Investigating how education is shaping the modern Surveyor/Geomatic Engineer

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Key words: Surveying education; Curriculum architecture; Pedagogy; Geomatics

1. SUMMARY

In an age of rapidly changing technology and huge volumes of information exchange, there is scarcely a profession that has not been significantly impacted. Technologies such as GPS, GIS, laser scanning and robotics are all features of a fascinating profession still unfamiliar to many: Geomatics Engineering believed by a growing number of persons to be the modern interpretation of the profession traditionally known as Land Surveying. The modernization of Land Surveying has lead to an expansion of its functions in many jurisdictions. Technology now affords high precision and accurate measurements at the touch of a button. This automation has prompted an increased focus on the management of spatial information and spatial systems and the 'Geomatic Engineer' can be viewed as the ultimate land management expert. The discipline is at the forefront of employing state-of-the-art technologies in the execution of its widening functions; it offers the perfect mix of technology with management and affords equal opportunities for the spatially intelligent to work indoors and out.

Surveyors have traditionally been shaped through a number of processes among which formal education has been central. It is widely accepted that much has changed in the discipline but there is not a great degree of appreciation of the changes which may need to be made in the educational programmes. Can the educational strategies used in traditional Land Surveying programmes produce the competencies required of the Geomatic Engineer/ modern surveyor? What philosophies underlie contemporary surveying education? How have universities sought to navigate the complex issues surrounding the education of surveying students in this evolving discipline? This paper outlines some aspects of university-based surveying programmes highlighting some of the issues being explored through research.

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1. INTRODUCTION

There has been some discourse on the role of the surveyor within this modern context (e.g. Derby, 2008; Hannah et al. 2009) and a relatively lively debate on whether or not the impact of technology is presenting a real threat to the profession. The role of education is central to this debate and understanding how educational institutions have sought to address these issues is important for the restitution of a profession that is perceived by some to be at risk. We are currently doing a study to explore differences that exist in current university-based surveying education programmes. The study will not only highlight the differences in curricula and pedagogical approaches, but hopefully will also provide insights into the philosophical underpinnings of the variations found and the implications for the surveying profession. To some the term geomatics is little more than a name change from the traditional terminology while to others it signals a paradigm shift in the structure, content, delivery and philosophy of the educational programme. Some universities and the surveying professionals within their jurisdictions, insist on making a distinction between land surveying and other areas that come under the umbrella of spatial information science. This paper will attempt to go beyond labels to explore the issues relating to curriculum and pedagogy within university-based surveying programmes. It will first look at curriculum then pedagogy and then in a concluding section consider the implications of the findings for surveying education.

2. SURVEYING CURRICULUM

The curriculum for a course of study is the definition of what is to be learned (Ross, 2000), the structure of the learning programme and the broad supporting mechanisms that come into play to make this system work. It is reasonable to expect a profession-based university curriculum to produce graduates who can effectively function in the associated field of work/profession. If surveying education programmes were to be effective in producing novice professionals, graduates must have acquired a body of knowledge and developed a range of skills and competencies in the application of certain prescribed techniques and methods and have a good grasp of the social practices associated with the surveying profession. It is argued, however, that these skills alone are not adequate for preparing graduates for professions. Professional degree courses are now seen as more effective if they develop life-long learning skills in students which prepare them for progressive professional upgrading following their initial period of professional preparation. This is perceived to be a crucial skill in professions like surveying where change is a constant reality (Enemark, 2002). The discipline has in recent decades been integrally linked to computer, electromagnetic and satellite navigation technologies. These technologies have undergone rapid developments over the last few decades and this has meant that surveying curricula are almost constantly in a state of flux.

University-based surveying curricula in countries from four continents are included in this study. In most of the countries considered, surveying has had and continues to have a strong foundation in Mathematics and Physics and is broadly perceived to have a primarily technical emphasis. The influence of technological advances is evident in all curricula but with varying degrees of concentration. There appears to be little consensus regarding both the content and the structure of surveying curricula. However, some similarities have been identified and include the following:

- Inclusion of core modules in key surveying areas such as plane surveying, engineering surveying and geodesy.
- Practical components that work in tandem with theory and/or done on practicum exercises (off campus residential field courses)
- Influenced by professional bodies and market demands.
- Sensitivity to the need to change content, content focus, teaching methods, instrumentation etc as the technology changes.
- The desire to obtain accreditation from recognized bodies influences content, equipment, staff arrangements, delivery methods, assessment strategies.
- Constraints imposed by institutional guidelines.

Some variations in surveying curricula are understandable since the role of the surveyor varies in different countries. In some countries the surveyor primarily serves the traditional cadastral functions related to property boundaries while in others the role is wider, encompassing various aspects of land management and spatial data management. These differences would obviously be reflected in the educational programmes. In some programmes there is marked reduction in the traditional surveying components to add technology-related areas such as Geographic Information Science (GIS) and Remote Sensing. The programme focus tends to be associated with the academic unit with which the programme is linked. For example when the programme is within the Civil Engineering Faculty there tends to be a strong engineering emphasis and there is a strong environmental science emphasis when closely linked with areas such as forestry, planning and architecture. There are also variations in teaching contact hours and the duration of school year can result in disparities. Finally the relative affluence of universities can be reflected in the availability of modern technologies.

