really struggle when they are weak in maths so we have to find a way to strengthen their maths base. It does make an impact on curriculum. [PD]*

A surveying lecturer explained how teaching students who have diverse abilities in mathematics influence how he sequences the content and the pace of his delivery.

> *I teach surveying to a class that combines geomatics students with varying mathematical abilities. Whereas I can most often, accurately assume that the students with good A'level maths will catch on quickly to many of the mathematical concepts we cover in this module, others do not and we can't leave them behind. As you will observe, I firstly will make sure that they understand the concept of basic trigonometry through the method of vertical heighting with total station. That they can grasp basic sine, cosine, tangent; in*

terms of the outcomes from the skills they should have and are going to need to be able to compute vertical traversing by the time we go on the Field Course. [Lecturer]

It is, therefore, argued that lower entry requirements bring about the need to increase the module composition in the courses. Additionally, as indicated by the lecturer, it also impedes the efficiency with which lecturers can covey knowledge content. However, in spite of these impacts on curriculum and pedagogy, students are encouraged in the programme to have a sense of developing competencies that will be valuable to society as much as graduates from other programmes, even those with higher entry requirements. The comment from the PD encapsulates this belief:

Geomatics students are at least on par with graduates from other programmes, even the high status ones what attract graduates with the highest A 'level profiles. Our graduates have a significant value added when we compare what they come in with and what they have by the time they complete our Geomatics programme. [PD]

Whereas the staff expectation of students impacts the students' dispositions, the students' own perceptions of themselves as geomatics students are a determining factor in regards to their *habitus*. Based on students' comments, they generally view themselves as dependent on the content experts who teach them. Students generally demonstrated an acceptance that their prior knowledge provides only basic preparation competencies for studies in geomatics. There is, therefore, a strong dependence on lecturers and wide acceptance of an instructional approach to learning.

Sometimes the geomatics students are positioned figuratively between the civil engineering students and the geography students.

One of the problems we have with such a large cohort is that students have diverse mathematical abilities. There are civil engineering students at the high end and geography students at the low end. Geomatics students are perhaps somewhere in the middle. [Lecturer]

This is likely to have an impact on students' dispositions and how they perceive themselves. Comments from students and observations done in a mixed group (civil engineering, geography and geomatics students) class did not reveal any clear dispositional differences between the groups. However, a comment from the lecturer from the class suggested that there are likely to be some effects on students' dispositions:

> *Working with mixed groups is really difficult. Whereas the civil engineering students will likely be bored by the process I will go through because they all are quite good at mathematics, the geographers will be totally lost if I do not carefully go through the basics. Perhaps most of the geomatics students will be somewhere in the middle of the spectrum.*

In this instance, geomatics students are not perceived to be best in their class at the foundational skills required for this module. This has the potential to act as a de-motivator though the data showed no evidence of this. It is worthwhile, however, to note that students are made aware of the differences between them and those non-geomatics groups with whom they share modules. This is important for considerations of factors impacting students' dispositions.

Technically Capable

The field course represents a significant feature in creating within geomatics students a specialised acquired scheme of perception, thought and action. According to one lecturer the field course "is about getting the students skills levels up to really to do something constructive…" One student put it this way:

> *The field courses are very influential because if we didn't have them there would not be such a clear picture of what surveying actually is. You can study all day long but you never get the actual feeling of it unless you try and do it. It [field course] was like actually work. [2nd year student]*

There is, therefore, an effort from early in the programme to orient students towards practical competencies and work-related skills. Students are initially given a 'feel' for the geomatics field in an introductory field course early in their first year. At the end of the first year, they are engaged in an extensive 10-day residential field course which seeks to consolidate the theoretical principles taught through related practical exercises. In interviews with staff and students, several references were made to the importance of the field courses in aligning students' knowledge, skills and dispositions with pre-stated expectations. Through exercises such as this, students are conditioned for the outdoors and for using state of the art technologies to collect spatial data.

With many supervised sessions in computer labs working on specialist software, the students are also conditioned to using 'black box' technologies to produce usable artefacts. Two such lab sessions were observed and students demonstrated a high level of engagement in the process. The supervising lecturer and the demonstrators confirmed that most of the students in the sessions completed the majority of the tasks to expected standards. These findings demonstrate that a high level of technical competence is developed in students within the programme.

Assessment Driven

The discussion of findings under the first major theme characterised the programmes as highly structured. One of the most prominent aspects that impressed me was the system of assessment in force within the programme. ‘Assessment box files’ were very neatly and systematically stored for each student by a staff member dedicated to what appeared to be a well-developed system of managing students’ performance in written (including reports, essays, drawings and computations) assessments. The artefacts in those files were numerous for students in both specialisations. As much as 20 pieces of assignments were counted in some first year box-files and up to 34 for some students at Stage II. Having looked at an entire set of coursework pieces and examinations for one academic year for the SMS and GIS programmes, it became evident that assessment was one of the primary activities used to monitor student performance and motivate knowledge acquisition. It took the major part of a day to look closely at what was being assessed and the type of feedback given to students. Dedicating this time to looking at assessment pieces was considered important since studies have shown that assessment frames student learning, creates learning activities, orientates all aspects of learning behaviour and determines the focus of courses and curriculum (e.g. Brown et al., 2003; Gibbs & Simpson, 2004; Gibbs 2006).

With numerous graded coursework assessments per year and a two or three-hour examination for the majority of the 30 modules sat during each course, along with a major project in the final year, I was surprised that students did not seem overwhelmed or demonstrated any form of protest. Most students when commenting on assessment, suggested that they valued the assessment culture and considered it important to: (i) keeping them motivated; (ii) emphasising the important aspects of the curriculum; (iii) ‘encouraging’ them to keep engaged with the body of geomatics knowledge; and (iv) convincing them of their ‘abilities’.

> *Exams are very much like the state exams I did at the end of school back home. It is very official, very strict and very thorough. I believe it is a very good system of examination … that is a good indication of knowledge. (2nd year European student)*

> *I don’t think I’d learn as much without an exam. For me, it’s important – that last final to learn and cram and practice for the exam, it sticks better. You know what you have been tested for. (2nd year student)*

> *It forces you to learn. (2nd year student)*

> *I feel more controlled, the learning is more controlled. I am able to know what is coming on the exams. (2nd year student)*

Based on my own knowledge of the discipline and experiences as a student and lecturer, I was able to make a judgement about the range and level of knowledge and skills covered in the assessment pieces seen. They showed coverage of a wide range of knowledge and skills from basic surveying at stage one to more complex tasks such as least squares computations at stage two and the design, setting out and analysis of a civil feature at stage three. Most of the coursework assignments showed written feedbacks from the lecturers. Both students and lecturers indicated that students had access to these returned assignments, but were required to return them so that they could be evaluated in total by the external examiner at the end of each semester. The consistency observed in the format of the written feedback suggested that the lecturers followed set guidelines in their assessment of student work. Feedback typically identified areas of weakness and strength and gaps in what the students produced relative to what was expected of them. My personal observation was that during interviews with some lecturers, students made impromptu visits to solicit feedback for graded assignments or advice on current assigned tasks. These observations were some of the evidences that showed formative assessment practices within the programme. Studies have shown that formative assessment with thorough feedback promotes learning (Sadler, 1998), more so than summative assessments used solely as a means of judging students’ performance (Black, Harrison & Lee, 2004). This type of feedback also promotes self-regulation in learners (Nicol & Mcfarlane-Dick, 2006).

I was also able to view whole sets of examination question papers and key answers prepared by the examiners/lecturers. A large proportion of the modules were examined at the end of each semester. One student's comment describes the nature and frequency of examinations:

> *Most of our modules have between 4 and 6 coursework and then they are examined at the end of the semester. Most exams represent 70% of the module gradate but some are 50-50. The exams are very official, very strict and very thorough. I believe it is a good system of examination because all students get the same questions, the same problem sheet. So this is a good indication of knowledge. [Stage 2 student]*

It is on the basis of these assessment practices, within NU's geomatics programmes, that it is described as having a prominent assessment culture. This description demonstrates some inconsistencies with modern higher education practices in regard to the balance between summative and formative assessments. It then raises questions about the appropriateness of the assessment strategies used, even though the feedback from students did not show a desire for change. In fact, the students interviewed were generally of the opinion that the assessment system supported their learning. Some even hinted that the workload sometimes 'gets heavy', and that they usually 'get the job done'. They consider that frequent and thorough assessment practices are 'for our good'. The system of assessment is believed to have a positive effect on producing successful graduates, particularly in regards to students achieving passing grades as alluded to by the PD:

> *The overwhelming majority of our students successfully complete their programme [PD]*

However, success at assessment exercises does not necessarily equate to successful learning, even though it is likely if the assessment has a predominant formative function. This resonates with the concept of assessment for learning which sees assessment exercises as fundamentally a means by which learning is assessed primarily to reinforce learning (Black, Harrison, et al, 2004). It is argued that 'successful completion' of a professional geomatics degree is better evaluated by considering the likely impact of assessment methods on students' preparedness for geomatics work. The taxonomy of learning, for example Bloom's (1956) cognitive scales, when considered against the observed assessment pieces, showed a range of learning from the lowest level of knowledge-recall to the highest levels of synthesis and evaluation. The PD's comment indicates that the lower levels of the taxonomy are concentrated in the first year. Similarly, the comment from a 3rd year students and a lecturer show that students are expected to work at much higher levels of the taxonomy as they progress in the course:

> *Some of our Stage I exams are multiple choice so they address questions of fact rather than asking the students to discuss or describe something. At Stage I that is where you would expect to find assessment – of basic knowledge as opposed to assessment of ability to handle ideas and concepts. [PD]*

> *A surveying module in the 2nd year builds on the surveying module in the 1st year. The 2nd year module goes into more depth and you are expected to do deeper analysis of your work. [2nd year student]*

> *This is a 3rd year module so we expect our students to do more background reading. With the assessment exercises, some of the questions they are expected to do further readings after the practicals in order to answer all the questions. The in-depth questions they have to go away and write up a narrative style report which shows that they have done more than just press the buttons, but that have looked into the meaning of what they are doing. They often will get some answers that they weren't quite expecting. [Lecturer]*

Dynamic Outlook

Even within the highly structured setting, there was a sense of dynamism as it relates to how contemporary knowledge and technologies were perceived. This was evident in the use of new technologies in an atmosphere of readiness to adjust as new information emerges. Comments made by both staff and students illustrate this reality.

> *This is an upgrade to the software so we are learning the new features as we go along. [Student]*

> *There are some new features on this new instrument but it is quite user-friendly. We are learning it together. [Research assistant/demonstrator]*

> *We have to keep abreast of the changes that come with new research and feed these into our teaching. [Lecturer]*

> *In one of our recent lectures, the lecturer excused himself to take a telephone call. On return to the class, he asked us to change some information he had*

given us on GNSS as he had just received fresh information that the algorithm had been changed. (Student)

Even in preparing for examination we have to be mindful that information discussed in class may not be current at the time of exam. (Student)

Summary

Based on the preceding discussion, it is concluded that NU's Geomatics students generally have a sense of security in a well-structured and closely monitored programme that offers them scope for adding value to their pre-university qualifications. They typically see their course as work-relevant but not in a narrow sense that limits their options. They are excited by their exposure and portray confidence in the use of technology in applied ways; yet they demonstrated uncertainties about their ability to apply these skills in work settings. There is general recognition amongst the students that they are involved in an unpopular programme affiliated with a professional field with a scope that is not widely known or appreciated. While students displayed dexterity and confidence in the use of surveying equipment and related computer software packages, they also demonstrated great dependence on the academic staff as the main guides to their learning. Some students indicated that not much reading and research occurred outside of what the lecturers direct. Furthermore, they are strongly assessment-oriented and generally consider the existing pedagogical arrangements to benefit their success at passing the course. The general lack of industry exposure in the programmes is believed to be a reason for the expressed insecurity about work readiness and career aspirations. The students' evaluations of the effectiveness of their courses are predominantly linked to assessments and the cordial relationship they enjoy with their lecturers and to a lesser degree, with their fellow students.

The findings showed that academic staff within NU's geomatics programmes was critical agents in determining the pedagogical arrangements. An understanding of their role and habitus are also important to a holistic understanding of the pedagogical arrangements.

6.3.3 Academic staff - habitus and pedagogical role

The research data support the conclusion that the academic staff plays a central role in determining the curriculum content and structure and the emphases placed within individual modules. Therefore, curriculum planning is primarily the responsibility of the academic staff. Thus, it is important to understand their habitus and the values that they hold in high esteem in regards to geomatics education. The PD stated that the department has ten academic staff members who are supported by teaching assistants, a technician and a small research team. He explained that lecturers are employed primarily on the basis of their expertise in particular specialist areas.

> *with 10 staff, each of us has our own specialisation that covers– one colleague's research is in satellite orbit determination, so he is a mathematician basically. There are other colleagues who are interested in Remote Sensing and they are more like environmental scientists. And there are others who are interested in measurement sciences so they like engineers. But we all come from different backgrounds; we all are teaching different parts of the geomatics syllabus. [PD]*

In relations to the drivers of curriculum design and its development, the analysis of staff interviews suggests that academic staff have the greatest influence. This is illustrated in two comments from the PD:

> *Our teaching-away days occur every year and are when the academic staff review our curriculum. We are quite open in discussing new ideas and we also have the skills in the academic staff to present new ideas and look at ways of developing the curriculum. [PD]*

> *While our students are asked to complete a feedback form for each module and we consider their comments, they are not responsible or have any kind of input in the initiation of the curriculum development. The major specific development of the curriculum is done from within our cohort of academic staff. [PD]*

The changes that are referred to in these comments impact the programme at the macro level. Additionally, the academic staff is responsible for micro changes within individual modules. Both the programme document and the analysis of interviews showed an expectation that staff research should inform teaching content. The curriculum document stated the following as one of the programme objectives:

> To provide teaching which is informed by current scholarship, research and professional activities of the staff. [Student Handbook, 2008/09]

Also, the PD identified the importance of research activities for the academic staff and the practice of incorporating research findings in lectures.

> *We expect our teaching staff to be current and aware of modern Geomatics practices and development. We are involved in our own research activities, and these are fed into our teaching materials. They do not totally dictate what we teach but they are incorporated so that along with the fundamental basics of Geomatics, students also get exposed to current research in the field. [PD]*

The analysis of student interviews supports the finding that currency in research is expected of lecturers and it is seen as a relevant component of teaching material. One student noted that his lecturers' research findings and publications enhanced his confidence in the knowledge he is acquiring.

> *Geomatics knowledge is evolving so quickly, and students expect cutting edge information to be portrayed. But if ever the lecture notes from the year before are recycled, and I don't think that's how it is, they are always looked over and updated. They do seem to cover current research themes normally. Towards the end of a lecture series there is always that covered, stating what's going on that follows on that, from the background information.*

> *…from researching around the areas and finding work that the lecturers have produced in the past and are producing that gives me confidence – to find published work that you can then relate to from who is teaching you. [3rd year student]*

The PD made clear that changes to the curriculum go through a rigorous quality control mechanism within the University. However, it was seen that the expertise of the academic staff exerted a major influence on the curriculum content and determine the emphases placed on individual modules. One lecturer identified his area of expertise as Cartography, another Remote Sensing, another Database Systems, and so on. The modules taught by lecturers were closely related to their areas of expertise. This, therefore, means that staff change is likely to lead to change of module content and content emphasis. Although this is understandable, there is an inherent limitation in the maintenance of consistency where this is advantageous to the learning programme.

> *Our module focus is strongly influenced by the expertise of our lecturers. Also, the lecturers feed their research into their teaching. Hopefully these decisions are well thought out and balanced so that the module is not only about the academic's narrow research area. [PD]*

This practice requires careful management to maintain consistency in the quality of the module content and emphasis.

The PD and lecturer interviews demonstrated defence of the boundaries of their learning environment. This was demonstrated in how the PD responded to the newly arranged teaching of IT by an out of department lecturer:

> *We are concerned about how students will cope with the programming module being taught out of school. We are going to have to monitor that closely. (PD)*

Apart from two remedial mathematics modules offered as support subjects for first year students with low A'level mathematics grades and one computer programming module in the second year, there was no input in the programme from general education and other disciplinary areas within the University. In fact, the programme leader confirmed that even the computer programming module was taught by a geomatics specialist until recently. The new arrangement to have an IT specialist teach the module was an economic decision taken by the University. Students taking this module will be required to share lectures with students doing degrees in IT. It was evident from the PD's comment that this is not considered to be an ideal arrangement for Geomatics students:

The PD's comment regarding IT being taught out of department implies a desire to keep geomatics students separate from other disciplinary groups and taught exclusively by geomatics lecturers. This was seen as one way of maintaining greater control over module content and emphasis. On the one hand it can be argued that this is a better arrangement for educating students in this highly specialist field. On the other hand, it can be argued that since Geomatics is considered to be a 'widening subject area' (PD), then opening up the educational exposure beyond what is available within the pool of geomatics lecturers, might be more aligned to that thinking.

Though it has been shown that the academic staff play a central role in curriculum development, the data also suggested that the Geomatics industry through an industry advisory board and more so through professional accrediting bodies do impose some degree of influence on the structure and emphasis of the curriculum. The influence of the Geomatics industry is discussed later in this chapter under 'academic-vocation dichotomy'.

A consideration of the deployment of the academic staff focuses on how their functions are operationalized. From what was observed lecturers had a close and cordial relationship with students. Students were seen consulting with lecturers throughout the day in and out of formal teaching sessions. Lecturers were observed to be supportive of student learning during these consultations. For example, during an interview that I was conducting with a lecturer, two students made an impromptu visit. The lecturer explained to them that he was busy but stated that he could accommodate a short question or suggested another time for the consultation. I intimated that I was okay with the break in the interview, and the students proceeded with a question about an assignment they had been working on. In the lecturer's response, I noted two things: (1) he engaged the students in a line of questions that helped them to consider how they could arrive at a solution without relying on him to provide it and (2) he listened to their response and, in turn, responded by identifying some principles they needed to consider in arriving at their solution. At the end of the short consultation, the students were asked if they were any clearer on what to do. After responding in the affirmative, they left the room and my interview proceeded. The lecturer's response to my question about the nature of staff-student relationship was:

> *We are a small department and we know all our students and they know us. We have an open door policy and students can consult us when they need to. [Lecturer]*

The relatively small cohort of students along with a low staff: student ratio (1:10) engender close and cordial relations between staff and students which is generally viewed as a supportive and effective learning environment. Lecturers' functions were observed to be multifaceted, involving the more formal lectures along with supervision of lab work and field work. Two lab sessions were observed, one of which was supervised by a research staff member, and the other by both a lecturer and a teaching assistant. In the two field practical exercises observed, both lecturers and demonstrators were present. They were observed to play similar roles in guiding students in the proper use of the equipment for the collection of surveying data relevant to issued instructions.

6.4 Academic- vocational dichotomy

As discussed in the literature review in a more general sense and later in more surveying specific terms (Chapter 5), there exist tensions between the academic and vocational foci within higher education programmes. The problem in surveying education in the British context, as will be demonstrated in the analysis, is seen to be two dimensional: a labour market issue and an issue of philosophical differences.

6.4.1 Labour Market Issue

Based on the analysis of English employer interviews, the problem has an acute manifestation in the English context. There was wide agreement amongst the England-based professional surveyors (employers) and representatives of UK-based accrediting bodies that there exists a misalignment between surveying/geomatics education and the needs of the surveying industry. The following comment identifies one issue that clearly contributes to this tension.

> *The polytechnics upgrade to universities has been a complete disaster. Now we have ended up with a huge gap in the market. The Geomatics companies in the UK, in the TSA do not need graduates- not so many of them. What they need is technical surveyors, people who are proficient, who are able to self-start, who are able to get up in the mornings go to a job, if it changes, to be able to have the wherewithal and intelligence to change their specification or data capture and be able to do the job successfully. [UK Chartered surveyor]*

What this comment highlights is a gap in the Geomatics labour market created by the discontinuation of sub-degree technical surveying programmes in England as a part of the bigger upgrade of polytechnic certificate and diploma courses to university degree courses. The comment that this change has been 'a complete disaster' is particularly telling in regards to how this issue is perceived within the Geomatics industry. One outcome is that the industry has tried to fill these vacant technical positions with degree graduates. However, industry representatives have expressed that most graduates are unwilling to accept technical positions, and that those who have, are unsuitably trained for the positions. This emerges as the main reason that current university graduates are considered by employers to be ill-prepared for the reality of the Geomatics industry. The following comments capture industry's position on the relevance of the educational programme relative to industry reality:

The current generation of university graduates, a lot of them are not prepared for what is expected of them in a work situation. Surveying, land surveying, geomatics is a vocational area of practice. I think that there is only so many geodesists that the world needs. What we actually need are practical people who are able to bring a broad-base education. [RICS Geomatics representative]

The surveying industry in Britain does not need degree graduates, not so many of them. What we need are technicians, people who can get out there with an instrument and get the job done. [Professional surveyor]

The employers also asserted that even if degree graduates were to accept the technical jobs, they do not possess the skills to operate effectively in them. However, as the academic staff stated, university education is not about a narrow focus on technical competencies.

At the same time there is a perceived limit to those traditional jobs that are considered better suited to individuals with higher education surveying qualifications such as, geodesy as identified by the RICS representative. To illustrate the severity of the situation, the RICS representative and a chartered surveyor made the following comments:

Out of 150 companies in the TSA, how many principals from those firms use graduates? You would be lucky to find 15%. That gives you an indication of what this business is like in the UK. So if your boss is a technical surveyor do you think he will actively be looking for someone with a degree? The nature of the business is vocational, it's about data capture. [RICS Geomatics representative]

There are probably 10,000, we reckon, people working in the land Surveying/Geomatics sector in the UK. The vast majority of those will be technicians. We normally have a rule of thumb that for every one chartered surveyor there is usually five technical surveyors underneath them doing the actual data capture work. [Chartered Surveyor]

Comments from the PD also show that he is aware of how this problem in industry impacts NU graduates. Based on responses from industry some of the geomatics graduates have been dissatisfied with what they end up doing. One of the reasons for that is, until about 15 years ago, there was quite a vibrant technical layer of education in Geomatics. You could do an HND, diplomas and certificates in surveying. And those are the people who would go off and do the levelling of the RAF runway as part of a contract – mindless job. Creating a grid over a mile long runway at about a 10m interval or so and it would be immensely boring.

> *Nowadays because <u>geomatics is a graduate entry profession</u>, because there aren't any technical courses anymore, there aren't any technicians. There are people going out in industry doing that kind of job as graduates and finding it tedious and a bit of a strain. On the reverse side we are <u>taking people in to embark on a degree course who really would be better suited to doing diploma or certificate level course.</u> The people who 20 years ago would have been directed toward technical education in Surveying rather than being told that the only way you are going to get on in Surveying is to get a degree. That is the nature of the industry I am afraid. It is the nature of technical education in this country. [PD - researcher's emphases]*

His comments highlight two important elements (underscored in quotation) that demonstrate that this situation is unsustainable. Geomatics is now a graduate profession in the sense that all new entrants to the industry are degree graduates. The PD claimed that this situation means that persons with interest in working at the technical level in surveying typically find themselves doing the degree course. In his capacity as PD, he asserted that some of the students are, indeed, better suited for technical courses.