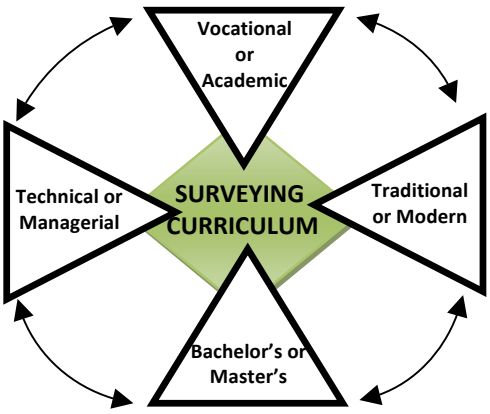

Figure 1. Factors impacting Surveying Curriculum Development

Several issues have emerged from this study as having a strong influence on surveying curricula. Four are highlighted in Figure 1 and will be used as broad headings for the discussion that follows. The issues are complex ones with varying degrees of influence from the profession, governments, academic staff, students and other stakeholders. Though analysis requires careful contextual considerations some generalisations can still be made.

2.1 Traditional or Modern

The Geomatics paradigm has lead to the transformation of many surveying curricula. GIS, Global Positioning System (GPS), Remote Sensing and Laser Scanning are some of the technologies that have been incorporated into surveying programmes. Are these technologies to be viewed as mere tools that improve the accuracy and efficiency of the surveyor's traditional function or should they be viewed as sub-disciplinary fields? The philosophy behind reforming surveying programmes will determine the degree to which the programmes can be perceived to be traditional or modern.

Some universities offer separate degrees rather than attempting to 'legitimately' combine the contents from a rigorous surveying programme with that of a Geoinformation programme. Other universities have sought to make adjustments to their surveying curricula to factor in the new technologies in measurement science, land data representation and spatial data management. Adding new content to a curriculum has several implications e.g. loss of some modules[1] and reduction in content in other modules. There is also the risk of overloading the curriculum and thereby not offering much depth in the numerous subject areas. Finding a good balance is an ongoing tedious task that programme designers and managers must constantly work at.

A question of modernisation here points to the extent to which "surveying" is becoming "geomatics" through curriculum reform. Students in programmes that seek to combine measurement science and GIS for example, have often questioned why the curriculum requires them to do significant amounts of work in both areas when their interest is in one. There are however, other students who prefer a generalist approach that exposes them to as much as the curriculum can allow.

2.2 Bachelor or Master?

In most countries a Bachelor's degree is the academic requirement for becoming a registered surveyor. Work in engineering surveying and geoinformation typically does not require the type of post university registration that cadastral work requires. A Bachelor's degree in surveying and or geoinformation or a related field is normally seen as a suitable qualification for work in geoinformatics.

In one country, however, the three-year Bachelor degree offered is considered inadequate as an academic qualification for a professional surveyor. Students therefore do an additional two

[1] A module refers to an educational unit that covers a subject or sub-division of a subject. In some universities the term 'course' is used in place of 'module'

years for a Master's degree which serve as the foundational qualification for becoming a registered surveyor.

Some universities offer a three-year undergraduate programme in surveying while with others the programme is for four years. The matriculation requirements are difficult to compare across countries but within regions and where international secondary school examinations are used real comparisons can be made.

The following summarises two of the undergraduate structures found:

- 4 Year programme consisting of: A generic first year with surveying and/or GIS specialisations starting in the second year. The second year has basic foundational surveying principles with closely supervised labs and field work and supporting sciences (Math, Physics and Computing). The third year has more advanced specialised subjects with the supporting science and management subjects. The fourth year has a focus on industry experience and/or research work.
- 3 Year programme with specialisation starting from 1st year with limited general courses and electives. The inclusion of industry experience and field courses tends to be limited in these shorter programmes.

The findings here point to questions about what should be considered as an appropriate academic level for the surveying profession. Is the undergraduate degree sufficient qualification for a professional surveyor or geomatic engineer? Will wide scale promotion of surveying as a more academic field with more intense research work benefit the profession?

2.3 Vocational vs. academic

The term *vocation* is a loaded one with a variety of meanings depending on its context of use. In some countries vocational study signifies a clear distinction from academic studies with the former being at a lower academic level. Academic study would then refer to what is perceived to be a higher level more generalised or generic education geared towards graduates entering the job market at a more managerial level. In these contexts vocational studies tend to be skills-based or have a technical focus and prepare graduates for narrowly defined functions in industry below management level. In other contexts the distinction between the two concepts is not as clear cut and individuals can make a transition from 'vocational' to 'academic' with relative ease Moodie (2008).

It has been argued by some that vocational training is not the prerogative of universities which should be concerned with higher learning (e.g. Barnett 1994). Assiter (1995) notes that vocational skills are typically viewed as low-level, mechanical attributes and further outlines a classification of the concepts of training (associated with vocation) and education (more associated with profession): training – skills, narrowness of application, instrumental value; education – knowledge, understanding, broad cognitive perspective and intrinsic value. In spite of this contention, there is an increasing demand for graduates to not only have intellectual capabilities but also practical relevance to meet market demands. Research by Golding & Vallence (1999) showed that a growing 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 is the reality in at least one of the cases being considered in this current study.