The analysis of the employer interviews shows that the geomatics industry has put measures in place to address this shortfall. A council member of the UK-based, The Survey Association (TSA), stated that, as an association of professional surveyors, they have sought to 'fill this gap by offering short courses to train technicians.' Some British Geomatics companies have looked beyond Britain to fill job vacancies at the technical level.

> *what we see in the company is that there are insufficient graduates at the correct level of ability coming from the UK system to come into our business. So a large number of people within our business, particularly the sort of younger blood that's coming over the last 10 -15 years, I would say are typically foreign nationals and encompass people in skilled positions from Germany, Spain, Holland, some of the previous Eastern Block areas: Moldova, Romania, Poland, etc. [Principal in large geomatics firm]*

In this current scenario, there is a real risk to British geomatics graduates, who may eventually find themselves totally displaced from employment in their local sector. The data show the real potential of this happening, as one employer mentioned that graduates from other countries are willing to work in highly technical positions even with postgraduate qualifications, but British graduates with first degrees are typically unwilling to accept those positions.

> *We are left with a few universities that produce undergraduate, first degree level people and even then their expectation is too high in the UK sectors. An undergraduate from a UK university would have a salary expectation that is too high. So really, that's the problem; there is an insufficient level of the sort of technical grade people coming through. The non-UK employees tend to be happy to work at the sort of technical grade level within the company. They seem to have less of an expectation that they are going to become the managing director in a year. [Principal in large Geomatics firm]*

While aspiring for the better job opportunities has it virtues, it is argued that these aspirations must be grounded in reality. With no student comment directly relating to this issue even while discussing job prospects, it appeared that the students interviewed are oblivious to the state of the local geomatics industry. However, the PD acknowledged concerns about the geomatics job market, and noted that students see the degree as 'a passport to industry'. He, however, does not perceive the identified tensions as limiting job prospects for graduates, and expressed that geomatics offers a broad range of options to students not limited to jobs typically associated with the discipline.

> *The vast majority of graduates regard the degree course as vocational, as a passport into the industry... We don't say this is the be all and end all. We do say you will be in possession of a degree that will allow you do to a large number of things in different areas and it will not necessarily be restricting in terms of what you can do. So, the vocational thing is almost by accident. We think that Geomatics is an excellent discipline, as you say, to follow a university career of scholarship and enquiry and be able to come out with a degree that has taught you how to do research, how to set hypothesis, how to undertake experiments, how to write computer codes, how to write essays, ... a whole range of different things. We are just doing it through the vehicle of geomatics which is great because it's an exciting discipline. [PD]*

Notwithstanding this 'broadening' perspective, the PD further stated that the graduates continue to be sought after within the UK, but mainly due to on-going work in one sector:

We have been quite lucky in the UK because still the biggest market sector for our graduates is the offshore oil industry out of Aberdeen. If that was not there I don't know if we would have been here because the major demand for geomatics graduates is from one specific market sector in the UK. [PD]

It is assumed that the positions being filled by degree graduates in the oil sector are at a grade higher than technicians though the shortage of technicians was not mentioned by the PD. The PD offered another ray of hope in what so far appears to be an uncertain future for Geomatics degree graduates in England:

the British surveying students are looked upon kindly overseas although they haven't necessarily got knowledge of the Torrance Law they can still go and work in Australia and pick up licenses as they do. [PD]

In an era of aging surveyors (Jeffress & Barnes, 2010; Hannah, Kavanagh et al., 2009 etc.), it is important that education institutions should be encouraged to continue running Geomatics programmes. This will ensure that the Geomatics industry is supplied with highly qualified individuals who continue on to chartered status with the capability to operate at the highest professional level. This does not diminish the shortage of the technicians which it is argued, is a separate issue that should concern not only universities but other stakeholders in the wider Geomatics community. It is outside of the scope of this study to explore issues in technical level surveying education though much of the issues discussed in this section are related to it.

Whereas higher education is being promoted as a modern virtue for the masses (Schofer and Meyer, 2005), arguments as presented from the employer interviews suggest that such higher pursuits are not warranted within contemporary English surveying industry. Some questions that emerge from this debate are:

- Should university-based geomatics/surveying programmes orient their education towards technical expertise to address the gap in industry?
- Does this mean a reduction in the academic focus and an increase in the vocational?
- What are the implications for other opportunities within the geospatial industry; particularly, those related to the perceived widening geomatics scope?

The first two questions relate to the second aspect of this tension - the philosophical issues regarding the relationship between academic and vocation. These will be discussed in the following paragraphs and the third question under the next theme – 'The Geomatics Paradigm'.

6.4.2 An issue of philosophical differences

It is asserted that another reason for the academic/vocational tension is an underlying philosophical variance in the perceived role of the university relative to the role of the profession in the preparation of persons for professional surveying work. One belief is that the university should produce work-ready individuals; and another that it should produce graduates with developed intellectual capabilities, who are professional novices yet to be trained for professional engagement.

Both the student and staff interviews showed widespread expectation amongst both groups that education should target employability skills. However, some differences were evident in what staff and students regard those skills to entail. The data showed that students' conception of employability were mostly associated with the efficient use of the 'tools of the trade' i.e. use of Geomatics equipment in its hardware and software formats and the manipulation of the data to produce typical industry-produced artefacts. On the other hand, the academic staff's responses pointed to more generic intellectual skills such as problem-solving, critical-thinking and the ability to innovate and function effectively in a variety of work situations.

> *This [course] is very oriented towards people gaining knowledge and skills required in the industry, so it's not quite the average schooling. I came here [university] to gain knowledge and expect it to lead me into a career. (2nd year Geomatics student)*
>
> *I plan to go into Remote Sensing and what I learn here, particularly in the labs I consider most important as I am learning things I will actually do as work. [3rd year student]*
>
> *They will have undergone an educational experience which combines academic rigour with the skills like critical thinking and problem solving which are essential for the world of work (PD)*

It was noted that employers were also of the view that universities should target employability skills but many felt strongly that universities have failed to do so effectively. One employer expressed the opinion that universities focussed too much on technical competencies and not enough on the business aspect of the industry.

> *I think universities have failed to prepare students to operate effectively in industry. Work in industry is more than being able to use an instrument; it involves skills or project management and problem-solving among others that I see very little of it in university graduates. (Senior partner in Geomatics firm and council member of professional accrediting body)*

This perspective positions the university as a place for moulding a novice professional in the broad functions of the disciplines. It speaks of a system that engenders the technical and business aspects of the profession along with other attributes directly related to the work readiness. A previous comment from the PD contradicts the view of this employer. It implies that Geomatics education at NU is not narrowly focussed on preparing graduates for professional engagement within the Geomatics sector. He claims that though this connection is sometimes made by students, the programme philosophy is not restrictive. Instead, it is about preparing graduates in a more generic sense.

Preparing students with generic competencies is perhaps not so much what industry desires but rather, a greater awareness of the limits of academic qualification and the virtues of post university professional preparation. This is illustrated in the comment from the RICS representative:

> *I think there is a lack of understanding within the academic world about the difference between academic qualification and professional qualification. Legal people don't have any problem with this. When you do a law degree, that is your academic qualification, you then go on to do your solicitor's examination, the LLB. Even after your lower degree you have to do this. Then you become a solicitor and that's your professional qualification. I have always thought that there has been a reticence of the academic community to fully grasp the significance of professional qualification and the relationship with the academic i.e. the academic qualifications are not the end of someone's professional development – it's a start. So I think the courses need to look at how they create a framework for future learning for people. But in Geomatics, I have always thought that people think that the course itself is more important than what the person will do professionally and in the future. [RICS representative]*

The illustration by the RICS representative identifies an expectation that geomatics education must be tempered with awareness so that their academic qualification is only one step in the journey to professional status. From all indications, this is a message that needs to be understood and agreed on at both ends of the academic-vocation spectrum. The profession appears unprepared to support the induction of graduates into work and the academy appears to be unclear about how to satisfy industry's desires. It is proposed that greater dialogue between both parties with student involvement would help to improve this situation.

The PD interviews, in particular, showed that the profession exerts its values unto the education programme through its accrediting bodies. His comment shows that accreditation status comes with some degree of conformance with professional desires:

> *In a sense, we feel like we are beholden to the professional accreditation bodies. Accrediting bodies have varying levels of input into curriculum design. [PD]*

As mentioned earlier (habitus of academic staff), the boundaries of the *field* are heavily guarded. They are also protected by the accreditation status which serves as a cultural capital. The programme documents and comments from the PD show that accreditation status is used as a marketing tool to attract students to the programme and also as a way of satisfying professional requirements which is important to those students who make direct links between their education and a career path in professional Geomatics work.

> *I wanted to study in an accredited programme so that I can obtain professional status from the RICS [3rd year SMS student]*

> *Graduates from our programme have direct membership to the RICS as we are accredited by them. [PD]*

Both staff and students value the programmes' accreditation status. The accreditation from two notable professional bodies is seen by both staff and students to represent cultural and symbolic capital that has recognised value within the Geomatics industry as well as in academia. The access to the profession that being in an accredited programme offers, was described by Goodhead (2011) as the 'second prize' with the degree itself being the first. It appears though, that some students consider this access as the 'first prize' as the previous comment from the 3rd year student implies.

The analysis has identified multiple layers of perception regarding the effectiveness of surveying education. Contradictions exist between the various stakeholders as well as between different members of industry. Whereas the message from industry is that graduates are not vocationally oriented enough for existing jobs, a message from the academy is that though some practical competencies are targeted within the programme, there is a greater commitment to building broader skills base at a high academic level. The commitment of the academy, according to NU's PD, is not about producing highly skilled technicians but rather about opening up a wide spectrum of opportunities through a rigorous and scientific academic programme.

6.5 The geomatics paradigm

This theme allowed for an exploration of the range of perceptions about the meaning of 'geomatics' and the impact it has on NU's geomatics educational systems. Furthermore, it will consider whether or not there is capital gain by 'geomatising' traditional surveying curricula within this case context.

The interview data from students, academic staff and members of the surveying profession showed a range of views about what geomatics is. **Table 13** illustrates comments from each group of participants about how they perceive 'geomatics'.

Table 13: Matrix of perceptions about geomatics

Students	**Academics**	**Professional Surveyors**
As I see it, geomatics is the science of geographical data and analysis and presentation. I did not have a clear picture of it when I was choosing the course but it came to me as I went on. (Stage 2 GIS student) *Geomatics is such a wide variety of things ranging from basic topographic survey it to GNSS – the whole concept of GNSS and the science behind it as well as its application. And then Photogrammetry and Remote Sensing interested me as well as laser scanning which was unknown to me and I was really interested in what could be achieved in it. So I was drawn into it by the range of things. (3rd SMS year student)*	*To me geomatics is the science of geospatial data handling. That includes geographic data, however it is manipulated or processed in computer based system which is what GIS is. (Lecturer)* *Geomatics should not be viewed as a narrowing of options it is a very broadening subject, you learn everything from plate tectonics to land law. This is true too for the employment sector we encourage them to go to. (Programme Leader)*	*Geomatics is a good umbrella term. All those skills set within that term: land surveying, engineering surveying, photogrammetry all still exist. So there are lots of jobs within this umbrella term. That is the way we see it within the RICS. (Head of Geomatics Professional Group, RICS)* *I don't think changing the name has done very much to those of us who are involved in it. It has changed our perception of what we do. By changing the name from land surveying to geomatics we have created an umbrella that allows us to embrace air surveyors and seismic surveyors and all of these people who would not have been seen to us to be 'land surveyors'. But I don't know that it had an impact yet at least on the role we play in the greater surveying community. And if that was an intention, and I don't remember it being trumpeted as an intention at the time of the name change. If it was an intention then we need a bit more education about this which is probably bringing us back to my point about broadening the outlook of the people within geomatics. I don't think we have achieved that at all. (ICES Representative)*

Students, academics and professional surveyors generally agreed that geomatics represent an umbrella term that incorporates various aspects of geospatial sciences and technologies. The interview data from all groups also strongly supported that a significant and continuous growth of technologies and their applications to the discipline has opened up new opportunities for the modern surveyor. These comments imply that geomatics does represent a shift not only in how surveying is done but more importantly it offers a greater scope in the functions carried out by modern surveyors/geomaticians:

> *We are exposed to a vast array of technologies in the instruments we use, from total stations to laser scanners, digital levels and GNSS for example. We can do so much with the knowledge we have been exposed to. [3r year student]*

> *Geomatics has changed significantly in the last few decades. We now teach some things that when I was a student were never even thought of. The students are now exposed to such a wide array of data colleting and data manipulation technologies. These have opened up new opportunities for them and so we tell them there is no limit to how they can apply this knowledge when they leave us. [PD]*

However, the employer interviews revealed a view that the change in name has had very little effect on how surveyors themselves perceive their professional roles. One surveyor suggested that members of the profession need to be educated on this new way of perceiving the profession in order to promote a wider scope of functions consistent with the concepts of a geomatics paradigm as described in chapter 2. This suggests that, in some respects, geomatics is not so much perceived as a paradigm shift in the profession but rather an issue of packaging to enhance the image of a profession faced with many challenges as described in chapter 2. It is asserted that adding ‘Geospatial Science’ in the School title is also related to the desire to improve the image of the courses offered and their appeal to a wider student body.

It has been shown that NU’s Geomatics programme has a history of association with different academic and administrative 'camps' and, at one point, had its own unique department. The reasons given by the PD for these changes and the current association with civil engineering are primarily related to administrative exigencies. Due to economies of scale, the relative small geomatics programme is forced into administrative ties with other disciplines. Comments from the PD imply an underlying issue more complex than the necessary administrative arrangements. I refer to the stifling of surveying/geomatics and the resultant need for recognition as a unique, distinct and attractive field of knowledge. I have termed this ‘the smallness stigma’, not only in terms of size (student and staff numbers) but more importantly in terms of cultural and symbol capital. This points specifically to what I argue is a problem with identity that impacts not only the NU geomatics programmes but also the surveying profession at large as have been alluded to in Chapters 2 and 5.

NU’s geomatics programmes reside in the School of Civil Engineering and Geosciences. The relationship between the two broad specialisations in this school, according to the PD, is primarily on the basis that civil engineers are taught a limited aspect of surveying. He explains that the reverse relationship is, however, not true. In the case of NU the more natural relationship appears to be with Geography which, through the Faculty of Sciences offers a joint Geography-Geomatics degree in which the specialisations are shared 50-50 according to the PD. This description points to what has emerged as a general issue with geomatics programmes, i.e. the issue of deciding how to position the courses since they are generally not large enough to be placed on their own as economically viable courses.

6.6 Summary of findings & introduction to second in-depth case study

NU’s programmes, because they are based in a research-focussed, Russell Group University, understandably upheld the values of this higher education group. The value of new knowledge from research was one of the factors that informed the pedagogical arrangements. Being a profession-oriented programme, accreditation by professional bodies was also a feature that was highly valued by its stakeholders. These two elements appeared to have some contradictions in the sense that a research-based university status elevates research, knowledge development and transmission above professional preparation while the professional accrediting bodies emphasise professional preparation through more structured content with explicitly stated expected learning outcomes. To the latter group, research is not unimportant but does not take precedence over the more utilitarian benefits of a professional education.

The structured nature of the academic programme was found to be generally supported by the academic staff as well as by a large majority of the student body. A look at the habitus of students and academic staff demonstrated some explicit characteristic features of both these primary agents in the geomatics education field. Beyond this, the data also suggested some underlying features that inform the dispositions of students and staff. This level of analysis provided critical insights into the pedagogical arrangements that will be discussed further in chapter 8. In chapter 8, the pedagogical arrangements within both in-depth case studies will be comparatively examined.

Having explored the major themes within the first in-depth case study, these same themes will be used to examine the more innovative educational system used within the Aalborg University surveying programme.

CHAPTER SEVEN

CASE STUDY – AAU SURVEYING PROGRAMME

7.0 Chapter Overview

The case study of the surveying programme at Aalborg University (AAU) is strategically placed after the NU case study. NU's more conventionally structured surveying programme is a good comparison relative to AAU's innovative educational approach. As done in the previous chapter, the discussion of findings will proceed under the four major themes. The findings articulate the roles of the various agents in the surveying education field within AAU and .represent the elements of a pedagogical model, developed in chapter 8. Also to be considered are the implications of such a model for curriculum and pedagogical development. Having done both case studies, the closing section of this chapter will consider how the findings from both case studies can together contribute to a clearer understanding of contemporary surveying education. Theoretical concepts from field theory (Bourdieu, 1984) are used throughout the analysis to frame some of the findings.

7.1 Introduction

In Chapter 2, a brief account was given of some foundational principles upon which AAU was built. More specific information is provided here as a lead up to the case analysis.

The University was established in 1974 as a direct response to the unease of the 1960s, when students began making demands for a change in the autocratic educational system that gave little credence to student voice (Enemark, 2009). AAU's programmes document (2009) indicates that the University was conceived through a vision of two distinct characteristics relative to other pre-existing universities in Denmark at the time. The documents identify these characteristics as 'inter-disciplinarity and inter-faculty studies which together led to the innovative pedagogy that came to be known as the 'Aalborg Educational Model'. Barge (2010) described the University's ethos and explains the major factors that constitute its educational model:

> From a philosophical and sociological standpoint, they [AAU] were interested in providing students with an active role in the acquisition and creation of knowledge and the higher academic standards that come with students' necessarily heightened engagement in learning. They were further interested in a redefinition of the role of the teacher in the learning process. Rather than communicating knowledge to students, often in a lecture setting, the teacher was instead to act as an initiator and facilitator in the collaborative process of knowledge transfer and development. A synergy effect—peer learning—emerges in this shared educational process. Together these paradigms influenced the educational model adopted by Aalborg at its inception (p. 5).

Enemark, Kolmos & Moesby (2006) and Kolmos, DeGraaff et al., (2008) describe the AAU educational model as one based on an arrangement that is project-organised and problem-based. They further explain that small group projects are used as the basic educational methodology, with the curriculum divided into 'themes' that represent its general aim which is associated with specified professional profiles. Therefore, the model is considered to be strongly linked to professional preparation as is claimed by proponents of PBL (e.g. Boud, 1985; Boud & Feletti, 1998; Poikela & Poikela, 2005).

AAU's surveying programme is a distinct disciplinary group within the Department of Development and Planning. The wider administrative link is with the Faculty of Engineering, Science and Medicine which is the largest of the three faculties in the University (AAU Programme Document, 2009). Within Denmark, AAU is the only University offering surveying degree programmes. Therefore, it serves a critical role in supplying graduates for the Danish surveying and related industries. The department offers a five-year surveying programme that includes a 3-year Bachelor's component and a 2-year Master's component. Together, these two qualifications form the academic requirement for the surveying profession in Denmark (Enemark, 2009). At the time of the study, the programme had over 150 students enrolled over the five years and 12 fulltime academic staff members (Enemark, 2009). The students within the first and second years were spread between the Aalborg and the Copenhagen campuses but in the remaining three years all the enrolled students were on the Aalborg campus (AAU Programme document, 2009).

7.2 Curriculum Architecture – an unconventional structure for surveying education

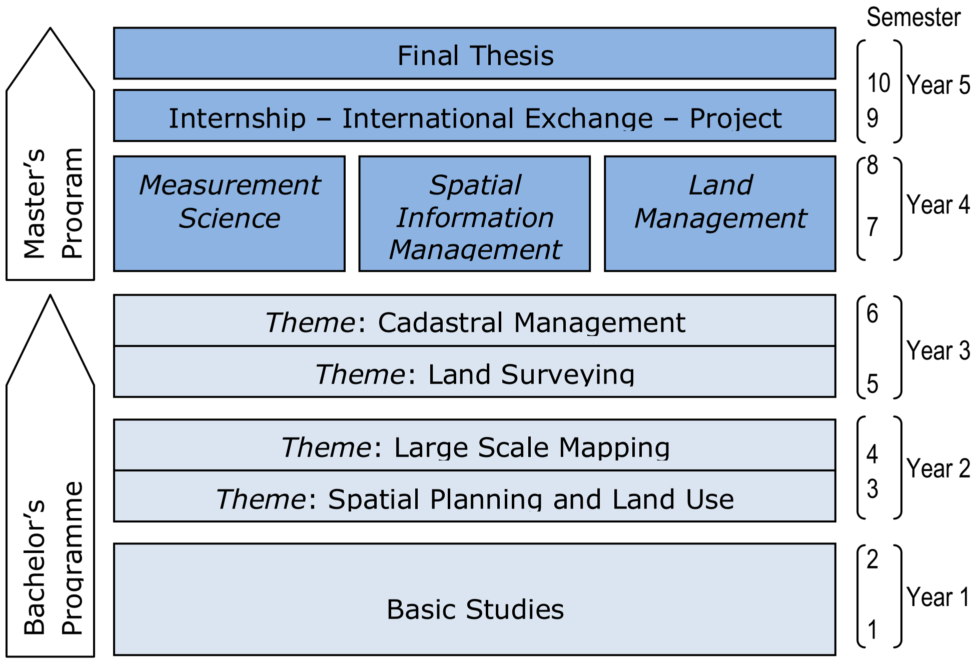
As was done in the previous in-depth case study, four separate features of curriculum architecture will be discussed. It will be shown that there are distinct structural arrangements between the curricula within both case studies. However, some similarities may suggest features of disciplinary culture that transcend educational cultures and practices.

7.1.1 Curriculum structure, content and process

Some features of the surveying programme at AAU were introduced Chapter 2, as part of the rationale for its selection as a case study; and in Chapter 5 a number of the unique features of this model were discussed relative to other programmes in the study. Additionally, the data from this in-depth case study are used in this chapter to provide a deeper understanding of how AAU's curriculum compares with the others in the study in terms of structure, content and process.

There are distinct differences in how the AAU programme is arranged relative to the other programmes in the study. Central to this distinction, is the project-organised, problem-based learning (PoPBL) principles upon which the AAU model is built. **Figure 16** illustrates the explicit structure of the programme.

Figure 16: AAU's surveying programme structure (Based on Enemark, 2003)



The first year consists of what the University terms 'basic studies' which focuses primarily on aligning students' approach to learning with the PoPBL approach. This is one of two features that make the AAU programme particularly distinct from other programmes in the study. The nature of PoPBL and the dispositions (*habitus)* of the primary *agents* within this *field* will be discussed later in this chapter. The second and third years are dedicated to general spatial science education leading to a Bachelor's degree. In comparing the curriculum contents at this level with the content in the NU programme, many similarities were identified. These will be discussed as the chapter progresses.

A clear difference in the arrangement of the education, compared to the first case study, is the inclusion of the Master's level of the programme (fourth and fifth years) as part of the requirement for professional qualification. The Master's level of the programme is dedicated to specialisation in one of three options as indicated in Figure 16. Another distinction from the other case study is the inclusion of industry attachment or internship. Both programmes include a major research project conducted by individual students in their final year. However, within the AAU programme, this project (thesis) is done at a higher level being a major element of the Master's component.

Another feature that makes the AAU programme distinctly different from NU's is the way the education is structured around small group projects. The staff interviews highlighted the activities that are in force to support students in effectively executing project-related tasks within small groups. However, in addition to these PoPBL preparation activities, the first year includes a compulsory mathematics module. This aligns with the mathematical focus in other programmes as described in Chapter 5. The following samples of staff and student comments illustrate this finding:

> *The first year is a basic year that focuses on teaching the students about our model of education. We help them to understand things like group dynamics, project organisation and presentation and so on. [First year lecturer]*

> *In year one, we [Surveying Department] do not see much of the students unless they visit for a short lecture on some surveying instrument or technique. Their main focus is to learn about PBL and project based learning. We have a special team that is dedicated to preparing our first year students for this. [Senior lecturer]*

We do quite a bit of maths in the first year but we also do many sessions on how to do project work and work in groups and so on. We also do a small project in the first year. [2nd year student]

The arrangement of the curriculum around themes is also a unique feature of the AAU model. As illustrated in **Figure 16**, most of the semesters are assigned themes which, as the staff and student interviews showed, are used to guide project selection. As was attested to by staff and students and observed during my visit, the small group projects are supported by other pedagogical arrangements, namely lectures, labs and practical sessions.

We do have some subjects that are taught in very traditional ways like mathematics for the surveying students but all these subjects support the projects. The projects are an application of what is taught. [PBL administrator]

What is taught in lectures is based on the semester theme and the project done in that semester is also based on that theme. [Lecturer]

We do have lectures based on the theme for each semester. These cover many topics but overall we spend most of our time working in our groups on our projects. That is where we really learn, by doing. [3rd year student]

While it has been shown that the first year of the programme has a focus on conveying to students, competencies for effectively engaging in the PoPBL culture, it was also evident that students in the first year may also be exposed to specialised subjects. One first year lecturer indicated that depending on the students' specialisations, there are other subjects that may also be introduced to students in their first year. Based on comments from lecturers, these other subjects are primarily associated with the 'small' projects that students are asked to do in the first year that initiates them in the application of their knowledge and skills in project-oriented, problem-based learning.

Our first year students do a number of subjects but primarily the first year is designed to help them to develop their abilities to work in our particular model of education. If they for example are doing a mapping project then they will have introductory classes in surveying and mapping. [Lecturer]

The range of comments from three 2nd year students in one project group indicated that, depending on their project assignment and projected specialisations, the subjects they are required to do in their first year may vary. This is illustrated by the following comments from year 2 students in the same specialisation small group:

We all did math, GIS, society class i.e. politics, economics and sociology in one class. [Student I]

We had some lessons that you didn't have. Our theme was Urban Ecology. [Student II]

We had to produce a map so we received a lot of information from our supervisor. [Student III]

The students confirmed that the first year was primarily geared to induct them into the PoPBL culture. Their accounts seem consistent with socialising students in the educational culture with most activities supporting this ethos. There appeared to be a level of flexibility regarding what specific activities will be used to develop the requisite collaborative skills in preparation for the later years in the programme. Additionally, based on the students' comments, mathematics appeared to be the only subject treated in a more traditional sense and as a standalone. The primacy of place given to mathematics was not unique to AAU, since this subject is treated as foundational competency for surveying programmes generally.

The themes in the second and third years show a range of subject areas including urban planning and land management (more social science aspects of the discipline), large scale mapping and land surveying (the traditional technical and engineering aspects), and cadastral management (legal aspects of boundary surveys). Based on the interviews of senior academics and administrators, these themes are intended to expose students to the wide field of spatial sciences, incorporating all aspects, one of which the students select for specialisation in their final years. Both staff and students stated that the wide exposure offered, at this level of the programme, helps the students to make informed decisions about their specialisations. Furthermore, the academic staff and administrators perceive that a more important benefit is that it develops in students a broad-based knowledge about the multiple functions of the professional surveyor. This is further discussed under the next subsection that considers the programme duration.

The specialisations offered in first year of the Master's programme are in essence, themes at the higher level. According to the programme leader, these higher level themes are treated differently in the sense that students are given greater autonomy in the selection of projects. According to him, the original intention was that a semester would be reserved for students to develop work-based competencies through an industry attachment (internship). However, for practical reasons, he stated, students are given the option to do a work placement, or an international academic exchange, or another project at the University in the ninth semester. He added that the thesis in the final year is also related to the 'theme' or higher level specialisation. In this regard, the final two years of the programme are treated, in some senses, as the specialisation years in some of the programmes mentioned in Chapter 5.

It has been demonstrated that the AAU Surveying programme has unique curriculum features relative to others in the study. Its structure appears to play a predominant socialising function in terms of developing collaborative problem solving skills in students. While the small group projects appear to encourage some degree of learner autonomy, there was also evidence of significant staff direction in the selection of themes that largely determine the direction of the study programme.

7.1.2 Programme duration

It was explained in Chapter 5, that Denmark is one of two countries in the study that requires a Master's degree for professional qualification as a surveyor. Both staff and students stated that the Bachelor component of the programme is dedicated to a generalist education that exposes students to a broad range within spatial sciences as indicated in the curriculum model (**Figure 16**). The students generally viewed this arrangement as helping them to make informed decisions about their specialisations as shown in the following comments.

> *I think it is best to do the Bachelor programme first then choose my specialisation because by then you get to try everything before you have to make that decision. [2nd year student]*

> *A lot of people change their minds during the Bachelor. [2nd year student]*

Comments from staff suggested that the generalist focus for the Bachelor and specialist focus for the Master's is a strategic mechanism to develop a particular type of graduate. It was suggested that graduates from this programme will have a generalist orientation that gives them broad based knowledge of activities in surveying and related fields, along with more focussed expertise that is perceived to more specifically prepare students for professional work.

The first three years of our programme expose the students to spatial planning and land use management, land surveying, large scale mapping and cadastral management. By the end of the Bachelor years they would have been widely exposed to this wider field. The last two years are most important for developing in them the readiness for work. This is where they specialise. [Senior Academic]

It takes five years to produce graduates that have the profile required of the modern surveyor. [Senior Academic and FIG representative]

Our education is geared towards producing a professional with strong specialisation expertise on a base of general education. That is what we get in a five year programme. A shorter programme would not work for us. This has been our tradition for a long time. [PD]

The data also showed that within the Danish context, the duration of the programme has a historical connection with an older education system for surveyors in a 5-year continuous course of study. The discussion in Chapter 5 showed that this tradition is related to the old professional education system in Germany. The shifting of the AAU programme to match the 3+2 Bologna Agreement (Enemark, 2005) did not, in essence, change the period of study for AAU students, since an exit after three years with a Bachelor's degree would not qualify them for the profession. The programme director supported this by indicating that:

almost 100% of our students continue their education to the fifth year as a continuous programme.

Another senior academic added:

We have no place in the surveying industry for Bachelor's graduates. To us someone with that qualification has not completed their studies.

Surveying education in Denmark is stratified with the five-year programme for the professional degree and lower qualifications available in technical institutions for the training of technicians (Enemark, 2009). Hence, it is asserted that the Master's degree represents more than a symbolic capital but has cultural and economic relevance to graduates. Professional development over a five year period (as opposed to the three years at NU and four years in most of the programmes in the study), can in this sense be seen as an advantage. It offers a period of three years dedicated to develop generalist spatial science knowledge and in the final two years a more in-depth knowledge in a specialised area. The product from this system is what Enemark (2008) described as ‘a specialist generalist surveyor’. However, comparing a PBL system with more conventional curricula is a complex matter. One argument from the literature is that PBL settings require more time to cover content knowledge relative to subject-based, teacher-led arrangements. Hence, five years in a PBL setting may be considered to be equivalent to a shorter period in a more conventional subject-based setting. An analysis of the staff interviews, particularly those members who had experiences as students in the old five-year system, suggested that the scope and standard of the education are not compromised as a result of the PoPBL model employed:

> *We teach as many subjects here as we did in the old system as I was educated in. The arrangement is different but the students are exposed to all the necessary areas. In fact, with the many changes in technology and so on, we actually expose our students to a lot more than was taught under the old system. [Academic staff]*

> *What this approach [PBL] does, is give space to new developments and changes in the professional areas. The traditional approach depends heavily on lecture courses and on the lecturers. They are inflexible and that jeopardises the whole profile of the surveying programme. [Senior Academic & FIG president]*

7.2 PoPBL pedagogy

Beyond the programme documents’ descriptions of AAU’s pedagogical arrangements, the empirical data have provided deeper insights into the nature of PoPBL within AAU’s surveying programme. Initially, the discussion about the pedagogical arrangements will focus on the structure of their arrangements and then on the habitus of the primary agents within it. It will be shown that the habitus of the students and academic staff manifested some distinct characteristics relative to those in the first case study.

In contrast to how NU’s staff and students perceived the pedagogical approaches used in their more traditional programme, AAU’s staff and students perceived their pedagogical arrangements as an innovation. A wide-scale belief amongst the academic staff is that other surveying programmes may benefit from adopting the AAU model. Comments from students in both cases broadly expressed satisfaction with the methods used in each context. Hence, this analysis is not focussed on student satisfaction but rather on how the pedagogical approaches may be distinguished from those used in the first case study. Furthermore, it is expected that this understanding will add important insights for the development of an improved model of surveying/geomatics education. It is useful to firstly elaborate on the nature of the pedagogical approaches as observed.

Although the observations and interviews showed that multiple pedagogical approaches were employed within AAU, the most prominent approach was small group projects that utilised PBL techniques. These group projects played a functional role in meeting course objectives that were incorporated within themes designated to each semester. These groups were under the guidance of supervisors but mostly involving student-student interactions in executing the project work and production of reports for assessment. Identifying small group projects as the predominant pedagogical approach is based on the fact that students were observed spending significantly more time on projects relative to other on-campus pedagogical activities (mostly lectures). Furthermore, small group projects showed prominence based on the high degree of importance placed on them as suggested by interview responses from both students and academic staff. A comment from a first year student spoke of the early orientation of students for group work.

> *We have lectures, like the math class we have in five minutes. But afterwards we usually return to our group rooms and work together on any problems we may have from the lecture. We also spend time together to do group work. So we are in our groups very often. [1st year student]*

The more senior students also spoke of the prominence of group work within the programme.

> *We meet every day to as a group develop our group project. In the early stage of formulating the project, which is usually at the start of the semester, we see a lot of our supervisor. The project has to be approved so we discuss ideas with the lecturers. After that we organise our work and within our groups develop the project. We sometimes have lectures and practical exercises but we continue to work on our projects. If we need the supervisor we call on them. They are available but we don't always need to consult them. [4th year student]*

This comment also showed that the pedagogical arrangements do not only involve small group project work but also traditional lectures and supervised practical exercises. The programme director stated that, traditionally two-thirds of the curriculum was dedicated to project-work and a third to lecture-based modules, some of which have associated practical exercises which may include laboratory work and/or field work. This he indicated has changed recently to an almost equal division between these two pedagogies.

> *Our system used to have 2/3 of the time used for project work. This is now being changed to have approximately 50% for course work. [PD]*

The lectures observed at AAU bore some similarities to those observed at NU. Common features were that the lectures were teacher-led with the use of multimedia and with some degree of interaction between lecturer and students. Also, students had prior access to the lecture notes and reading lists developed by the lecturers. However, one observed difference between the two programmes was that, whereas at NU the modules run over a semester, within the AAU programme they are done over shorter periods to allow for time dedicated to group work. This again reinforced the prominence of project work and the use of more traditional methods primarily as support for the projects.

> *We have set blocks for lecture courses and blocks for concentrated group work. Because the group project is such a big part of our system, students need to have time to develop their projects and the lecture sessions are to provide the knowledge they need to help them with the projects. [PD]*

An observed laboratory session was facilitated by a tutor who identified himself as a part-time lecturer teaching the application of a specialised software package that is used within industry. He indicated that one of the primary learning objectives was that *'the students should be able to use the software effectively within their project work.'* Though, the lab tutor was seen to provide individual attention to students in support of their learning the software, several lecturers noted that the teaching of software was not the norm within the programme. As the comments of one lecturer and a student suggested, the responsibility for learning software operations lie with the students; and the University's responsibility is to provide the physical resources.

> *We are not really into teaching software to the students. They have powerful computers and we provide the software they need to use in their projects. [Lecturer]*

> *They don't want to teach us software use. But if we have question they will assist us but they are not really part of the lectures. [4th year student]*

The early indications of this innovative pedagogical arrangement warranted a deeper investigation, particularly in the area of group project which manifested as the most prominent aspect. To this end, several project groups in most of the year groups were observed during group activities. A narrative account of one group meeting is included to illustrate some features that were found to be typical of the small group pedagogy:

> *It is 12:30pm and four students are seated in a well-lit and airy room opposite the open door of a lecturer/supervisor. Each student is intently focussed on laptop screens. The room has a chalk board with notes written on it and a notice board with a work-flow chart and other information sheets stuck to it. There is a general sense that the members of the group are in familiar space and company.*
>
> *The conversation between the students is low toned and in Danish. They appear to be focussed on different aspects of a project with infrequent interactions between the members. Two persons are positioned before one lap top in what appears to be a collaborative effort. One eventually leaves and returns to his own laptop at which point all four are at separate computers. Questions are posed by members at intervals. Responses typically manifest as a debate between various members.*
>
> *One member leaves the room and goes to another student room (perhaps for consultation or a needed break). Another student visits from another room. There is laugher and a quick chat. One person continues talking with the visitor but the others continue to work on their laptops. The visitor leaves shortly. There continues to be intermittent interaction between some members while others remain focussed on their computer-based work. Students are observed to work with word processing files, computational files and graphics (drafting) files and appear to use a sharing device that allows information to be seen simultaneously on different computers.*
>
> *Throughout the one-hour period of observation, the students remain focussed without any obvious supervision from staff.*

As I observed these students, a number of questions emerged: What compels their intense focus on group work? Is it the fact that their assessment will be based on the project? Is it that they are cultured to operate in this fashion? Are they genuinely interested in the project? Are they driven by their responsibility to the group?

To explore answers to the emerging questions, the group observations were followed by a focus group discussion with the students and interviews of their supervisor, some of their lecturers and their programme director. This observation provided interesting insights into the small group pedagogy, particularly for considering how group work is structured, issues related to group dynamics and the general disposition (habitus) of the students. The following is an account of what the data suggest about the surveying programme at AAU.

Group size

The size of the project group is considered to be a factor that impacts learner accountability and responsibilities. In this regard, the smaller groups were preferred as they were believed to encourage greater participation from group members. The group in the vignette had four members. However, based on wider observations, project work may be conducted by one to seven students. Also, it was observed that first year groups were larger with all three first-year groups of surveying students having seven members each. The smaller groups were mostly in the Master's years where students specialise and are given greater autonomy in their project work. Of the four master's group interviewed, one had four members, two had three members and one had one member (an arrangement that happens infrequently according to the PD).

Group membership

Due to the centrality of group work in the pedagogical arrangements, it was surprising that the selection process for group membership was not remarkably elaborate. Students spoke casually about the selection process and gave the impression that it was the cultural norm for students to engage with whoever they are placed. They further stated that group membership is determined mostly by shared interest in a project topic. The students in the featured 4th year group stated that they specialised in Land Management and that their association as group members stemmed from their shared ideas related to their specialisation (specialisation commences in year 4).

> *We all had some ideas from the start and said we wanted to work in spatial planning. [Group member]*

The students also indicated that during the Bachelor years they all worked with different group members and in groups of varying sizes.

Apart from the first group in the first year, students are primarily responsible for group selection though staff has the power to intervene where necessary [senior academic].

Project work takes precedence over lectures

In response to what was observed (as written in the vignette and summarised to the group in the discussion), the students explained that their focussed work on the project was necessary after spending most of the earlier part of the semester doing lectures.

Almost all of the first two months in this semester were filled nearly all week with lectures. In that period we only know we had time to get the project form, not to work in depth with it. [Student]

The comment suggests that the project is considered, by students, to be the more important aspect of their studies. Furthermore, lectures were seen as necessary, but a supportive component that is best covered quickly to give way to group work.

We had only about 1 day a week to form a project and frame up a problem. The first part of the semester is packed with lectures. [Student]

This general sense of 'making up for lost time' is one likely reason for the intense focus observed in the students' group activities. They also indicated that much work had been done outside of the meeting room by individuals based on assigned duties, which they pointed to on the task chart on the board. They indicated that they spend up to 8 hours in the room each school day. The nature of the group interactions was described by students in the group:

We come here every day- that is the culture here. [Student]

We don't just sit here completely still. We ask questions around from time to time. [Student]

It's a great forum to work here so we can draw the knowledge that the others have. When you read the same things, the knowledge is different so you can draw on that by working at the University. Also you don't get easily distracted when you are in a room with your fellow students. The main goal in the 8 hours is to make the project, is to write and also study some things. [Student]

The nature of the relationship between students and academic staff, though to some degree, mirrors the NU pedagogy, is inherently different as will be demonstrated by a look at the habitus of the students and academic staff.

7.2.1 Student habitus

The observations of project groups, as illustrated in the vignette, shed some light on the habitus of AAU's surveying students as relating to their general and some specific dispositions towards their study. The features that emerged as prominent will be discussed under sub-headings as was done in the NU case study. As will be seen, the aspects that are focussed on here are, in some cases, different to those focussed on in the first case study. This is due to the data-led approach used that concentrated on those aspects that were most prominent in the data. It is understandable that because of the PoPBL pedagogical arrangement at AAU, there would be variations in the focal aspects for analyses. The discussions will consider how these differences manifested.

Heightened sense of learner responsibility

Perhaps the most prominent feature of AAU's students' general disposition towards their studies was the high sense of learner responsibility relative to students in the NU case study. The observation of students consistently meeting over the two-week period of the visit, their engagement in regular and intense peer to peer interactions and to a far lesser degree student-supervisor interactions, strongly suggested that the students were highly self-directed, with a strong sense of responsibility to their peers. Students from as all levels of the programme appeared to embrace the concept that PBL group work was not only appropriate for effective learning but also that it had relevance to building competencies relevant to work.

> *PBL is good for group interactions. We will be required to work in groups as chartered surveyors. [1st year student]*
>
> *It is good to work with other people so we can help each other understand. [2nd year student]*
>
> *We get used to working in teams the way they do it in the real world. [3rd year student]*

In spite of this identified awareness of self-directed learning, there was also the demonstration of dependence on the academic staff for some aspects of learning. Students at all levels made comments that demonstrated their reliance on the academic staff as important guides for their learning.

> *It is a lot of work but we get a lot of help from our group tutor and our supervisor. [1st year student]*

> *When we have lectures they usually give us a list of references. These help us with our projects also. In some areas the books are not widely available so we get pdf files from our lecturers. [4th year student]*

Comments such as these suggest similarities with NU's students. However, relative to students in the more conventional setting at NU, AAU's students appeared to perceive the academic staff in a more supportive role rather than responsible for their learning. In regards to learning effectiveness, students rated peer interactions and independent research more highly than their interaction with the academic staff:

> *When we leave a lecture, we return to our group rooms and together discuss what was done in the lecture. I learn more from discussion with the group because we can explain things further. [1st year student]*

> *We can look at the Internet and other references after the class so we learn more outside the class. [1st year student]*

> *We share this room with another group and we like that because we help each other. We learn from each other. [2nd year student]*

> *Sometimes we have theoretical or technical problems with some of our programs and we might go to the next group room and ask if anybody else has a solution so we can get on. [3rd year student]*

Other comments by students and staff, highlighted progressive reduction in supervision and increase in student autonomy as the students move from one year to the next. There appeared to be a deliberate change of supervision strategy as students move from the Bachelor's programme to the Master's. This demonstrated close alignment to the stated objective of the final two years to prepare the students for independent work which is perceived to bear some resonance with actual work. Some of the comments from students and staff that led to this analysis are included:

The first introductory practical we did when we started was the only one that the university picked the groups for us. That was when no one knew anybody. After that students select their own group. [Year 4 student]

We learn so much from each semester about how to go about projects and how to structure the report. So all four individuals in here learned some things over the last 3 years that made us able to make this year's project better than the previous years. And next year we are even wiser so we can do it even better. [Year 4 student]

In the Bachelor years we provide a lot of guidance for the students. We advise them on what to do as projects and we give them a lot of supervision. As they move up they learn more about doing things on their own and about working together on one project. They do not require as much supervision in the later years. In fact they usually choose their projects for the Master's years and come to us for advice and approval. [Supervisor]

Economical approach to knowledge search

The student interviews responses gave information on their efforts in sourcing information for their project work. There appeared to be an economical approach to knowledge search on the part of students. That is, they indicated that they only seek out information that they perceive to have relevance to their current project. These two comments suggested that student learning is limited to the project scope even if lectures have a wider focus.

We learn as much of the software as we need to know for the project. [4th year student]

Yes we get lectures but the stuff we focus on are the things we need for the projects. [2nd year student]

Even a lecturer's comment supported this action. It suggested that lecturers' actions may encourage knowledge search within the narrow confines of project work.

I try to find out what students are doing in their projects and use that to focus my lectures. [Lecturer]

These comments confirm what the programme documents described as a curriculum that is highly project oriented. This observation could be seen as a threat to the effectiveness of PoPBL where developing a wide knowledge base in students is beneficial for professional development. It was noted that some modules, and the lectures associated with them, may be considered to be useful only to those students whose projects have a direct bearing on the subject matter being covered. Some students suggested that some lectures have little relevance to their selected projects, and, in those modules they may display little interest. This is illustrated by comments from a student and lecturer in the post-class interview:

> *I do attend for general information but I am not as focussed as I would have been if the lecture material was more closely related to my group project. [2nd year student]*
>
> *Students do try to make a link between lectures and their project work. They may not pay much attention to lectures that they don't think help with their project. [Lecturer]*
>
> *Lectures are designed so a group can do what is meant to be done in a project. [Lecturer]*

This finding suggests that lectures are treated as serving the projects. Hence, students demonstrate selective tendencies in what to engage with in subject-based, lecturer-led classes. That is, students determine the relevance of lecture material to their projects. It is argued that this can inhibit a wide scope of learning if projects have narrow foci on specific aspects of the theme or if students consider particular lectures irrelevant to their projects. In spite of the perceived threat of limiting the knowledge of students within the PoPBL model, one lecturer asserted that that are greater benefits to be derived from the model relative to more conventional approaches to learning:

> *Our students are expected to think for themselves and question what they hear. As an exchange student in another country I was with students who were expected to learn what is written and n ot what it means. I think you are better off knowing how to use the knowledge you have even if in some cases it means knowing a little less than what is written. I think that problem based learning supports this quite well. [Lecturer]*

An interesting contrast with the NU Geomatics programme is that as was shown in the previous chapter, NU students highly valued activities such as detailed lectures from subject experts as they perceive these to effectively prepare them for success at examinations. It is argued that within the AAU context, relative to NU's, lecture content is more likely to be evaluated for relevance at the point of information delivery. The data have shown that students within the AAU programme are oriented towards project work from early into each semester following the basic year. They tended to weigh the significance of lecture materials to their projects at the time of the lecture as their comments suggested. However, the data in the first case study showed that NU students were more likely to make this consideration prior to their preparation for examinations, which is mostly focussed near to the end of the semester as was shown in the previous chapter. This finding corroborates what has been identified as a disadvantage with PBL i.e. relative to conventional pedagogical methods the breadth of knowledge coverage is likely to be less.

Socialised through separation in early part of programme

A surprising and interesting feature of the first year pedagogical arrangement was the way in which the surveying students were physically separated from the other AAU students. Students in the first year of the programme were grouped with other first year students at a campus located some miles from the main campus. While it is not clear if there are economic reasons for this arrangement, comments from an academic staff, teaching the first year students, suggested that there are philosophical advantages. He expressed that the physical separation of level-one students was designed to:

> *develop a culture of learning-to-learn so they can be socialised in the new learning culture separate from the technical demands of specialisations. [Lecturer]*

This arrangement suggests that the acquisition of the skills for PoPBL is developed in a specialised field that acts as an incubator that prepares students for actual PoPBL on the main university campus.

As in the NU programme, members of the academic staff played an important role in the pedagogical arrangements.

More driven by commitment to project work rather than assessment

When the focus group discussions with students were allowed to flow organically, assessment did not feature significantly. During those times of organic discussion students tended to focus on explaining their collaborative strategies for conducting their projects. When the discussion was steered towards assessment, responses suggested that students considered assessment to be an important element of the course, but it appeared to play a minor role relative to what was observed in the more conventional first case study setting. Students even shared their opinion about their brand of education relative to the more conventional model.

> *We have an exam in Maths in the first year but most of our assessment is based on our group project. [Student]*
>
> *I have a friend who is studying in another university and he just attends lectures and then goes home and writes assignments on his own and then writes big exams at the end. That for me is not real learning. [3rd year student]*

From interviews of staff and students it was determined that the primary means of assessment is an oral examination at the end of the semester, based on the group-based project work. However, in the first year, Mathematics has a significant focus and is assessed separately. The students indicated that assessment methods used for Mathematics have varied over the years and have included traditional paper-based examinations; computer based multiple choice examinations and oral examinations. The staff and student interviews also indicated that formative assessments are based on peer interactions within groups and feedback from supervisors which vary according to groups and supervisors.

> *We have been working on this project all semester. For the exam we will all present our project as a group for our supervisor and the sensor [external examiner]. And then we will go in individually to be examined. [3rd year student]*
>
> *They ask us questions but it's different each year. Each supervisor has his own style. We may be asked to pick a part of the project to talk about. We are asked questions relevant to the project but we can get from the 'pencle' (from the wider knowledge group covered under the current theme). [4th year student]*
>
> *We try to do a better project each time. We learn from each one to do better on the next one. Exam, we think about that when it's time for it. [4th year student]*

Socialised for collaborative learning

Responses from students gave a general sense that they were 'comfortable' with the collaborative approach to learning. Not only are the skills developed in the first year as discussed in the first theme, several students also stated that they were introduced to the concept in high schools:

> *It works better with the rest of the system in Denmark. In high school we have some project work. We do it as well in some elementary schools. And we are getting used to working as a team, the way they do it in the real world, in companies. I think this works better than the old school university teaching where you have lectures and you write a paper and you get grades back. [3rd year student]*

> *I really enjoy the fact that you get the theoretical knowledge but you also get to use it and you get really down to it in the projects. That's where you really learn it by heart so I think it's the best model around. That is one of the reasons I chose Aalborg. [3rd year student]*

While there were concerns expressed about group work, the majority of students offered positive feedback on the learning approach. They generally perceived it to be beneficial to their learning. The four comments are from students in the same Year One group:

> *We learn from each other, when one understands something well that person can help the others to improve their understanding.*

> *People have different ways of looking at things and that can help others.*

> *The democratic approach can be a disadvantage because it takes a long time to come to consensus.*

> *I like it too because it helps me to understand better.*

Generally Surveying career focussed

While the enrolment challenge within most of the other programmes in the study was also true for this programme, one sticking feature relative to the NU case was the high proportion of students who indicated interests in a career in surveying. The educational model appeared to attract students who either come into the programme with a desire to become surveyors or who developed the interest after enrolment. Even one student who desired a part-time career in archaeology indicated a clear link with the programme:

I have not yet decided on my major, but I am having some thoughts about measurement science because I would like to work in archaeology. [2nd year student]

The majority of the other students had clear career aspirations in areas specifically aligned to the programme:

I am definitely going to do surveying after university. [1st year student]

I will either specialise in surveying or land development. [1st year student]

I chose this university because it's the only place that offers surveying which is what I wanted to do. [1st year student]

Most people here are very focussed on becoming a surveyor and some people choose it because it sounds interesting but most people have thought it through before they start. [4th year student]

That is one of the ethics of group work. If someone is negative about the work, we encourage them and that helps them to see the benefit of this course. [4th year student]

It is believed that the simulations of actual surveying works, as done through the semester long projects, contribute to students' awareness of being prepared for a career in surveying. While a few students indicated that they choose the University because of the educational model, the overwhelming majority indicated a motivation related to the desire to pursue a career in surveying. The PoPBL education model does not appear to offer a solution to the enrolment challenge in Denmark, but it does appear to enhance the interest of students enrolled in the programme in regard to following through with a career in surveying. This contrasts with the findings from the NU case, which showed diverse career ambitions among the interviewed students. Moreover, within the NU programme, several students expressed uncertainty about remaining in the geomatics field after graduation.

7.2.2 Academic staff habitus

There was an interest in having a perspective on the general dispositions of the academic staff towards teaching and learning and towards the surveying profession. This was of particular interest since AAU was built on a principle of an innovation that democratises the teaching and learning arrangement, which in essence, changes the role of the lecturer from leader to supporter or partner or guide in learning. Thus, there was an expectation that the role of the academic staff would reflect this constructivist paradigm. As outlined in the methodology chapter, a focus on the *habitus* of the academic staff is specifically concerned with coming to an understanding of their roles and functions, the nature of their relationship with students and with the surveying profession, and the challenges they perceive themselves to have in the execution of their academic duties.

Of the academic staff interviewed, approximately one half indicated that they were AAU graduates and the others had been educated in more conventional programmes. One member of the academic staff expressed that as a student at AAU, he was '*happy to be a part of the big experiment*' as he was amongst the first batch of students at the then newly established University. Another lecturer who was educated in what he described as '*the old system of education in Copenhagen*' expressed what was found to be a generally expressed view from the academic staff interviewed (both AAU graduates and others):

> *This is a new way of guiding student learning and we had to learn this special approach and appreciate what it has to offer. We still see ourselves as teachers who organise knowledge content and deliver it in lectures to students but more than that we are project supervisors. We guide students in their project work which is the core of our model. This is an interesting and exciting way to learn which is beneficial to both students and academic staff. [Senior academic]*

The feedback from staff indicated their perspective that they were a part of a programme that models a successful application of an educational innovation. Success for them appeared to be a measure of how well students are prepared for work.

> *Innovation is no longer based on individual knowledge; it is now based on collaborative knowledge. Innovation and team work are combined. Our students learn to collaborate, to be more innovative, to relate knowledge from one single discipline to another – the cross disciplinary approach. Our students learn to solve problems and that is useful for work and life. [Senior Academic]*

The academic staff saw themselves as playing the dual role of lecturer and small group supervisor. It is argued that each role requires different skills, and I was interested in finding evidence that verified or refuted this claim. From the observed lectures, there appeared to be no noticeable differences in how theoretical knowledge was presented in lectures, relative to NU's lectures. Students had prior access to the lecture notes (presentation slides) and there was a typical teacher-centred approach to delivery of the material with intermittent lecturer-student interactions. Since the lectures were in Danish, my interpretation of what was being presented and discussed are based on my interview with lecturers and students following the observed classes. Students appeared to ask questions that sought clarification on aspects of the lecture, as was the case in the NU setting. However, an additional feature of the lectures at AAU was the fielding of questions that connected student projects with lecture information. This suggested that the academic staff's role, as project facilitators, was prominent in their functions. They appeared to expect and readily entertain questions about projects. One lecturer indicated that

> *I am always willing to disregard lecture plans to entertain students questions because this is where real learning occurs.*

There was a general sense that when students were focussed on group projects whether in their assigned rooms, in a lab or in the field, the academic staff remained accessible. Supervisors' doors were observed to be opened and students rooms across from them occupied with students in group meetings but not many instances of supervisor consultations were observed. Where supervision was observed, the consultation appeared cordial and mostly brief (between 15 minutes and half an hour). Comments from supervisors and students portrayed group facilitating as playing a supportive and guiding role. Supervision according to them is intense and regular in the early years but less so in the more advanced years.

> *We provide close guidance in the projects for the first three years. We suggest projects and we provide regular and close supervision. In the Master's years we expect students to develop their own projects and then we guide them but they are more in charge than in the earlier years. [Supervisor]*

> *We are doing a map for our project. There are many things we don't know but we are getting a lot of help from our supervisor. We see our supervisor once a week. [1st year student]*

> *We have a planned meeting with our supervisor every two weeks but if we have questions we see him at other times. [4th year student]*

However, students' comments also suggested that the nature of the supervision is also dependent on the level of perceived student confidence in the project being undertaken.

> *We had a few ideas but wanted to know if the professors had some good ideas that could spark our interest even better. They had a great idea and we took that. It is a fairly new area to us so we meet regularly with the supervisor. [4th year student]*

The discussion has shown that there are indeed differences in the functions of lecturer and those of project supervisor at AAU. There were indications that project facilitation was the academic staff's more important function within the model, and lectures were secondary and supportive of projects. However, it appears that the reduced emphasis on the lecturer functions has met the disapproval of a government quality control body for higher education. This was mentioned by several of the lecturers interviewed and by the programme director.

> *Recently we were told that we had to change our structure and do more lectures and reduce the project time. We think that is a wrong move and are hoping they will see the real value of our model of education. [Senior academic]*

The comment suggests that this is seen as a challenge to the educational model in its established form. Many expressions of concern about the ability to maintain AAU's unique model, strongly suggested that that change has negatively impacted the habitus of the academic staff. It however, appears to be beneficial in at least one way that was suggested by an academic:

> *Even when the students come up with a problem we expect them to solve it within the confines of the knowledge we provided them.*

The comment suggests that lecturer-led knowledge is embedded in the learning process even though an equal amount of time is dedicated to project work. The proposed equal division between lecture courses and project work supports the notion that a mix of pedagogies is best for developing a wide range of competencies in students (Schweitzer and Stephenson, 2008); and also that more supervision and didactic approach is appropriate for novice students than it is for more mature students (Di Napoli 2004).

However, some of the interview data show that this matter is not as clear cut. As did NU lecturers, AAU lecturers identified themselves as experts in narrow specialisations based on their research. However, some AAU lecturers acknowledged that while their expertise was important to knowledge transfer, their narrow research focus was not viewed as a limitation to student exposure. Many of these lectures' comments suggested rather, that guiding students in learning was done in an environment of openness. The comments suggest that the openness allows lecturers to share their knowledge while at the same time allowing students to share what they know and together they construct new knowledge.

> *The supervision in our PBL setting is encouraging for staff because it's nice discussions with the students about their approaches to dealing with their projects. Students would sometimes try to address problems that are close to the research areas of certain professors so that they (students) can benefit from that. And the other way around, the professors find areas being addressed by the students so interesting that they will carry on with it in their own research. So that's a dynamic interaction there that's a real engine in the system that works well. [Senior Academic]*

> *We have to be prepared for the fact that students very often and very quickly find more information about a subject than you know yourself as a teacher. I cannot say you only have to read what is in the text book, it may be 5 years old and the student may have found new information on the net which is much newer and better and based on much more research and I should be prepared to reflect on that stuff because of our learning environment the student can integrate this stuff in his problem solving. [Lecturer]*

> *I am a supervisor and a teacher. The idea is that they [students] should seek knowledge themselves and sometimes they dig into stuff that you [the lecturer] may not be quite aware of. That's the way it works here. We [academic staff] have been here a long time so we have a good idea of how solving problems should be tackled so we are open-minded. [Lecturer]*

Training for the academic staff is typically done in short courses such as the three-day course that was observed. The course was attended by new PoPBL facilitators and led by staff dedicated to executing the training needs along with conducting and reporting on research in PoPBL. In light of concerns raised about PBL facilitation (e.g. by Savin-Baden, 2000), the practice of facilitator training reflects positively on the AAU model. However, comments from some supervisors indicated that though they all had access to published materials on the subject, not all supervisors had formal training in facilitation.

I have chosen to attend a 2-day course but it turned out to be without value in this context. I am instead relying on the teaching sills I was taught in the army and the fact that I have been a student at this institution. [Lecturer & Group Supervisor]

It was observed that systems were put in place to ensure that both staff and students are provided with specialised training to prepare them for engagement in the PoPBL model. Differences were observed in how the academic staff members were trained for their role as PoPBL facilitators / group supervisors and how students were educated about the model.

7.3 Education-professional dichotomy

The fact that the AAU surveying programme is pitched at the Master's level, implies that professional qualification for Danish Surveyors has an academic emphasis. This argument was supported by a number of academics who were keen to represent the programme as such:

We are an academic programme; we want to produce students with the highest academic capabilities who can function at the highest professional level. [Lecturer]

It is much more attractive to employ graduates that have the full competence of an academic. A Bachelor is not capable of doing that. [Senior Academic & FIG President].

The latter comment also shows a popular view amongst academic staff that the two levels of the programme represented the development of vocational skills at the lower level, and higher professional and more academic competencies at the Master's level. In response to the question '*How would you describe your programme in terms of its academic and professional characteristics*?' One lecturer's response clearly supported this notion:

At the Bachelor's level we take a very practical approach using projects to ensure that students can undertake the tasks that they will have to deal with in professional practice. At the Master's level it is scientific and problem-based, a very academic approach so students learn how to address open problems or questions in a scientifically correct way. [Senior Academic]

The pedagogical approaches employed were considered by both staff and students to be oriented towards preparing students for professional engagement and in that sense were perceived by them as having a professional focus.

> *We use project-based learning that requires collaboration and problem-based learning that uses real problems like the professionals deal with in their work. In our programme we model what is done in real life. [PD]*
>
> *The Aalborg model is good for group interactions as we will be required to work in groups as chartered surveyors. [Student]*
>
> *In real life we have to work with other people and solve problems. That is what this education teaches us. [Student]*

Though the representatives of the Danish surveying profession did express agreement that students do have strong collaborative and problem-solving skills, they also expressed some dissatisfaction with the technical skills of the graduates. The comment from one professional surveyor who holds a leadership position in the local and regional Surveyors Associations captures the concern of the profession:

> *They [graduates] are not as good in the technical abilities as graduates from the pre-existing institutions. They are quite good at group work and problem solving but we in industry need people who can project manager as well as carry out the technical functions.*

To enforce his point, this employer compared graduates from the former surveying education to the AAU programme. He added that the profession took measures to address what they perceive to be a shortfall in the education programme:

> *If you go back 25-30 years ago when you left university you were able to perform as a surveyor immediately. You had e.g. during summer courses all the necessary skills using the instruments and everything. Nowadays when they finish the Master's they still need a lot of technical skills. That is why we invented some courses for young surveyors to improve their skills before they can apply for the licence.*

This point resonates with what was identified in the literature as a trend in which university graduates following up their studies with more vocationally oriented training (see e.g. by Golding & Vallence,1999). It also resonates with the notion of academic drift in which professional courses gradually lose their vocational relevance to greater academisation (see e.g. Jonasson, 2006; Harwood, 2010). The rebut to this, from a senior academic, demonstrates that the debate surrounds a variance in *capital* within the university relative to capital within the profession.

> *The concept is not university as learning for life but for lifelong learning. So you will have to keep up during your professional career. It's important that the profession in collaboration with the university establish the necessary courses for keeping up to date and for upgrading the professionals. So that interaction between profession and university is very crucial.*

While the programme representatives accept that some competencies will need to be developed after graduation, they also assert that university's role is not merely to train students to perform surveying functions (learning for life) but to pursue learning as an on-going process (lifelong learning). The view expressed by the professional surveyor resonates with a functionalist philosophy, a context in which technical competence is a primary *capital*. On the other hand, within the academy, based on the senior academic's rebuttal, the primary capital is the orientation towards learning that promotes personal and ultimately professional development.

It is asserted that the positioning of the professional programme as an orientation towards lifelong learning is in conflict with industry expectation. The AAU pedagogical model is seen by its staff as an embodiment of this ethos. While acknowledging that the practical competence of graduates may be less than in previous programmes, one senior academic asserted that the programme's overall impact should be judged against the type of *capital* that it conveys to students:

> *The profession and the employers were very sceptical in the beginning about using problem and project-based learning for surveying. But it turned out that these graduates are actually good but a bit slightly less good in the more practical things from day one but much better in undertaking, analysing big and complex problems and deal with them in a professional way. [FIG president and Senior AAU Academic]*

Another criticism that came from the employer interviews was that graduates were under-developed in their ability to make unilateral decision, a skill identified as important for project management in professional surveying practice.

> *They are used to working together in their studies and it's an advantage in many aspects but also sometimes a disadvantage. They are used to solve*

problems in groups but in a lot of our work, when you go out in the field you are alone. We expect them to manage the situation as on a building site where it's chaotic and they are expected to make on the spot decisions alone. Also they are not used to project management and we have to spend the first year teaching them this. [Principal in large private surveying firm]

In spite of this apparent tension between the university and the profession, the educational model does appear to engender close relations between the two groups of agents. While collaboration and problem-solving are *capitals* within both the education and professional, the profession appears to value technical competence as equally important yet not so treated within the academy. The expressed opinions of both sides of the argument represented what appeared to be a healthy relationship between both agents (academy and profession). It is believed, that this relationship is fertile ground for coming to solutions whenever tensions arise within the Danish surveying education *field*. This is considered to be a distinct difference between this case and the NU case study.

Another feature of the programme was what the data suggested was an inbuilt mechanism to socialise students into the profession during their studies. This came out of comments such as these from both academic and administrative staff:

Our students are integrated at a very early stage into the profession. They take part in professional activities within the profession through their projects and actually feel like being part of the surveying profession community at a very early stage. [Senior Academic]

There is a close interaction between the university and professional practice. We include our students into practice like the annual meeting every year which usually have more than half of the active surveyors in the country in attendance. This is quite amazing compared to other professions. So students have a strong sense of being a part of a professional community. [Senior Academic]

As was found in England in the first case study, there is also a dichotomous relationship between academia and the surveying industry in Denmark. However, there are differences in the points of tension in each context. In the case of England, the tension is largely linked to the discontinuation of sub-degree surveying courses. In Denmark, however, the tension appears to be associated with philosophical differences between university and the profession. While the surveying profession in Denmark has expressed concern with the technical abilities of the AAU graduates, the University strongly supports its curriculum and pedagogical approaches as conveying an orientation towards lifelong learning that will enhance professional development.

On this argument, the acknowledged deficiency in practical competence upon graduation can be addressed through post-university arrangements, if graduates are oriented towards continuous professional development. Thus, it is argued that effective surveying education should not be judged only on the basis of either point of view. While technical competency is important, the capacity to learn new things driven by an orientation towards on-going learning can, and sometimes do lead to a much wider pool of professional competencies. One drawback is that industry may see this approach as delaying productivity. However, where it is seen as an investment in human capital, it may well yield greater productively in the long term.

Furthermore, developments within the discipline have created a much wider knowledge pool and possibilities for exposure to a broader range of techniques being applied to spatial data collection, manipulation and management. The impact of this scenario is what will be explored in the next section.

7.4 Geomatics paradigm

Unlike within UN, 'geomatics' was not a term used often in my interactions with AAU's staff and students. Since the term's French origin and modern use in Francophone Canada then later in Anglophone Canada, it has spread to many English speaking countries including many of those in this study. However, the term appears to have not infiltrated Denmark. Notwithstanding this, the idea that surveying practice and education have evolved beyond their traditional definitions, is well established in the Danish context. Hence, the underlying concept of the 'geomatics paradigm' is considered to have relevance to the Danish context.

The analysis of the university staff interviews indicated wide agreement with Enemark's (2002d) report on the evolution of the surveying profession in Denmark, particularly over the past three decades. Some comments from university staff spoke of change in the profession induced by technology and societal changes:

Many things have changed in surveying since I studied in university three decades ago. The black box technology means that many things can be easily done with the touch of a button. Computers are used in every sphere and information is readily available to all. Economic activities are now closely linked to the management of land. That is where the real focus is now. [Senior Academic]

Governments and private businesses require more extensive information on land. The technology now allows us to do so much more. Surveyors have far greater skills than just land measurement; they are now land experts who can offer so much more to society. [Academic]

Enemark (2002d) has shown that the Danish surveyor has historically been mostly concerned with cadastral work and small amounts of mapping and engineering surveying, planning and land management. Additionally, Enemark (2002d) noted that since the late 1980s there has been a remarkable change in profile of the Danish surveyor. Of particular relevance here, is the increased involvement of surveyors in planning and land management and non-surveying specific areas such as 'general management, general information technology development and other business development' (Enemark, 2002b: p. 5). This trend shows a reduction in the traditional cadastral focus and a more balanced approach to the profile of the professional, in regards to the distribution of the tasks in which they engage in professional practice. As such, it is asserted that this change in surveying practice is a manifestation of the 'geomatics paradigm' as described in Chapter 2.

In regard to the research objective, it is now considered, how this 'geomatics paradigm' impacts the educational programme. Several members of the academic staff mentioned that flexibility of the educational model has meant that the changes in professional practice have not been difficult to incorporate in the course.

The difference between our model and more traditional ones is that we are able to adapt to changes in the profession. We change our curriculum content according to the needs of professional practice and also consistent with technological development. [Senior Academic]

Both the programme documents and staff interview transcripts identified flexibility of course content as a foundational principle of the University's pedagogical innovation. Hence, in the AAU context, the flexible approach to course content cannot be seen as primarily due to the 'geomatics paradigm'. However, the data reflect what Enemark

(2002c) described as the changing profile of the Danish surveyor. Not only did the staff responses reflect this but also the number of students enrolled in land management relative to the more traditional measurement science:

> *Half of the students in this year (4) are in the Land management specialisation. The rest are divided between Measurement Science and GIS. [Year 4 Student]*

Though AAU students specialise in one of three areas (see Figure 9), the programme takes a generalist approach in second and third years leading to the Bachelor's degree. This generalist approach followed by a specialist concentration is seen by the staff as producing graduates with a grounding in the wide spatial field but who can also with expertise in the specialist area that is conveyed during the final two years of the course.

> *We teach them both the breadth and depth of surveying. In the Bachelor years our students learn about the many sub-areas of surveying that they will need to know for professional practice. Then at the higher level we get more scientific and they specialise and go in depth in certain areas. [Academic]*

The FIG president and senior academic expressed that AAU's model supports the development of surveyors, with a new habitus relative to traditional surveyors. He purported that the AAU model seeks to convey the knowledge and competencies for much more than the society is accustomed to from surveyors:

> *With our current wide expertise and adaptation of high technology in solving complex problems in various spheres of society we have so much to offer as surveyors. Many people still do not understand how important our functions are but we have to take the lead in changing the perceptions that we mainly carryout out technical functions. [FIG President & Senior Academic]*

The belief expressed by the FIG president was representative of the academic staff in general. The consensus among them was that the course is sensitive to changes in industry as well as societal needs.

7.6 Summary and discussion

Apart from the more obvious structural arrangement of the two case studies, some features of curriculum and pedagogy are considered to be quite distinct. The findings suggested that the programmes have different philosophical groundings. The NU programme appears to be driven by a desire to conform to a rigorous quality system that is a product of the university and accrediting bodies. The acquisition of prescribed knowledge and skills through conventional pedagogical approaches is central to the NU programme. The data presented AAU's programme as primarily driven by an ethos to convey professional skills development that is centred on the approach to learning rather than learning content. This is not to say that the content of their surveying programme is deficient relative to other programmes in the study. In fact, there was evidence that much of the theoretical knowledge content bore similarities to the content in several of the other courses in the study. However, it may be argued that the emphasis (in terms of time) placed on conveying theoretical knowledge by subject experts (lecturers) is less in the AAU context relative to the NU context.

Among the staff and students within the NU programme there was a general view that the pedagogical innovation was an effective approach to conveying relevant competencies for professional engagement. The staff emphasised collaborative skills, inter-disciplinarity, critical thinking and problem solving skills as particular competencies conveyed through the pedagogical arrangement at AAU. There was evidence that while members of the surveying profession in Denmark recognised that graduates had highly developed collaborative skills, they desired to see a greater emphasis on the development of technical skills that they perceive would be better developed through more directly supervised and arranged teaching of those principles as in the NU system. Mainly because of the centrality of projects in AAU's PoPBL pedagogy, it was surprising that under-developed project management skills were identified by an employer as a deficiency in graduates. It might be that the group work develops collaborative skills but not necessarily the skills to manage projects.

How the 'geomatics paradigm' impacts surveying education

A shift in the emphasis of surveying practice in Denmark was evident. It has been shown that surveying practice has evolved considerably over the last three decades. Land management and the application of high technology in spatial data management have now taken up a larger proportion of surveying practice than is traditionally the case in Denmark (Enemark, 2002b). This means that, in Denmark, the surveying profession is as much impacted by technology as in many of the other countries included in this study. Not only has this impacted measurement techniques, but on a deeper level the role of the surveyor in society has been transformed. This argument is strongly supported by representative of the FIG and the Danish Surveyors Association. This may be the reason that more students from the cohort studied, selected the land management specialised over the more traditional measurement science specialisation.

How different educational strategies impact student preparedness for professional engagement.

The data showed a correlation between the pedagogical approach used and students' awareness of professional practice and dispositions towards career planning. It was found that AAU students related how they learned with what they expected to do in professional practice. They demonstrated familiarity with professional surveyors and their practices. The confidence demonstrated by students and also by staff in their students, strongly suggested that PoPBL promoted a habitus in students that is aligned to aspects of professional practice. Moreover, it was found that the students generally had definite career goals with the large majority interviewed indicating intentions to remain in surveying. This is in contrast to the findings from NU which demonstrated that students were less sure about career after university as well as of the realities of industry practice.

CHAPTER EIGHT – DISCUSSION OF FINDINGS

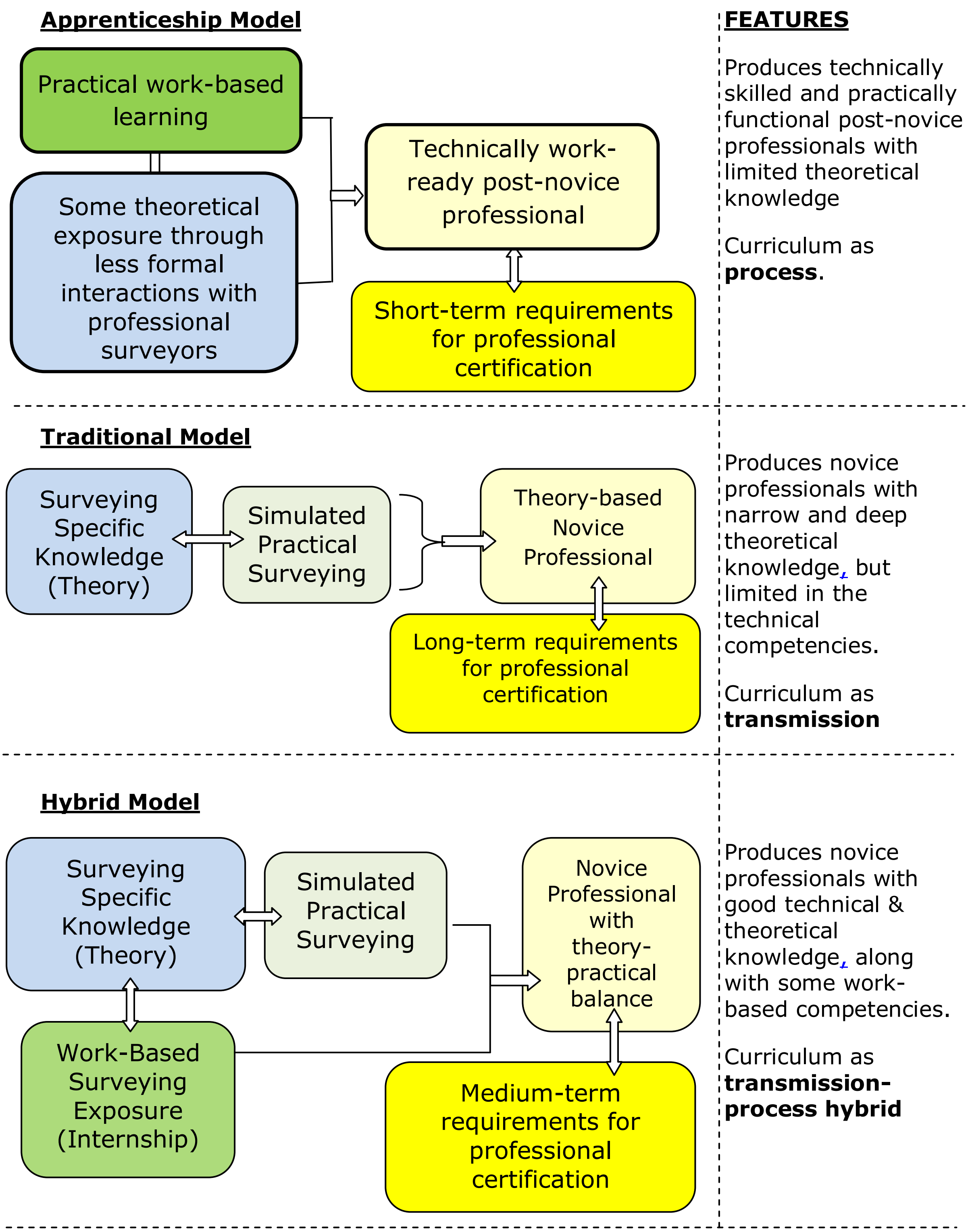
8.1 Introduction

This chapter presents key empirical findings in regard to various models of surveying/geomatics education and develops a proposed new educational model for the discipline in its contemporary form. This new model can be used to support sustainable development in the surveying/geomatics profession. Importantly, consideration is given to the suitability of the model for different professional cultures and contexts. Therefore, the model is a useful tool for developers of surveying/geomatics courses.

8.2 Changes in approach to surveying/geomatics education

In the earlier discussion about the history of surveying education (Chapter 2), it was highlighted that the predominant vocational ethos associated with surveying, is rooted in the philosophy of the traditional apprenticeship arrangements. The data has confirmed that the institutionalisation of surveying education, particularly the development of university courses in the discipline, has led to a gradual change in curricular and pedagogical strategies. While the earlier arrangements emphasised vocational and technical competencies, with close industry links, my research revealed a shifting in focus to more scientific content, which increasingly mirrors the curricular and pedagogical approaches used in more academic programmes. It was also found that demands from the profession and students for greater work relevance, have influenced the emergence of a hybrid model with elements of both the traditional apprenticeship arrangements and the more academic approach. This recent development can also be described as combining elements of the transmission and the process models as described by Smith (2000). The progression in curricular and pedagogical strategies was illustrated in three models that were presented in an early publication from this study by Young, Smith & Murphy (2011) (**Figure 17)**:

Figure 17: Models of surveying/geomatics education



With regard to pedagogy, the study found that in the large majority of the programmes, theoretical knowledge was conveyed in lectures with some noticeable emphases on teacher-centeredness and content transmission. It was found that the core subjects, in many of the programmes, were delivered in small classes of thirty five and less students. Although for economic reasons, small classes were not considered by programme administrators to be ideal, some pedagogical advantages were derived. In particular, it was observed that these small cohorts facilitated close interactions between lecturers and students, in ways that not only enhanced knowledge transmission, but more importantly, promoted knowledge construction. Thus, to the extent that universities can support courses made up of small cohorts, they should be viewed as potentially beneficial for the development of professional surveying education.

Another important layer of surveying pedagogy is the use of practical exercises to consolidate theoretical principles. Practical learning activities were found to be utilised in some programmes more than in others. In fact, the data showed that in some contexts, there was a reduction in practical exercises that was largely due to economic reasons. Programme representatives explained that practical exercises placed significant demands on staff and required extensive and expensive equipment that often cannot be made available in large numbers, if at all. In light of these constraints, students in some programmes were expected to engage in practical exercises beyond those directly supervised by staff within scheduled classes. Arrangements such as these are important to develop the technical capabilities in students that the profession requires. Hence, it is suggested that an improved education model should make adequate accommodation for practical learning experiences.

Interestingly, comments from some programme directors and lecturers, suggested that the increase in theoretical emphasis and the concomitant decrease in practical focus may be the outcome of shifting values in the educational field. Since emphasis on practical and other work-specific competencies is historically associated with vocational training at sub-university levels, university education is expected to offer something more. Even though surveying/geomatics has prominent practical and work-specific elements, there was an expressed desire for the university-based courses to model values of traditional higher education. It was shown in chapter 2, for example by Higman (2001), that historically, there has been a desire to elevate the profession from a widely perceived vocational-technical level to a higher professional level. Hence, the scientific and theoretical elements are sometimes prioritised above technical competence. However, it is evident that a satisfactory balance has yet to be found, since the profession has expressed a general dissatisfaction with an educational system that they perceive to elevate scientific and theoretical elements at the expense of practical professional preparedness. The tension described here highlights the need for an educational model that will not compromise one value over another, since it has been shown that they both have fundamental relevance to modern surveying/geomatics practice.

Additionally, while work-based learning was considered to be beneficial to developing work-related competencies, only a few of the programmes incorporated aspects of it. This too was found to be desirable but impractical, mostly due to resource constraints. An improved model would thus consider how this important element of professional development may be incorporated as something other than a traditional internship arrangement.

As a radical example, the curricular and pedagogical arrangements used within AAU, demonstrated that an innovation in teaching and learning surveying/geomatics has been applied on a broad scale with some successes. More importantly, the AAU case study has demonstrated that innovation in surveying/geomatics education can provide avenues for tackling some of the challenges faced in educating surveyors/geomaticians for contemporary contexts. While it was shown that both the innovative and conventional models have challenges, the innovation highlighted the importance of enhancing learner autonomy as a critical component of professional development. This aspect of the AAU model contributes to the development of individuals who are adaptable to change and oriented to problem solving. Within the unpredictable and constantly changing geomatics working environment, these competencies are critical.

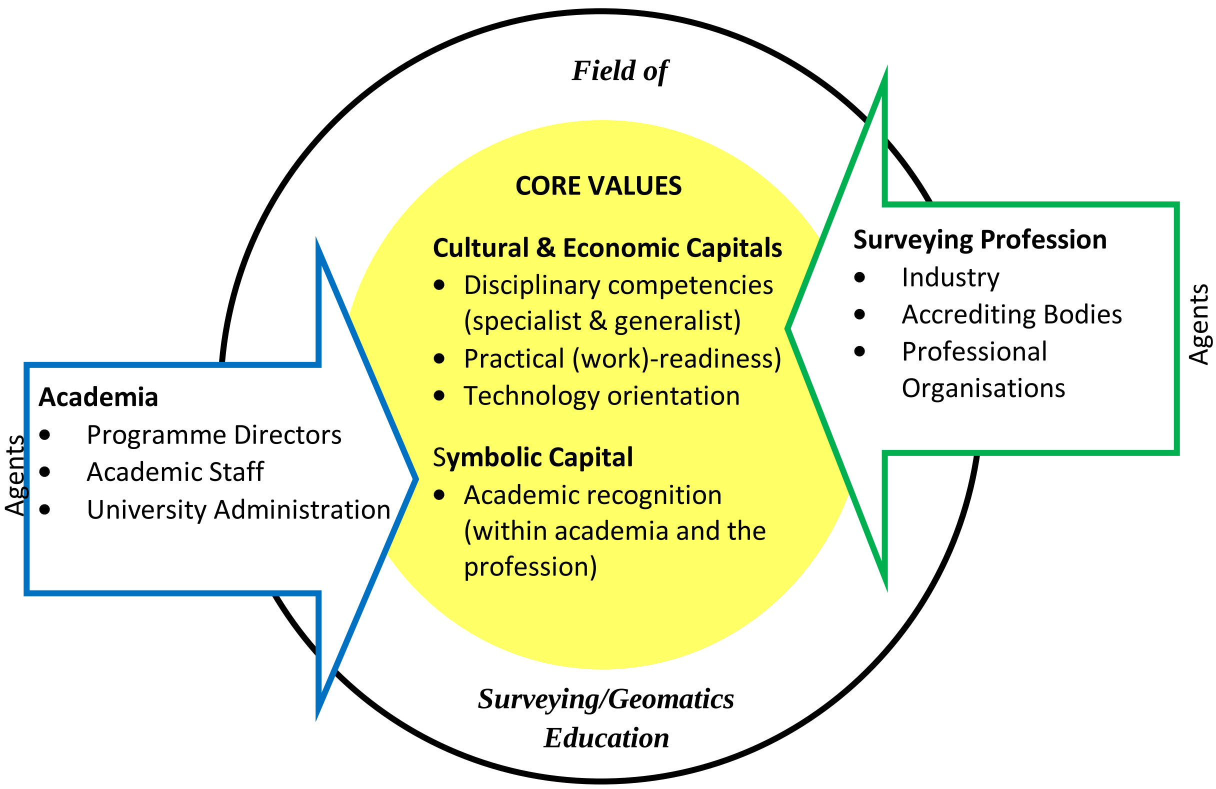
Importantly, an examination of the pedagogical approaches used within the studied programmes, demonstrated that the more conventional programmes identified with elements of curriculum as transmission (Smith, 2000). Using Smith's classification, the more innovative AAU model was assessed as a hybrid of curriculum as process and praxis. Within this innovative educational system, content and pedagogical developments occurred through interactions in the learning process as participants make judgment and meaning and through this process construct knowledge together. Notwithstanding the importance placed on this feature by the AAU staff and students as well as some of the Danish professionals, it was clear that theoretical rigor and specialised technical competence are seen as equally important for effective professional engagements. The development of an improved educational model requires consideration of what the stakeholders' expectations are (the capitals of the professional field). Moreover, an improved model should not merely seek to satisfy stakeholders' demand at face value. It is even advisable that curriculum developers should question why the identified capitals are valued and to assess if they are desirable or beneficial to maintain in their present forms.

8.2 Capital features of surveying education

The discussions under the first theme highlighted a number of capital features of the curriculum architecture of surveying/geomatics courses. The following were identified as characteristic of the large majority of the courses: high specialisation, close linkages with the professional, and technology oriented. These were found to be driven by mostly utilitarian motives strongly influenced by the profession. Analysis of the other themes identified tensions in the relationship between the profession and academia. One of the identified reasons for the tension is a misalignment of academic values (symbolic capital) with professional values (cultural and economic capital). While the programme representatives expressed the desire that their programmes should have work relevance, there was also an expressed desire that academic standards be aligned to the more generic and theoretical values of higher education. Although these values may have work-relevance, they have manifested in ways that are at variance with professional values. This tension between the two fields was also identified as a major theme of the study.

The degree to which these capitals are upheld is influenced by key stakeholders in the process. These include surveying academics, professional surveyors, university administrators and students. The identified *capitals* in the surveying/geomatics education *field* along with the *agents* identified in the analysis as being most influential players are illustrated in **Figure 18**. It was found that the influence from the profession was the primary reason for the specialist focus on curricula, and the demand for the development of practical and modern technical competencies. On the other hand, academia's influence was found to be primarily focused on the more symbolic capital of academic recognition. It is important that developers of surveying/geomatics courses recognise that although these values are often presented separately as they are here, they are in fact inseparably related and all important to professional development.

Figure 18: Illustration of capitals in surveying/geomatics education field

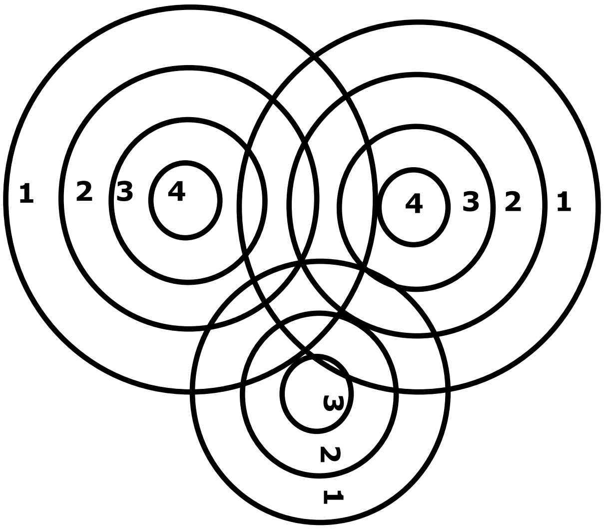


Adaptations of Grenfell and James' model of interesting fields (**Figure 19 & Figure 20**) were useful for highlighting the characteristics of the fields of influence in surveying/geomatics education. The use of these models shows contextual differences between the two in-depth case studies. Each field is shown to have layers that describe their contextual uniqueness. The nature of the *field* is more thoroughly discussed as a whole system after the various elements have been identified in the developing model.

Figure 19: The interacting fields in NU's surveying education (based on Grenfell and James, 1998)

University Programme

1. Russell-group University
2. Highly structured curriculum
3. Traditional pedagogy
4. Professional Preparation – primarily focussed on contemporary disciplinary knowledge and technical skills



Professional Practice

1. Historically apprentice-based practice with military & academic influence for higher positions.
2. Technology-based. Highly influenced by changes in related technologies.
3. Contemporary Practice – dis-equilibrium in supply and demand. More technical graduates required.
4. More distinct specialisations projected. Smaller pool of graduates for managerial positions and large pool of those with technical expertise.

Professional Organisations

1. FIG affiliated.
2. National Professional Groups – Surveyors Association & RICS.
3. Accrediting Bodies – RICS & ICES.

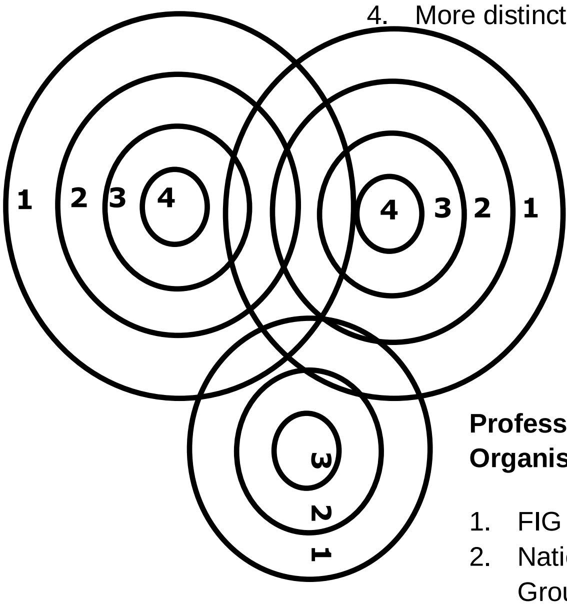
Figure 20 : The interacting fields in AAU's surveying education (based on Grenfell and James, 1998)

Professional Practice

1. Apprentice-based historic practice
2. Technological Influence – high
3. Contemporary Practice – dis-equilibrium in supply and demand. More technical graduates required
4. More distinct specialisations

University Programme

1. PBL University
2. Innovative curriculum
3. Innovative pedagogy
4. Professional Preparation – primarily focussed on specialised & generic skills



Professional Organisations

1. FIG affiliated
2. National Professional Groups – Surveyors Association
3. Accrediting Bodies – Denmark University Council

8.3 Modelling two distinct fields of surveying/geomatics education

The analyses of various aspects of the two case studies, under the four major themes, have highlighted elements of the *field* that can be used to model each system. Modelling the two distinct fields of NU and AAU geomatics programmes allows for consideration of how context impacts on educational systems. Each case is analysed with a view to developing an improved educational model.

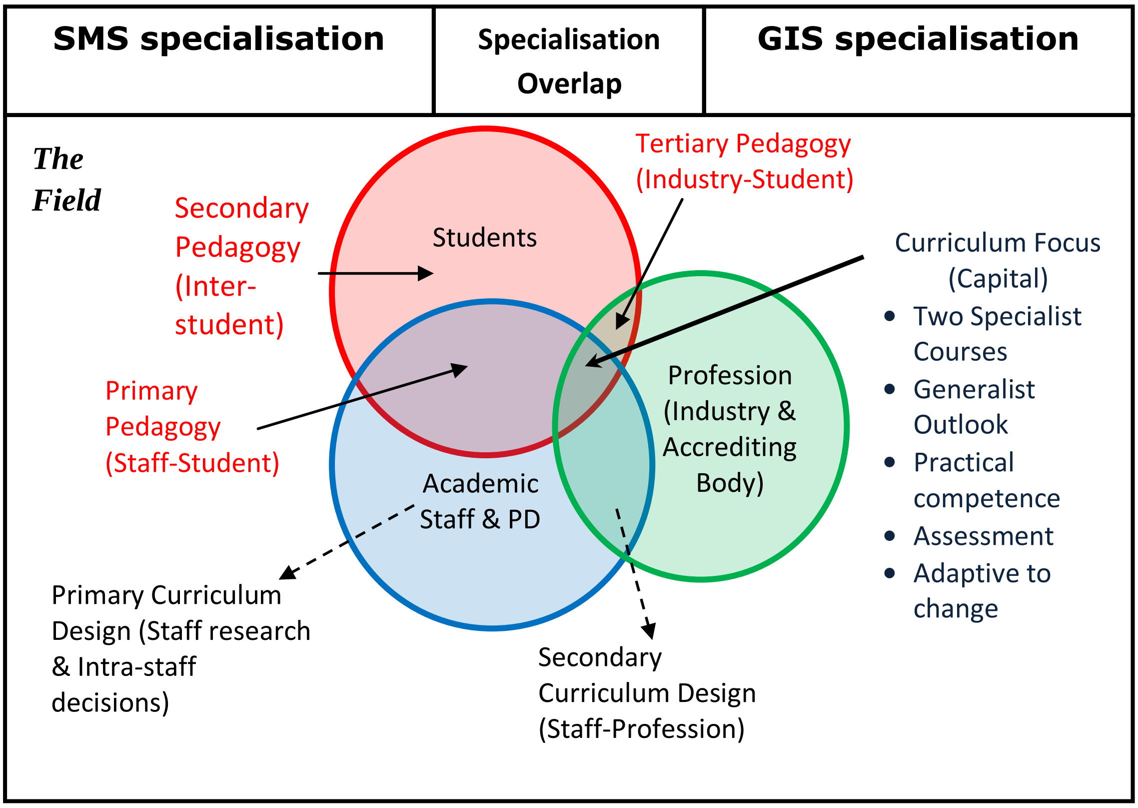
8.3.1 NU's geomatics education field

Based on the findings, the NU geomatics programme is characterised by the following features:

- A small department within the University, offering distinct and highly specialised courses relative to other courses offered by the University;
- Two very structured specialisations with approximately a third of the modules shared between them;
- Highly assessment oriented and research driven;
- Strongly influenced by lecturer expertise and accreditation requirements.

The dispositions of students and the academic staff were considered as useful elements in modelling the field. This is particularly helpful in modelling the system, because its directional course and impact are determined by the dispositions and inter-relationships of key players within it. The role of the relationships within the pedagogical arrangement is illustrated in **Figure 21.**

Figure 21: Education model of NU's geomatics programme



The model in **Figure 21** illustrates the three primary agents that are active in the *field*: students, academic staff and the profession represented by accrediting bodies and employers/industry. The sizes of the circle overlaps symbolise the relative impact of the relationships between the various agents upon the curricular and pedagogical arrangements. 'Primary pedagogy' is shown as resulting from interactions between academic staff and students as was demonstrated in the mostly conventional pedagogical arrangements observed. This relationship is mostly lecturer-directed as discussed earlier. 'Secondary pedagogy' describes the relationship between students as found in unsupervised group work and the sharing of knowledge between new school leavers and students with work experiences.

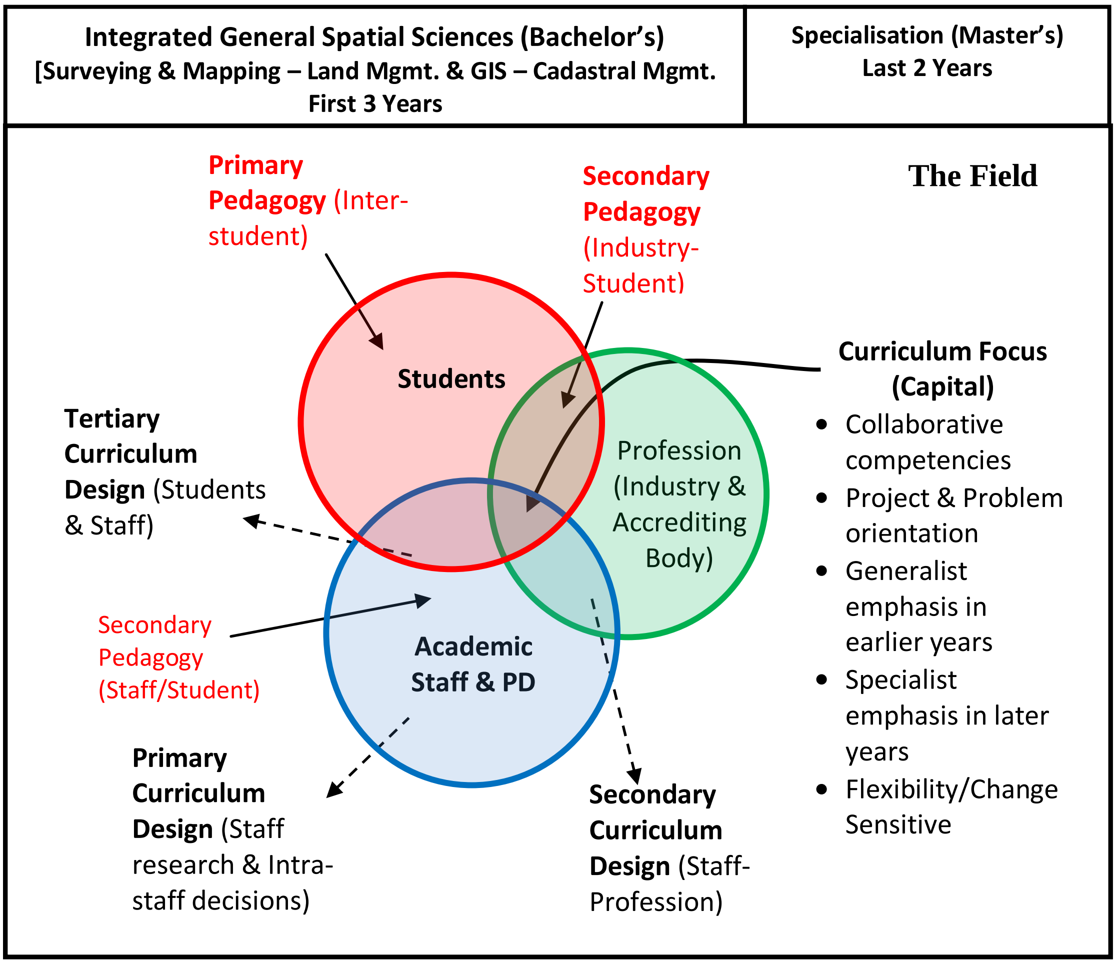
However, within the NU model it was found that the curriculum is primarily influenced by the academic staff and to a lesser extent by the surveying/geomatics profession. The data also showed that, the industry influence is mostly through the bodies that have granted the programme professional accreditation. Importantly, the model shows the intersection of all three circles (agents' habitus) as representing those values considered important within the programmes. These are referred to as symbolic and cultural capitals (Bourdieu, 1986); and are the factors that were found to drive the direction of the curriculum, and fundamentally determine the nature of the product (graduates). On this basis, the graduates from NU's geomatics programme are described as highly theoretical, mostly due to the emphasis on instruction and traditional assessments; technically capable resulting from the level of technical exposure gained from supervised practical sessions and applications of some of the latest technologies used in geomatics; diffident as relating to work-readiness, mostly due to the low level of direct interaction with the industry; and fairly generalist in the geomatics field resulting from overlap in the two specialisations.

In the next subsection, the AAU context is similarly examined to provide a contrasting perspective on modelling surveying education.

8.3.2 AAUs surveying education field

Figure 22 illustrates AAU's surveying education field. It represents the relationships between the active agents in the field, and through this, provides an understanding of how these social relations impact the programme.

Figure 22: Modelling the AAU surveying programme



As with the NU model, the overlaps between the circles illustrate aspects of the pedagogical arrangements. With this model, the primary pedagogy is within the red circle indicating the prominence of inter-student learning as is typical of PBL settings. This was identified in the NU model as a secondary pedagogy with the teacher-student interaction being primary. Unlike the NU model, AAU's pedagogical arrangement includes a student-industry component. The student-industry component of the pedagogy strengthens the professional awareness of students as, through their interactions with members of industry, the development of professional capital is fostered. This is an important socialising link that also presents an access to economic capital as it was showed that through this relationship, students had secured employment after graduation.

Also, distinct from the NU model are the social arrangements for curriculum development. Within this model all three primary agents collaborate together to develop the curriculum. Multiple stakeholder collaboration appears as a common thread in both the pedagogical arrangements and in curriculum development processes. Within the NU model, the primary curriculum determinants were considered to be academics with a more indirect influence from the profession through accrediting bodies. The data did not support student contribution to curriculum development within the NU context.

The comparison between both models shows that surveying curricula differ in terms of the social arrangements. Importantly, these arrangements have a discernible impact on both staff and students' habitus. The habitus of these agents as they cohabit the field, impact on how students are perceived to be prepared for professional engagement by the students themselves, the academic staff and employers. The findings have shown that the perceptions about both models may be construed as either beneficial or not depending on the dispositions of the examining agent. Also, it is important to note that perceptions sometimes bore group characteristics which align with Bourdieu's notion of cultural characteristics among certain agents. Thus, it was unsurprising that members of the surveying profession expressed group opinions as did students and academic staff.

8.4 Summary discussion on collective case studies and the two-depth cases

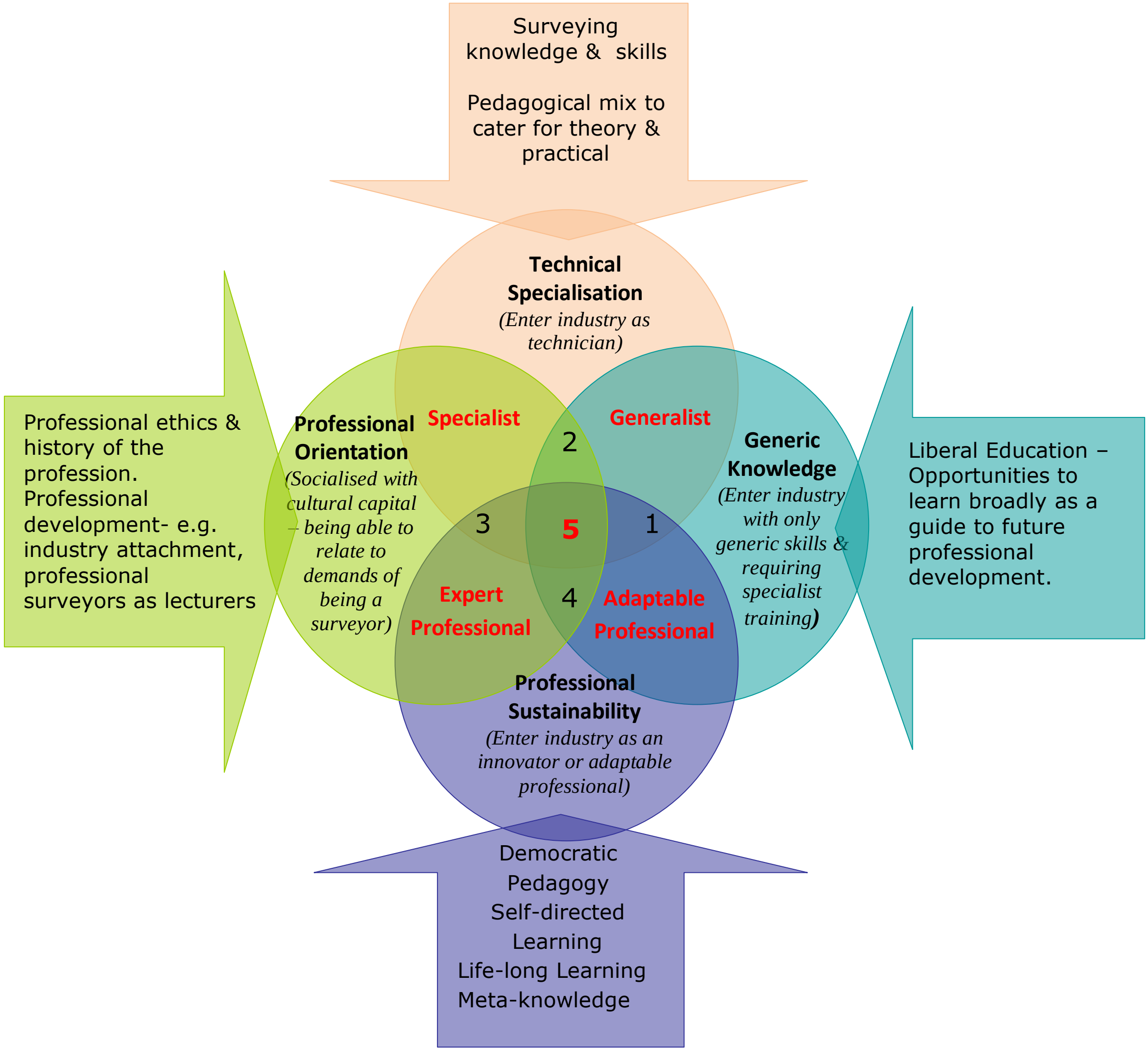
Having explored the data from the fifteen programmes and the two in-depth case studies, four major groups of competency have been identified as important elements of an effective surveying/geomatics education model:

(a) Discipline-specific and technical knowledge and skills.
(b) Generic knowledge and skills.
(c) Professional orientation.
(d) Professional sustainability.

Bearing these critical areas in mind, a separate but related model has been developed (see Figure **23**).

This model illustrates those areas that the research data suggested, were of particular relevance to professional development within the discipline. Some of the features resonate with concepts from the higher education scheme proposed by Bennett, Dunne et al. (2000) with nuances for this distinct discipline and field of practice. The model also, incorporates elements of the body of surveying knowledge proposed by Green & Potts (2007).

Figure 23: Model of surveying/geomatics incorporating key elements



In **Figure 23**, the portions of the circles with no overlaps represent educational strategies with a singular focus on one of the four specified competency groups: technical and discipline-specific emphases, generic/general knowledge and skills, professional orientation, and professional sustainability. These areas, with singular focus, represent level-1 in the model. Progressively, the numbers 1 to 4 are at level 2 of the model. They represent the continuum of possible outcomes when various combinations of the level-1 components are incorporated into surveying/geomatics courses. For greater cohesion of educational objectives, the central component of the model (labelled 5) represents the ideal outcome resulting from combining all the elements in a balance negotiated by the stakeholders.

Whilst historically the education of surveyors, in many contexts, has had a primary technical focus, the current scenario is, that within some courses, the focus has shifted towards a greater mix of competencies. This scenario aligns with Enemark's (2001) assertion of a shifting in educational focus for the field of surveying/geomatics.

As I have shown, there is a variety of outcomes achievable from this model. The dynamic model represents four elements that classify broad and specific competencies. The sustainability of the profession in this context is considered to be linked to what has been identified in this thesis as the geomatics paradigm. This new paradigm requires flexibility and sensitivity to technological changes, societal needs and dynamism in stakeholders' orientation towards the professional field. This has resonance with the notion of habitus of professional surveyor as well as surveying academics and students. Surveying students are socialised into localised fields that influence their dispositions towards teaching and learning surveying/geomatics, and becoming surveyors/geomaticians. Thus, stakeholders' involvement in the decision making processes, is critical to the success of the model in meeting established objectives.

The data showed that a primary focus on liberal education is widely perceived by professional surveyors and some academics, as inappropriate for effective professional preparation. This is clearly a reason for the highly specialised compositions of the large majority of the courses in the study. Furthermore, several academic staff and representatives of professional accrediting bodies, demonstrated robust support for the high specialisation of surveying courses. Ironically, even within what appears to be highly technical courses, many academics expressed that a greater academic emphasis is more appropriate for university courses.

Additionally, the close relationship between the profession and the academy, as in the AAU case and to a lesser extent the NU case, demonstrates that the profession in the various contexts studied, have asserted their partnership in the educational programmes. It has been shown that the relationship between profession and academia, though varied in its nature, is generally seen as important to building professions in general and professional courses in particular. It is for this reason that this social aspect represents a key component of the meta-cognitive element in the model.

The model illustrates varying levels of educational outcomes when courses combine different strategies that target particular knowledge types and competencies. This feature of the model is particularly important to help course developers determine what emphasis is best for their courses. For example, the combination of the elements that seek to convey technical specialisation, with those that seek to convey professional orientation, is classified as a producing a specialist graduate. This example refers to graduates with highly defined technical knowledge and skills combined with an understanding of how the related knowledge and competencies are applied within professional practice. At the deeper level, for example, as labelled '2' in the diagram, combinations of specialist and generalist elements would produce what has being described as a 'generalist specialist'. This refers to graduates who are highly developed in specialist technical aspects of the discipline, but also have been exposed to some liberal aspects of education along with professional orientation. The other classifications of combinations are illustrated in the model diagram. A major feature of this model is its dynamism, which allows for adaptation to varying national, university and professional contexts.

CHAPTER NINE

CONCLUSIONS, REFLECTIONS AND IMPLICATIONS OF THE STUDY

9.1 Overview

This final chapter provides a reflection on various aspects of the research. Specifically, it summaries the major research findings, considers how the study contributes to theory and practice and discusses the appropriateness and impact of the research process employed. The reflection on the research process analyses areas of strength as well as limitations of the study. Furthermore, the reflection considers how the study has impacted me as an educational practitioner within surveying/geomatics. Since much interest was generated in the study by surveying educators as well as professional organisations representing practicing surveyors, the chapter will also discuss implications of the findings for professional surveying courses and for surveying practice.

9.2 Summary of major research findings

Major findings of the study included understandings about curriculum structure and content, pedagogical arrangements, relevance of education to professional practice and insights into the relationships between three groups of individuals identified as primary agents in the surveying education field. Additionally, a model of contemporary surveying education was proposed by amalgamating the complex issues that were discussed.

9.2.1 Curriculum- Rapid change in knowledge content and emphasis

A prominent commonality among the studied programmes is the evidence that technology-induced changes within the geospatial industry, or the perception or expectation of those changes, have influenced remarkable changes in subject composition and knowledge emphases within the courses. This rational approach to developing the educational programmes aims at aligning the courses with industry practice.

Within the universities that were studied there is a general belief that employers are matching specialist competencies with specified sub-sectors within the wider geomatics industry. Furthermore, it was found that students within the studied programmes are increasingly showing interest in narrow specialisations. In a few cases student-interest in measurement science remains a popular student choice. However, it was found that greater numbers of students were opting for specialisations in newer sub-disciplinary areas such as GIS and Land Management. These newer specialisations are in areas that may have once been topic or subject features within older course structures or areas newly introduced as a response to a diversified industry. A few of the courses integrated the various aspects of traditional and contemporary surveying, thereby supporting the new geomatics viewpoint. However, there was an expressed intention to change those course structures to narrower specialist education.

This change in knowledge content and emphases has meant that traditional surveying education, with a central focus on measurement science, has given way to a new educational paradigm. Within this paradigm, the education of the modern surveyor or geomatician (as they are referred to in some contexts) has a two-fold function. Firstly it is geared towards preparing graduates for conventional professional functions using new methods with greater efficiency. Secondly, the educational programmes have embraced the wider spatial sciences and technologies. In this context the discipline is seen as having relevance to many unconventional areas. Thus, modern geomatics programmes are distinctly different from surveying education of a few decades earlier. As one programme director described this paradigm, '*geomatics is a widening field*'.

While some functions of the past are maintained within modern programmes, the technical functions are increasingly perceived and executed in more sophisticated and innovative ways. Of greater significance is a change in how learning for the discipline is perceived. It is concluded that the changing content and the dynamism in the knowledge emphases have encouraged an orientation to life-long learning that caters for the changing methods of practice, as well as the evolving and expanding functions of the profession in society. Based on the strength of the negative feedback from industry, the need for a wider and more focussed adaptation of life-long learning principles would strengthen the educational model.

9.2.2 Tensions between industry and the academy

Since the surveying programmes studied are all intrinsically linked to professional practice, it was important that consideration was given to the perceived relevance of the educational programmes to professional practice. It was found that there were well established linkages between the two fields (surveying practice and surveying education); yet tensions were evident between both.

The rationale for programme directions, according to many of the programme representatives, was alignment of the courses with industry demands. However, industry representatives expressed dissatisfaction with aspects of the educational programmes. As relating to specialisation, it was found that smaller surveying firms favoured graduates with generalist competencies, capable of working effectively in a wide range of areas. Thus, employers in this category target graduates who are able to demonstrate traditional competencies using either conventional or modern methods, as well as having competencies in the application of other aspects such as GIS. An integrated course such as the ones offered by UTJ and MU may be ideal if this type of market is being targeted. However, the dynamic nature of the geospatial industry and wider issues, such as globalisation, may require a different approach that looks beyond the perceived demands of local markets and small firms.

Moreover, it was found that larger surveying/geomatics organizations often employ graduates with highly developed competencies in specialist areas. A GIS specialist, for example, would be required to have a high degree of competency, upon graduation, within that specialist area. Equally, a mining surveyor would most benefit from a course with an emphasis on measurement science with specialised mining applications. If university courses were aligning their courses with the expectations of large firms, then early specialisations may be the rational approach to take. Programme directors indicated that in several jurisdictions GIS and GNSS applications had grown considerably. Additionally, both programme and industry representatives identified other high technology areas as growing interests that may warrant increased emphases within university courses. This implies that specialist emphases are likely to intensify within surveying/geomatics programmes.

The high specialisation approach to curriculum development was viewed by some programme representatives as opening up many new opportunities for geomatics graduates. However, although early specialisation may position graduates for some opportunities within industry it may also limit their professional scope. This could also pose a problem if market demands swing to other areas or if graduates interests change. Both scenarios illustrate that curriculum decision making involves an understanding of market demands and trends. These findings demonstrate some of the complexities involved in the development of the studied programmes. As one programme director indicated *'we have to be flexible with our curriculum if we are to prepare graduates who are able to cope with the changing demands'*. Thus, an improved educational model for the discipline should be guided by the need to make the educational programmes relevant to changing industry needs.

Issues of knowledge content and emphases emerged as one of two primary features of the industry-academy relationship. Another aspect was the perception within industry that university-based surveying education is threatened by 'academic drift'. Under the theme 'academic-vocation dichotomy' this has been discussed as one of the major issues that concern relevance of educational strategies to professional development. Thus it is important that while academic values are upheld, this is not at the expense of professional values. The academics interviewed were careful to indicate that the reverse should also be true. That is, the important elements of a sound academic programme should not be compromised. This issue is further discussed in the following sub-section.

9.2.3 The academisation of surveying education

The changing of formerly highly technical surveying courses to university-based degree courses is believed to be the catalyst to an increasing academisation of the professional education programmes within the discipline. Professional surveyors and surveying academics had conflicting opinions about this issue. To several of the professional surveyors interviewed, the increase in theoretical focus and relative decrease in the technical focus, compromise the adequacy of the courses for professional preparation. They perceive that this trend reduces work-relevance. This demonstrated that industry has an expectation that the educational programmes should prepare students for work in a rational way. In this sense employers expect that the substantive knowledge acquired, the technical capabilities and the generic skills should be closely aligned to the demands of professional work.

However, close examination of responses from the academics suggested a contrasting view. For several of the surveying academics, an increase in theoretical focus was consistent with a more appropriate emphasis for higher education. This philosophical stance considers the development of scientific reasoning and critical thinking along with other generic skills as foundational to professional preparation even within a highly technical field such as surveying. It is believed that these skills are later transferred to specific work-related competencies during professional engagements. Due to lack of stable forecasts about the nature of future tasks in working life and qualifications as outlined by Barnett (1990), it is difficult to assess the feasibility of professional courses with regard to requirements in working life. It is therefore concluded that preparation for surveying/geomatics work, while conveying the technical and discipline-specific knowledge, should also convey those generic and transferable skills that facilitate life-long learning. This approach, it is argued, engenders some degree of technical readiness but also promotes a disposition towards learning that facilitates an on-going evaluation and development of relevant competencies. This bears some similarities with what Reid, Dalgren et al. (2011) described as becoming professional by engaging in a wider set of discourses.

9.2.4 The reality of a geomatics paradigm

While the findings un-problematically demonstrated that surveying techniques have been revolutionised by modern technologies, it was more difficult to determine if the changes amounted to a new paradigm for the profession. The study concludes that among the stakeholders, there is a prominent perception that the discipline of surveying is in a heightened state of change. The local profession in the various contexts was seen to be at varying points along the trajectory from traditional surveying to modern geomatics. While for some, the application of newer technologies mostly represented enhancements to surveying methods, to others this meant much more. One poignant example is the shifting in the responsibilities for surveying data capture to technicians, leaving the professional surveyor to function in more managerial and consultancy roles. This in part, accounts for the reduction in the technical focus of some surveying/geomatics programmes and an increase in emphases placed on areas such as spatial data manipulation and management, project management and other land management applications. Moreover, the new paradigm appears to represent an opening up of opportunities for graduates into unconventional job prospects. Therefore, it is concluded that the geomatics paradigm is a reality in many of the studied contexts, and that it has an obvious impact on the associated educational programmes. Not only has this impacted on the purpose of the educational programmes but also the approach to education.

9.2.5 Change in purpose of surveying education

It has been shown that due to the changes in surveying practice, stakeholders expect contemporary education programmes to do more than prepare students for carrying out conventional functions using new tools. Additionally, stakeholders require that the courses develop competencies, which enable graduates to engage successfully within an uncertain and dynamic working environment. This reality is not unique to the field of surveying since technological advances have impacted many other disciplinary fields. However, as Hubbard (2009) argued, the impact on surveying is more than a change in the methods used in practice. It is also a change in professional functions and it thus dictates a change in the purpose of the associated educational programmes.

It was acknowledged by several respondents that change in the profile of surveying courses is evidenced by changes to course titles, changes in the subject compositions and in the creation of new links with other fields and disciplines. Specifically, GIS was found to be a major component of most courses in the study. Several of the programmes that started with GIS as a subject within the surveying courses, now offer GIS as a separate and often most popular specialisation. These changes within universities demonstrate changes within the geospatial industry. More importantly for this thesis, these changes underlie a change in the perceived purpose of surveying courses. Underlying the new course titles (e.g. 'Geomatics' or 'Surveying and Spatial Information') is a change in how many stakeholders perceive the purpose of surveying courses. Many programme representatives stated that contemporary courses are preparing a new type of graduates to engage in a vastly different working environment. As one programme director put it '*our graduates can find employment in many unconventional areas.'*

9.2.6 In search of a signature pedagogy for surveying

Surveying practice has traditionally involved highly technical aspects that require practical engagements in outdoor environments. However, the discipline has always included other aspects that involve in-office engagements that require different type of skills relative to the more practical outdoor skills. Often understated aspects of professional surveying practice are the social components of the discipline. In executing their functions, surveyors interact at the highest levels with their clients and others with interest in the land that is the subject of survey. This often includes government agencies, allied professions and owners of adjacent lands. Hence, though there has traditionally been a strong technical and practical aspect to surveying practice, there are important social science aspects to the profession. Using Becher's (1994) classification, the surveying profession, in its more traditional forms, may be described as primarily hard-applied with some soft-applied aspects. However, where the practice is more heavily focussed on land management, it may more appropriately be classified as primarily soft-applied.

In considering Shulman's (2005) idea of signature pedagogies for professions, the pedagogical practices were compared to the characteristics of the surveying profession. The pedagogical practices within the majority of the programmes studied showed some nuances of the profession. This was found to be truer for the hard-applied elements (Becher, 1994). Though there was evidence of a reduction in practical emphasis, this pedagogical approach was still a primary feature of the learning activities.

Traditional lectures were mostly used to convey the theoretical knowledge. However, it was found that even within those contexts there were many references to practical applications. The field, computational and drafting skills were often incorporated in individual modules. This reflected closely the reality of surveying operations in practice. The empirical evidence suggests that a signature pedagogy of surveying emphasises not only the development of practical capabilities but also the critical thinking skills that enable students to consider complex problem scenarios and justify choices. The latter aspect appeared to have a greater emphasis in the more innovative AAU pedagogies that is built around learning in small problem-based and project oriented groups.

Since technical competency remains a crucial component of surveying education, it is suggested that the pedagogy of field practicals, and extended field courses, represent one of the primary component of the signature pedagogy for the discipline. The massive influence of technological advances in the discipline demands that the principle of life-long learning should characterise surveying pedagogies. The notion of life-long learning in this context would require that the pedagogies result in the students acquiring both the ability to think critically about methods and techniques, and the capability to adapt new approaches to real work-related problems.

The expansion of geomatics in many contexts has meant that the social aspects of the discipline are increasingly incorporated in practice. The ability to negotiate with various stakeholders, arbitrate in instances of land disputes and other aspects of land management need to be developed through the pedagogical approaches. In some programmes students are required to find authentic problems and execute projects aimed at finding solutions. Aspects of this approach were evident in the AAU pedagogical model and to a lesser extent in some other programmes that facilitated students working in industry, where they had exposure to authentic surveying problems.

While traditional didactic approaches may retain some relevance in conveying theoretical knowledge, it is suggested that surveying/geomatics courses would benefit from a reduction in the use of this pedagogical approach. ***Table 14*** illustrates a likely matrix of pedagogical approaches that may be employed to convey the desired competencies as outlined in the model (***Figure 23***).

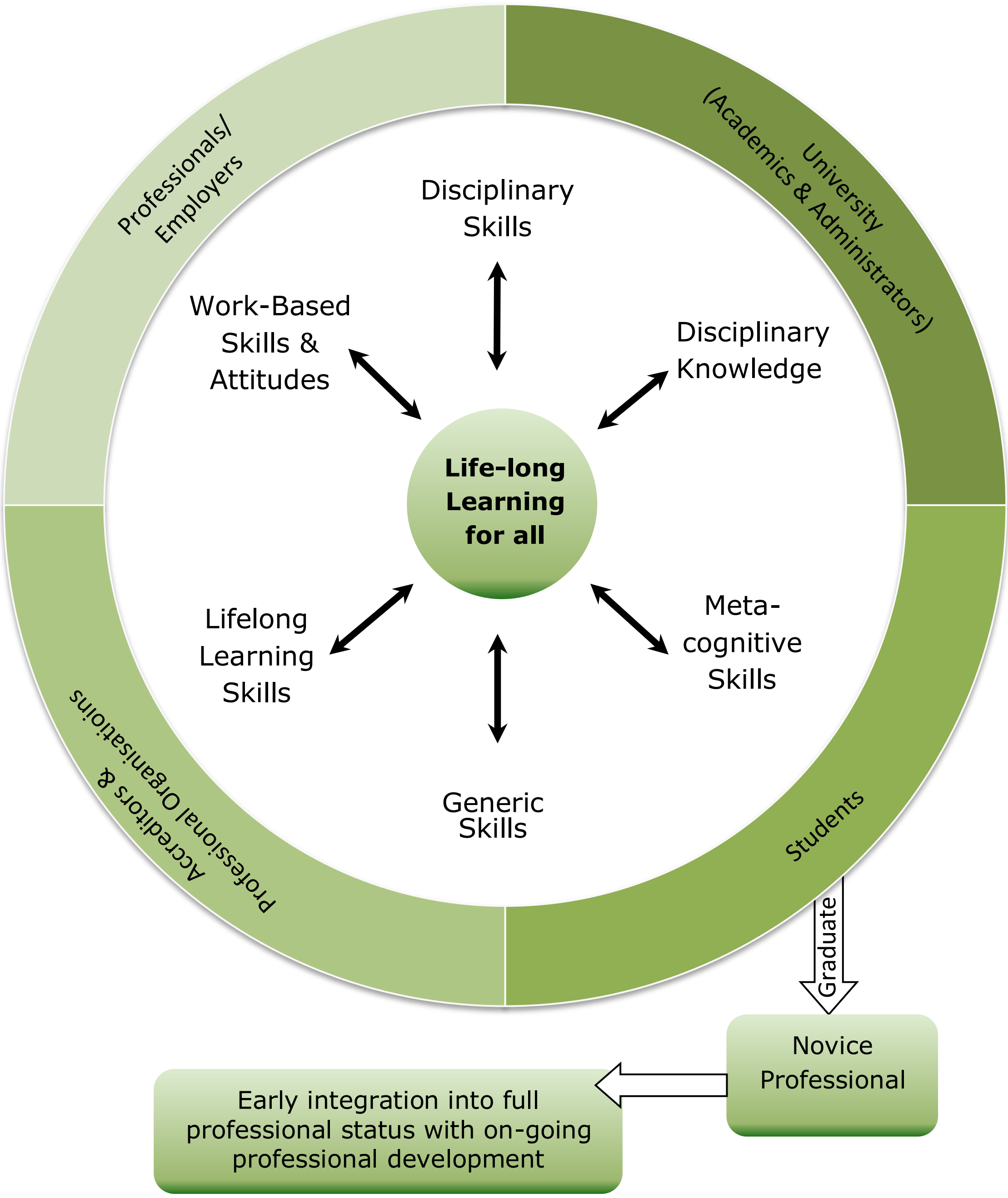
Table 14: Linking competencies with pedagogical approaches

Elements of Surveying/Geomatics Education	Linked pedagogical approaches
Disciplinary knowledge	- Interactive lectures - Research (staff and student) - Enquiry-based learning activities
Disciplinary skills	- Demonstrations - Practical field work - Field courses - Enquiry-based learning activities
Cross-disciplinary knowledge and general education	- Traditional lecturers - Seminars - Tutorials - Research - Enquiry-based learning activities
Professional orientation	- Seminars involving professional surveyors - Project work - Internship - Research - Enquiry-based learning activities
Professional sustainability	- Self-directed learning - Enquiry-based learning - Critical thinking tasks - Peer & self-assessment - Research

The matrix in **Table 14** illustrates an example of deliberate matching of pedagogical approaches with expected learning outcomes linked to key features of contemporary surveying/geomatics education.

Whatever curriculum emphasis is best suited to local demands (as illustrated in **Figure 23**), successful educational programmes can only be sustained if an approach is taken that involves all key stakeholders; and incorporate elements that facilitate the changing demands of the profession. **Figure 24** illustrates that university staff, students, the profession and accreditors can collaborate to develop educational programmes that incorporate disciplinary knowledge and skills, along with work-based, meta-cognitive and life-long learning skills. Based on the empirical data, these elements are what is necessary to produce novice professionals with the requisite competencies to integrate into working contexts relatively easily and be oriented to adapt methods and strategies to negotiate inevitable changes. The on-going professional development is encouraged by inculcating life-long learning skills. As the data demonstrated the educational process impacts all stakeholders. Hence, learning for the entire community of learners is at the centre of this model. This implies that the new paradigm requires an orientation to change on the part of all stakeholders. Furthermore, it demands a greater collaboration between the agents and collective responsibility for the direction taken and its results. This approach, because of the collaboration it encourages among the four key stakeholders, will reduce the tensions that exist between them in existing systems.

Figure 24: Components of a contemporary model of surveying education



Within the field of contemporary surveying education, all agents should play an active role in the dynamic construction of knowledge and development of competencies for the profession. The model supports learning for all agents in acknowledgement of the reality of constant changes in methods and technologies rooted in fundamental principles. The model gives room to contextual variations and different transitional phases in the geomatics paradigm.

Benefits of a model of surveying/geomatics education

The investigation into different approaches used for professional development of surveyors provided data for the modelling of the various approaches. The models demonstrate differences ranging from the historical apprenticeship system to the current paradigm. There were two approaches to modelling the educational systems. One approach considered the social interactions between main stakeholders and how the relationships impact the pedagogical arrangements. This modelling facilitated an understanding of how certain pedagogical arrangements are sustained or undermined by exploring the level of influence students, staff and the profession have in curriculum and pedagogical developments.

The second approach used emergent themes from the data as key variables for modelling contemporary surveying/geomatics education. The model gives consideration to discipline-specific knowledge and skills, generic knowledge and skills, an orientation towards work and the profession and professional sustainability. Importantly, the model offers a framework for evaluating course emphases and course relevance. Thus it may be useful for identifying imbalances between the various components of programmes and between the educational programme and professional demands. This system can be employed as a mechanism for inviting contributions from the stakeholders and through this collaboration, construct an educational programme that develops in sync with development in professional practice.

9.3 How Bourdieu's notions helped to theorise some findings

Notions of field, habitus and capital as used by Bourdieu (1984) were found to be useful conceptual frames in theorising some aspects of the findings. They were particularly useful in looking at the studied phenomenon, as a social construction involving multiple agents. Furthermore, this framework aided in considering simultaneously, the impact of the professional field on the education field. As a theoretical framework, Bourdieu's concepts facilitated consideration of the dispositions of agents in developing an understanding of how the social arrangements impact on contemporary surveying education. It was important for me to be able to give credence to the social elements of the studied phenomenon since I perceive my own development as a surveying practitioner and lecturer to be intrinsically linked to sociocultural structures.

It was found that surveying students perceive their current education in ways largely shaped by how their programme is packaged, and the dispositions of the academic staff. These elements were found to be prominent determinants of surveying students' habitus. This observation does not discount the influence of other experiences of students, for example from schools and through wider cultural settings. In fact, some students indicated that their early opinions about the surveying profession, prior to enrolling in universities, were impacted by poor public perceptions of the profession. Based on this finding, it is argued that some students, who come into these programmes, have doubts about their prospects in the course and the profession. However, there were also positive influencing factors, such as interest in and aptitude for subjects, which are considered to have particular relevance to the surveying profession.

In spite of the various and complex factors impacting the formation of dispositions towards a profession and towards higher education, it is argued that the social arrangements within the academic programmes either reinforce or challenge early dispositions of students towards the course and the profession. The findings suggested that the habitus of academic staff significantly impacts students' habitus. It was found that this often changed negative perceptions about the profession into more positive ones. Furthermore, the academic staff, who had a prominent social influence within universities, often elevate the academic value of the programme and thereby influence the students' habitus in a particular direction. Comments from students reflected much of what the academic staff portrayed as characterising the surveying/geomatics education field. For instance, where academic staff conveyed the supremacy of knowledge and thinking skills over practical competence, students reflected similar values. The views of professional surveyors also influenced the habitus of agents within the university.

Within both case studies, industry representatives criticised universities for failing to adequately prepare graduates for professional engagement. However, the accreditation statuses of these programmes suggest otherwise. They imply that the programmes are designed and delivered in alignment with professional expectations and established Bodies of Knowledge as proposed by Greenfeld et al. (2009). This demonstrates the complex relationship between university, professional accrediting bodies and professional surveyors (employers). It is asserted that this complexity impacts the habitus of academic staff, and may lead to divided loyalties, in which the staff may choose to promote one capital over others, depending on dominant influencing factors. Employability was often stated as an important capital within the field, as both staff and students made many references to the relevance of the education to work. However, the recognition of higher education status in more academic terms was more often presented as highly valued within the programmes.

The study challenges the criticisms from industry. It is asserted that industry supports an orthodoxy that perceives surveying education as narrowly preparing graduates for quick transition from university into the technical functions of the field. However, the modern field has been described by surveying academics and professional surveyors as changed and changing. In line with these changes are changes in the dispositions of surveying academics and of students towards professional preparation. However, professional surveyors have not shown concomitant changes in their dispositions, as to a large extent it was found that their expectations of graduates are still strongly associated with past expectations. It is proposed that an understanding of the variances in stakeholders' dispositions can inform strategies to better align the academia with the industry.

Students within the majority of the studied programmes represented a small percentage of university enrolments since in most contexts the discipline remains relatively unpopular. One outcome of this reality is the lowering of entry requirements within many of the studied programmes. An examination of the habitus of surveying students suggested that this latter reality contributes to insecurities about students' intellectual status relative to the intellectual status of students in more popular courses.

Since there is a separation in the circumstances that form dispositions of students and established professionals in industry, it is likely that some tensions between both groups of agents will remain. Furthermore, academic staff may be of the same educational era as decision makers in industry, and professional groups such as accrediting bodies, they are likely to have encountered similar circumstances that contributed to the formation of their dispositions towards work and education. However, as Bourdieu (1984) indicated, habitus is not static and continues to be formed and impacted by associations. The associations of the surveying academic staff within universities are primarily with academic colleagues. They compete for positions on the same terms as other members of staff in other disciplinary fields. If research and scholarship are capitals within the academic field (universities) then those are likely to inform the habitus of the academic staff more so than the capital of professional surveyors. A result of this may be the academisation of the professional course. Representatives of the surveying industry identified this risk as demonstrated by the comment from one employer: '*the universities are not doing as good a job as they did in the past to produce graduates with the technical competencies for work.*'

9.4 Implications of the findings

The study provided rich understandings of various features of a unique and highly discipline-specific higher education professional field. Hence, the findings from the study have far reaching implications. They have the potential to inform future developments of surveying/geometrics courses and may shed some light on how some of the challenges impacting development in this professional field may be tackled.

Moreover, an in-depth study into one higher education professional discipline may have some bearing on other disciplines, which seek to manage the alignment of the associated educational programmes with changes in professional practice. Course developers in other disciplines may therefore value the approach to considering their educational programme as a social construction resulting from the input of multiple partners in the process.

9.4.1 Implications for developing surveying/geomatics courses

Two specific findings have massive implications for future development of surveying/geomatics courses:

- The application of new technologies to conventional surveying practice and the introduction of newer areas to the wider geomatics field demand frequent revision of course content.
- There exists a two-fold reality within the surveying/geomatics industry. On the one hand, traditional surveying still requires highly technical expertise along with capabilities for engaging as a professional who interacts with clients and allied professions. On the other hand, the geomatics paradigm has opened up opportunities for surveying/geomatics graduates in some unconventional areas. These observations have major implications for curriculum development.

With regards to the first point, course developers within the discipline would be well advised to organise the curriculum in such a way that regular content revision can be applied. This implies flexibility in structure and form. The PoPBL approach used within the AAU model demonstrated a flexible approach to knowledge content. This contrasts quite vividly with the rigid curriculum structures found in some other courses, which tend to be dominated by decisions from university staff. This latter approach may not effectively support the new paradigm. It is an imperative that both the curriculum structure and the pedagogical arrangements employed have the capacity to systematically incorporate new aspects as they are developed. This requires sensitivity to changes in technologies and within the industry, and an orientation towards innovation, which positions the academics, students and the profession as partners in the educational development of the professional.

The second observation highlights the two-fold nature of geomatics practice. It is therefore argued that the educational programmes should seek to address both facets of the discipline. Whether this is done as an integrated education or as separate specialist sub-field, education should be dependent on the nature of the targeted labour markets. This proposition implicates several stakeholders: governments and private sectors involved in labour market planning, professional surveying organisations, university staff and students. It calls for a holistic approach to developing not only surveying/geomatics courses, but also other university-based professional courses. This requires a much wider perspective than curriculum change or localised pedagogical experiments. Rather it calls for a strategic and systematic look at the whole system involved in the development of professionals.

9.4.2 Implications for developing the surveying/geomatics profession

The study has reinforced the mutually beneficial relationship between the universities that offer courses in surveying/geomatics and the surveying/geomatics profession(s). However, developments and changes within the industry or how they are perceived by professional surveyors should not be assumed to be understood by universities. In fact, it is suggested that both parties should accept that academic orientation has some distinct features relative to industry orientation. This means that university academics and administrators will show differences in perspectives and in the interpretation of educational needs relative to the perspectives of professional surveyors within the industry. The surveying/geomatics profession stands to benefit significantly from bringing their perspective to bear on the course development processes.

It was found that existing industry input into most educational systems is confined to small accrediting groups and advisory committees who are engaged at specified times rather than an on-going relationship. This means that the dialogue between industry and academia does not have a wide impact either on the university courses or the industry. This accounts in part for the perception of a dichotomous relationship between the two groups. The tension between both groups partially stems from academia's perception that the industry imposes its demands on them without having a sound understanding of their perspectives on professional development.

The approach to educating students within the majority of the studied programmes implies a separation of traditional surveying from other specialisations within geomatics. As expressed by one programme director, the labour market may have two distinct manifestations warranting a separation of the educational programmes for the more technical professional area (traditional surveying) and the burgeoning spatial information management sub-field. This growing trend has implications for the profession as university graduates will increasingly target specialist work and so will seek out specialist education.

9.5 Reflections on the research process: strengths, limitations & recommendations for further studies

In reflecting on the research process, consideration is given to the effectiveness of the research methodology employed in the achievement of the stated objectives. Also considered are areas of strength as well as limitations of the study. Some recommendations for further research also came out of this reflection. Additionally, I reflect on what was personally learned from this study and consider how I might apply this knowledge as a practitioner in the field.

The methodology

Since no in-depth study of surveying education was found prior to embarking on this study, the emphasis of the study was on exploring holistically, characteristics of surveying courses. The novelty of the study is therefore clearly an area of strength as it has produced new understandings about the educational systems associated with this unique discipline.

As outlined in Chapter Four, the research methodology was grounded in an interpretivist epistemology and two major research methods were employed for conducting the study. Firstly, there was an interest in exploring how surveying/geomatics courses are similar or different. The survey of fifteen programmes sought to address this aspect of the discovery. In this mapping of multiple programmes, data collection was undertaken through documentary analysis and interviews of programme representatives rather than questionnaires. This is not to claim that questionnaires could not be employed in an interpretivist study. It is argued that an advantage in favour of choosing semi-structured interviews over questionnaires was that the former allowed for greater and more interactive dialogue between researcher and research respondents. Semi-structured interview allowed for more flexibility in the line of questions and the approach was able to be developed, in response to the specific views and interests of the informants.

Flexibility was taken to be an important tool for discovery and interpretation, since issues of relevance to the individual programmes could possibly be very different. In this case, predetermined questions as often used in questionnaires would restrict discovery and by extension compromise the validity of later interpretations. If validity is accepted to be the alignment of research findings with the realities of the researched, then it is seen as beneficial to give room to research respondents to elaborate on issues, which they consider to be relevant.

Since this approach has inherent dangers, such as a total diversion from the general area of interest, as a researcher I had to manage the process. Using a semi-structured approach meant that there were broad areas of interest which were used as flexible boundaries. This 'management' in some instances meant that I had to steer the interviews, in order to bring clarity to key issues raised by the respondent rather than allow them to run on to other issues. As the data collection progressed some common issues emerged. In the later interviews it was evident that some of the recurring issues cut across geographical boundaries and different manifestations of professional practice. I was keen to focus on those areas in the later interviews, and had to manage that to give room for new issues, which might be most important to other respondents.

The second research method employed was multiple case studies. This aspect was considered to be more appropriate at targeting deeper and richer interpretations of the educational strategies used in surveying/geomatics programmes. One of the advantages in using multiple cases is being able to compare findings from both. However, researchers need to be cautious about comparing features of programmes that are very different in the institutional and structural arrangements, as was the case in the two selected case studies. It is advised that the objectives of the course should be considered when evaluating its systems and methods. The alignment of purpose with methods can be a useful approach to comparing different educational settings, even where the courses have common disciplinary focus.

The data collection approaches used for the case studies included those used in the first research method. In addition, observations of teaching and learning activities, artefact analysis, student focus group discussions and interviews of lecturer, students and professional surveyors were done. The added layers of data meant that the discovery within the two case studies delved into issues raised, not only by programme directors and documents, but also the views of the other active agents in the field.

The combination of a survey of fifteen programmes from diverse countries along with two in-depth case studies is considered to be an area of strength in the study. While providing a broad perspective on the field of surveying education, the research also had an aspect that allowed for deeper understandings of the nature and impact of the educational approaches employed. Furthermore, the ability to compare two distinct case studies is seen as a poignant feature of the study that contributed novel understandings about an area that is under-studied. However, both in-depth case study sites were located in Europe. This limits consideration for the educational models used, for example in former colonies of Britain. The data suggested that surveying programmes may manifest unique ways of managing inherent tensions brought about by the imposition of European style education in local contexts. This speaks of an issue that is beyond the objectives of this study. Also, it is an issue for which no evidence was found that it has been studied within the field of surveying. This is clearly an area that would benefit from further research.

The explorative approach adopted for the research methodology meant that interview questions were often open-ended and yielded a significant amount of information. As I considered the emerging issues, my follow up interviews added even more data revealing even deeper issues. This meant that the interview data covered far more issues than I was able to report as part of this study. However, this is not seen as a limitation, but rather as an insight into areas that could benefit from further research. It is suggested that further research into the following issues will add to knowledge not only about surveying education, but may also offer understandings about professional education in other disciplines:

(a) The disciplinary characteristics of the surveying/geomatics academic and their impact on teaching and learning within courses in this field.
(b) The nature of the transition between university and work for novice surveying/geomatics professionals.

(c) A comparative study of competency building within university surveying courses and competency building within professional surveying practice.
(d) The impact of hegemonic higher education practices on the development of indigenous professional practices within surveying.

Though this study involved a large dataset, with diverse representations of communities of surveying education and practicing surveyors, it represents but a snapshot of the studied phenomenon. This is particularly important to consider since surveying practice and surveying education are both in a state of flux being fuelled by rapidly changing technologies and markets. This is demonstrated by the very recent change in one of the programmes involved in the study from an integrated programme to one offering sub-specialisations within geomatics. Though during the interview process, it was indicated that the programme developers were initiating a curriculum review, the process progressed surprisingly more quickly than the thesis development. The urgency demonstrated that findings from research of this nature are but a snapshot of a space in time. The understandings resulting from the study will thus need to be historically and contextually placed to avoid misinterpretations.

Another area of strength was the broad spectrum of data sources covered. The use of documentary analyses, interviews of various stakeholders, observations of teaching and learning activities and focus group discussions with students facilitated layers of interpretations of the issues explored. The multiple sources enriched the findings and allowed me to consider the varied perspectives during analysis.

My familiarity with surveying education was seen as both a strength and a limitation. It was undoubtedly a strength in terms of providing me with insights into areas that may be idiosyncratic to the discipline. For example, my understanding of the importance of mathematics and science as foundational elements in the discipline informed my investigation into the types of students enrolled in the programmes. Also the level of practical activities, particularly more authentic surveying field exercises, was anticipated to be a major part of the investigation. As a limitation, my personal experiences could result in the projection of my preconceptions and biases on the investigation. This had the potential to limit respondents' ability to focus on issues they deem important to their programmes. This was considered prior to data collection and I took deliberate actions to manage the process so that the imposition of personal biases was reduced. At the same time I was able to ask questions about issues that are widely considered to be essential to surveying education, but which in some cases were not initiated by the respondents. A significant and unexpected outcome of the study was the expansive networking that it facilitated with other surveying educators and professional surveyors concerned with development in professional surveying/geomatics education. This had real benefit to the study as I was able to separate unique issues from the more widely experienced ones with relevance to a wider field.

9.6 Personal lessons from the study and implications for my work as practitioner

The study has reinforced for me that teaching and learning surveying/geomatics are far more than conveying theoretical and practical knowledge. While these represent important parts of the process, it is evident that an often under-emphasised yet important component is the nature of the relationship between those stakeholders within the university and those within the profession. The implications for pedagogy must be given deliberate consideration in the design and delivery of curricula. Pedagogy can, and I believe should also, be informed by the social arrangements that exist within this professional education field. This wider understanding of the nature of contemporary surveying/geomatics education has reoriented my educational philosophy. I now believe that surveying pedagogy should have relevance to professional realities and so should include: strategies for engaging students as active partners in the learning and knowledge construction process, and actions to conveying strategic knowledge content and an awareness of the social arrangements that exists within the wider field of geomatics. I foresee that this will inform approaches to content delivery, assessment strategies and on-going evaluation of the processes. This has demonstrated that educational research can have a profound effect on practice.

As relating to pedagogical innovation, the study has stimulated an interest in exploring new ways of facilitating learning within the discipline. Since many of the learning exercises within the Surveying programme I teach are already problem oriented, some of the techniques learned from the AAU case study may be adapted to my university context. I now have a heightened interest in employing more enquiry-based learning approaches, as a means of facilitating greater learner-direction, and the building of critical thinking skills in students.

While the findings of this study have reinforced some aspects of my practice as a surveying lecturer, it has challenged other aspects. It has reinforced my perspective that social relationships form an integral part of learning and so should be planned for and encouraged within surveying courses. The recognition that much learning occurs within small groups, and results from student-student interchange, demands that learning activities should seek to exploits these benefits. I now have a new appreciation for group work. Not only do I see this pedagogy as an effective way of developing practical skills but also as a basis for implementing enquiry learning. Also I now believe that peer assessment may elevate the status of such social learning

9.7 Closing statements

The genesis of this study traces back to my early days as an enthusiastic college lecturer, desiring to inspire learning in my students. In the earliest stages of the study, I began to realise that there were yet many things I did not understand about the educational system of which I was a part. Particularly, I began to reflect on my Jamaican experiences in light of many other likely different realities in other parts of the world. I started to ponder the differences in approaches to educating individual in my chosen discipline - surveying.

There was a systematic build-up of curiosity as the execution of the research plan opened up many new avenues for investigating surveying education on a much wider scale than I was previously exposed. I was initially amazed at how the discipline had many universal principles. At the same time I came to understand that some features of programmes were idiosyncratic of their local or regional settings and manifested as differences. Also, my interactions with international professional surveying organisations, particularly the FIG established linkages that supported the study. However, beyond that I now have an expansive network of surveying academics and international practicing surveyors with whom I may engage in the development of relevant educational programmes for the development of the surveying/geomatics profession.

The empirical evidence has supported a number of findings that are both enlightening, and hopefully lead to suggestions for improving surveying/geomatics education. It is clear that surveying practice has changed drastically. Though there are uncertainties about the use of the nomenclature ‘geomatics’, there is undoubtedly a paradigm shift in how the functions of the modern surveyor is perceived in many national contexts. The data supported the notion of a geomatics paradigm within professional practice and within the related educational systems.

Also, my research exposed a number of tensions between academia and industry. There is clearly a divide between how both groups perceive professional development. However, though the debate about course relevance to work is quite strident, there was evidence of some convergence of values. It does matter to university staff that industry is satisfied with graduates. Additionally, it is important to academics that academics and the courses they offer are recognised as rigorous higher education engagements. Satisfying the academic criteria is sometimes at variance with satisfying expectations from the profession.

What do all of these issues/findings say about contemporary surveying/geomatics education? How are the many courses investigated similar and different? What can be understood about the relationship between pedagogical approaches and professional preparation? What value can be derived from what we now know?

Many answers to these questions have been offered throughout the analyses of the findings in this thesis. In summary, the empirical data strongly support that surveying education has changed and is still in transition. What is conveyed as knowledge and skills within surveying courses has changed so much that it has impacted several areas of the programmes. The new ethos is for courses that develop professionals with new skills, new outlook and an enduring approach to knowledge acquisition and skills renewal. While this new paradigm brings with it many new opportunities it also brings some uncertainties. There remain uncertainties about how to label the modern discipline and the associated courses. Also there are uncertainties about what specific areas to emphasise within the courses. While there are no quick answers it is suggested that active and mutually respecting collaboration between stakeholders will lead to workable solutions.

The idea of collaboration captures one of the core elements of the research methodology. Investigating the relationships between the various agents in the field of surveying education was considered to be of primary importance. This proved to be true as pedagogical arrangements are largely constructed through social relationships. The student to student relationship within the more innovative structure was hugely enlightening. It demonstrated how a non-traditional pedagogical approach can develop some of the competencies that have relevance to work. This observation does not discredit the more conventional pedagogical approaches as they were widely used and supported as having relevance. However, it is asserted that the more didactic approaches are more concerned with transmitting information and so may not offer the best means for learning. Surveying and geomatics education, and education in other professional fields, should seek not only to convey the knowledge and skills associated with the profession but also the attitude and dispositions. Educational strategies should seek to convey all these important elements, if they are to be successful at producing graduates with the competencies to function successfully in this modern work context.

While some students still opt for the more conventional surveying, the methods used within those traditional areas have changed significantly and are projected to continue on that path in pace with technological advancements. This will increasingly change the modus operandi of the professional surveyors. In this sense ‘traditional’ measurement science is not traditional anymore. It has been shown that these changes in surveying methods continue to dictate changes to the associated education programmes. Modern surveyors need new competencies, and a disposition towards life-long learning if only to keep pace with the application of changing technologies within surveying practice.

The findings of this study have added to the discourse on the relevance of professional education to professional practice. It has reinforced the importance of the social elements in professional course development. The study calls to attention the value of considering not only what constitutes the theoretical and practical knowledge components of professional courses, but also the relationship between the stakeholders who influence course development. In essence, the findings strongly support that the idea of relevant professional education is to a great degree a social construction.

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APPENDIX A

INTERVIEW SCHEDULE – Programme Directors

The listed items indicate broad headings to be explored in the interview. The sample questions below some headings are possible questions that may be asked to prompt responses. However, the intention is to allow for an organic flow of the interview addressing issues under the broad headings.

1. Confirm association of person being interviewed with the programme in focus.

2. The Surveying profession in the country/region.
   a. Describe briefly the role of the surveyor and the Surveying profession in your country/region.

3. Organisation of Surveying education in country/region
   a. How distinctive is your Surveying curriculum compared to other universities?
   b. Does your University dictate anything in relation to educational issues that influences your delivery of this course?
   c. Does the design of your curriculum/courses reflect any particular aims? What are these and to what degree are they achieved?
   d. Does your Surveying programme target students with particular characteristics?
   e. Do your Surveying courses appeal to an international student body?
   f. Does your Surveying programme have a stronger vocational or academic focus?
   g. Are there parts of your programme which are under review/causing concern?

4. Pedagogical approaches employed
   a. What pedagogical methods are used within the Surveying courses? Why? Perceived impact?
   b. Have there been or are there plans to innovate pedagogical approaches?

5. Impact of technology on the profession and on the course
   a. In the last two or three decades, how has technological advancement in Surveying impacted the Surveying curriculum at your university?

6. Relationship between Surveying/Geomatics profession and the University
    a. What type of feedback do you receive from industry regarding graduates?
    b. What role is played by accrediting bodies within the Surveying course?
    c. How does the curriculum relate the FIG's or RICS or ICES educational mission?

7. Anything additional information thought to be important for a clear understanding of the programme being studied.

8. Seek clarification on anything read from the curriculum and course documents that may not be clear to researcher.

END

APPENDIX B

INTERVIEW SCHEDULE – Representative of Professional Surveying Organisation

The listed items indicate broad headings to be explored in the interview. The sample questions below some headings are possible questions that may be asked to prompt responses. However, the intention is to allow for an organic flow of the interview addressing issues under the broad headings.

1. Confirm respondent's association with the professional organisation
2. Role of the professional organisation within the profession and the education programmes
    a. According to online information on your official website, the organisation you represent has quite an extensive international reach in terms of its membership and function as an accrediting body for professional Surveying education. How does the organisation perceive its role in this capacity? How far does its influence go in the development of these educational programmes?
    b. How have changes in the discipline of land Surveying/Geomatics impacted the organisation's requirements for accreditation of educational programmes and requirements for membership?
    c. Do professional accreditation requirements encourage universities towards a stronger vocational focus at the expensive of scholarship?
3. The Geomatics paradigm
    a. When does the organisation perceive the term 'Geomatics'?
    b. How has land Surveying changed and what is the role of academia in this change process?
4. Relationship between major professional organisations.
    a. How would you compare the role of your organisation and others that carryout similar functions?
5. Perceptions about effectiveness of university-based Surveying courses in regard to preparing graduates for professional engagement.
    a. What are your opinions about the effectiveness of universities courses in meeting the needs of the modern day profession?
    b. What are you perceptions of the future of land Surveying/Geomatics and what are the implications for the profession and for education?

END

APPENDIX C

PhD Research Project
Participants' Information Sheet
School of Education
University of Nottingham, U.K.

Project Title : Curricular & Pedagogical Developments in Surveying Education

Researcher's name: Garfield O. Young

Researcher's contact: Tel: +44 (0) 0755 237 7249, Email: ttxgy1@nottingham.ac.uk

Supervisors : Prof. Roger Murphy and Assoc. Prof. Martin Smith
Supervisors' contact: Email: roger.murphy@nottingham.ac.uk & martin.smith@nottingham.ac.uk

Institution: University of Nottingham, School of Education Wollaton Road, Nottingham, NG8 1BB, U.K.

The research has two primary aims:

1. To explore differences in the design and delivery of curricula and the pedagogical approaches used in surveying/geomatics programmes.
2. To consider how differences in curricula and pedagogy used in surveying education relate the issue of students' preparedness for work in the surveying/geomatics profession.
3. The study is being conducted by a PhD student from the University of Nottingham, UK and has achieved ethical approval from the University's Research Ethics Committee. Data will be obtained through (1) interviews with academic staff, students and professional surveyors; (2) observation of teaching and learning sessions; and (3) review of documents prepared by the universities for students of the surveying programme as well as review of student-produced artefacts.
4. The study is designed primarily as a case study research using three university-based surveying/geomatics programmes in three different countries. Your university has been selected as one of the case study sites because of its prominence in this country and its accreditation status.
5. If you desire further information regarding this study, please contact the researcher using any of the contact information listed above.

****

PARTICIPANT CONSENT FORM

[FOR INTERVIEW PARTICIPANTS]

Project title: **An investigation into curriculum architecture and pedagogical alternatives in surveying education**

Researcher's name: GARFIELD YOUNG

Supervisors' name : PROF. ROGER MURPHY, DR. MARTIN SMITH

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential unless otherwise agreed by myself.
- I understand that I will be audio-taped during the telephone interview.
- I understand that audio-taped data will be stored in a password protected digital file at the University of Nottingham. Interview transcripts will be stored securely in a key controlled cabinet drawer at the School of Education, University of Nottingham. The names of universities and staff will be changed on the transcripts to protect the participants. Only the researcher and his supervisors will have access to the data stored electronically and in hard copy.
- I understand that I may contact the researcher or supervisor if I require further information about the research, and that I contact the Research Ethics Coordinator of the School of Education, University of Nottingham, if I wish to make a complaint relating to my involvement in the research.

Signed ………………………………………………………………………… (Research participant)

(Please indicate appropriate status)

PROGRAMME LEADER ACADEMIC STAFF STUDENT
PROFESSIONAL SURVEYOR

Print name ……………………………………………………………… **Date** ……………………………………

Contact details

Researcher: Email: *ttxgy1@nottingham.ac.uk* , *telephone: +44(0) 7806 783 486*

Supervisors: *roger.murphy@nottingham.ac.uk and martin.smith@nottingham.ac.uk*

School of Education Research Ethics Coordinator: Professor John Holford
Tel: +44 (0)115 951 4486;
Dr Alison Kingston
Tel: +44 (0)115 951 4420
Email: educationresearchethics@nottingham.ac.uk

APPENDIX D

Case study protocol

AIM	ENQUIRY METHODS	TARGET	IMPLEMENTATION STRATEGIES
To obtain an understanding of the curriculum designs and the expected learning outcomes.	Documentary research - Detailed evaluation of curriculum document	AAU & NU surveying/ geomatics programmes	Obtained formal curriculum documents from programme leaders and from official programme websites or WebPages on official university websites.
To determine: • philosophy behind the curriculum and pedagogical choices • interpretations of the curriculum document • perceived strengths, weaknesses and challenges of the curriculum	Semi-structured Interviews	Programme leaders and head of administrative division or other accessible academic leaders	Conducted by researcher during visit. At each site, two 30-40 minute interviews to be audio recorded with permission from the interviewees
To explore academic staff's perceptions about the curricula and pedagogical choices.	Semi-structured Interviews	Three surveying lecturers at each site.	Separate interview with each participating lecturer to be administered by researcher during field visit.
To explore students' perceptions about curricula and pedagogical choices	Semi-structured Interviews	Two students from each year group. Total 10 students at AAU and 8 at NU	Separate interview with each participating student to be administered by researcher during field visit
To examine the practical interpretations (academic staff and students) of the curricula as demonstrated in pedagogical activities.	Non-participant Observation	Surveying students and staff	Done by researcher during field visit.
To consider the standards of artefacts representing products of students from learning activities.	Artefact analysis	Hard copies and electronic products of work produced by students	Observed artefacts in the presence of staff and students. Questions about the artefacts, methods of production and perceived standard relative to industry standard.
To determine the perceptions of professionals about the relevance of curriculum & pedagogical alternatives to surveying education.	Semi-structured interviews	Three professional surveyors in each of the two countries.	Administered by researcher during either face-to-face or by telephone.

APPENDIX E

First case study enquiry outcome

Subject	**Comments -Interviews, Focussed Discussions, Observations**
Staff	
The programme leader and 6 lecturers.	There were three 1-hour interviews with the programme leader. The interview with lecturers ranged between 20minutes and 30 minutes.
Students	
1st year student	one-hour interview
3rd year student	one-hour interview
Four 3rd year students	10-minute interviews with each student following observed lab session.
Group of five 2nd year students	15-minute focussed discussion
Class of 60+ 2nd year students	15-minute focussed discussion conducted at the end of a 2-hour lecture that I observed.
Professional surveyors	
Three England professional surveyors	30-minute interviews of director of large professional accrediting body, principal of large international Geomatics company based in UK and the principal for a small UK based Geomatics company.
Observations	
1st year Plane Surveying	2-hour lecture
2nd year Programming	2-hour lecture
3rd year Remote Sensing	3-hour lab session
2nd year Photogrammetry	1- hour of a 3-hour lab session
3rd year 3d laser scanning and total station control work.	3-hour field session
Students' coursework box files	Course work packages for two students of each programme year (total six students). These box files contained all assessed pieces submitted over a one-year period.
Examination papers	SMS and GIS examination papers for all subjects with a written final examination for one academic year.
Student work displayed in labs	Maps, plans, sections, terrain models, etc.
Several documents providing information about the programme structure and content, quality assurance and student guidance.	Curriculum document, student handbook, website, programme review reports

APPENDIX F

Second case study enquiry outcome

Subject	Comments -Interviews, Focussed Discussions, Observations
Staff	
11 academic staff	4 professors, 4 associate professors, 2 lecturers, 1 lecturer/PhD student. [30-45 minutes]
3 Administrators	Head of Department, Deputy head of Department, Chair of UNESCO PBL Centre. [45-60 minutes]
1 Technical staff	Equipment technician. [30 minutes]
Students	
10 PBL Groups	Focussed group discussions with 2 1st year, 2 2nd year, 3 3rd year, 3 4th year, (5th year students were on internship and so not available for interviews). [20-30 minutes]
2 Students from non-surveying courses	10-minute interviews. This helped to contextualise the findings as it offered a perspective of the AAU model from students outside of my focus group.
Professional surveyors	
4 Professional surveyors	President International Federation of Surveyors, president Danish Surveyors Association, president European Surveyors Association, vice president Danish Surveyors Association and director of Danish Cadastral Surveying. [30 minutes]
Observations	
2nd year Planning Law	Conventional lecture [1 hour]
2nd Video-lecture	Linked by video with class in Copenhagen [1 hour]
3rd Photogrammetry	Computer laboratory [30 minutes]
PBL Group Meetings	Four groups (one in meeting with supervisor doing surveying computations, two groups in one room working on different projects, one group processing data collected from field measurements)
Facilitator Training Course	Two half day sessions
General operations	Staff-student interactions, administrative support, resource support, etc.
Student work displayed in group rooms	Maps, plans, sections, etc.
Several documents providing information about the programme structure and content, quality assurance and student guidance.	Curriculum document, student handbook, website, programme review reports

APPENDIX G

Sample Section of Course Matrix

	NU, England	UEL, England
Course Title(s), Specialisation(s) & Duration	BSc(Hons) 3 years Measurement Science (MS) or Geographical Information Science (GIS)	BSc(Hons.) 3 years MS, GIS & Civil Engineering Surveying Double majors possible Foundation Degree in Civil Engineering Surveying. This provide access to BSc Civil Engineering Surveying or can be an end in itself as replacement for the phased-out HND & HNC courses
Enrolment	35 students per year, shared between MS & GIS specialisations. Student population mostly from UK. Small % of EU students	Total 120 students in the 3 programmes. 40 1st year, 55 final year. Relative to NU, large international student enrolment
History	• Started in 1964 as an element of a joint science degree. • Later changed to a single honours programme in Surveying • Now offering two 'Geomatics' specialisations – MS and GIS. • GIS less popular than Geomatics • RICS & ICES accredited.	• 1949 professional qual. - RICS. • First degrees in Land Surveying Sciences offered by polytechnic in early 70s. • Changed in early 80s to single degree in Surveying & Mapping Sciences. • Vocational diplomas and certificates were also offered: HNCs & HNDs. • 1989 split between SMS & GIS. Some rebranding/renaming of course titles over the period to the current SMS and GIS. • Civil Eng Surveying later introduced to meet industry demand. • GIS less popular than MS. Temporary cessation of recruitment for GIS this programme. • ICES accredited
Curriculum type & Pedagogical Approaches	Mostly fixed courses (a few technical electives) taught over 6 semesters. Traditional structure with one common year and two years of specialisation in Geomatics or GIS. Traditional lectures, directed practical sessions (field & lab). First year field course. Technology aids commonly used in lecturers.	Fixed modules taught over six semesters. Traditional structure with 3 courses. A variety of combinations are possible with major & minor options. Traditional lectures, directed practical sessions (field & lab) & Seminars. First year field course. Technology aids commonly used in lectures.