This gap between market demand and academic supply, according to Enemark and Pendergast (2001), may be due to a lack of understanding of how to meet that demand. They further stated that research is needed to determine how successful surveying courses have managed to evolve their content and delivery to provide graduate with the skills and learning ability that the market requires. Emerging from this debate are questions about the role of universities in finding ways by which education is 'married' with vocational skills development , or as Assiter (1995) put it 'breaking down the separation of education and the 'world of work'.

Ghilani (2000) in his analysis of the educational challenges facing the surveying profession noted that surveying became less important to society when there was a significant move from agricultural activities to manufacturing. He asserted that surveying was associated with scholarship, apprenticeship and professional status. The scholarship component of this mix he argued became secondary to apprenticeships as this became the requirement for licensure. In some instances educational programmes for persons desirous of becoming surveyors had such a strong emphasis on developing technical competencies that very little if any time is focussed on activities that could be more readily described as scholastic (research and innovation e.g.). This might be one reason that the discipline of surveying, at least in the eyes of some, was viewed as more appropriate for vocational studies rather than for academic studies.

Surveying has been described as a discipline that has not traditionally had a strong research base and so it may be difficult to appoint appropriately qualified (academically) individuals to drive the research component in university programmes. There are some indications that the influx of complex technology in surveying and the heightened dynamism in the expansion of the spatial science disciplines, are together tending to help to rectify this situation.

2.4 Technical or Managerial?

The changing nature of knowledge and technologies continue to fuel significant changes in professions. If universities are to be relevant, they must account for these changes in their curricula and pedagogical approaches. Vaatstra et al. (2007) underscored the importance of universities providing students with competencies that enable them to maintain their position in an ever-changing professional environment. They argue that the skills required in the modern day labour market are becoming less discipline specific and more generic. Already there is a move away from pure knowledge acquisition towards employment-related outcomes (Atkins et al., 1993). Universities therefore play an important role in developing generic and reflective competencies if graduates are to be employable within this modern paradigm. With expertise in knowledge creation and transfer and research capabilities, scholarship and practice-based activities universities are best placed to provide the learning experiences to fuel a high skills society King (2008).

Mulaku (2001) explained that earlier surveyors had a broad land development role. He pointed to a cyclical process that took surveyors through a measurement intensive focus then again to the broader remit of land management. If indeed surveyors are now expected to be not only measurers of the land but also managers of this crucial resource, then curricula should have a strong emphasis on management without losing their technical strengths. Universities therefore have to develop creative ways of finding the right balance and have in place a good quality assurance mechanism which monitors closely inevitable changes. Hence there should not necessarily have to be a choice between a management or a technical focus.

3. CURRICULUM ARCHITECTURE

The term curriculum architecture connotes not merely the structure and content of curriculum but also the extent to which the underlying aims of the curriculum are reflected in the pedagogies used (Boyd et al., 2007).

There are clear variations in the structure of surveying curricula in the universities being studied. The structure and content of surveying curricula are influenced by a number of factors including but not limited to:

- The faculty/department with which they are associated
- The local surveying industry
- The expertise of its academic staff
- The university culture and policies
- Student interests

An examination of how curriculum aims are reflected in pedagogies is a complex venture. Universities write detailed course outlines that indicate learning objectives along with pedagogical strategies. However, the relationship between these two educational facets is not generally considered on a deep level. Academic staff typically determines the pedagogical approaches they think appropriate. Whereas some academics are diligent in researching and developing effective teaching and learning strategies, others simple teach the way they were taught. Educational researchers provide an increasing amount of evidence supporting the link between pedagogical approaches and the building of particular competencies (e.g. Barnett and Hallam, 1999). Surveying education programmes, therefore, stands to benefit from informed pedagogical decisions.

In order to determine the impact of curriculum architecture on surveying education the main pedagogical approaches used in university-based surveying programmes will be discussed.

3.1 Pedagogies

Much attention has been given to the development of curriculum in higher education. It is apparent, however, that the attention given to pedagogy is markedly less and this is argued by Barnett and Hallam (1999) to be an issue in higher education that demands attention.
Pedagogy points not only to the chosen instructional methods but also the consolidation of the teacher's identity with the students' (Armour and Balboa, 2001) and the identity of the profession with which the specific education is associated. In addition 'pedagogy is about the

relationship between four key elements of education: teachers, learners, learning tasks and the learning environment (Leach and Moon, 1999 cited in Armour and Balboa, 2001).

The variations observed in pedagogical approaches used in surveying education programmes (shown in Figure 2) may be classified as follows:

- Traditional with modern flavour – the formal structure is primarily based on lectures supported by other methods with no or very little evidence of innovations.
- Traditional alongside modern - lecture-based approach used alongside other methods with some innovations.
- Modern with traditional flavour- mostly modern approaches with many innovations but traditional lecture-based approaches still evident.
- Significantly modernised – largely innovative with an obvious moving away from the traditional approaches.

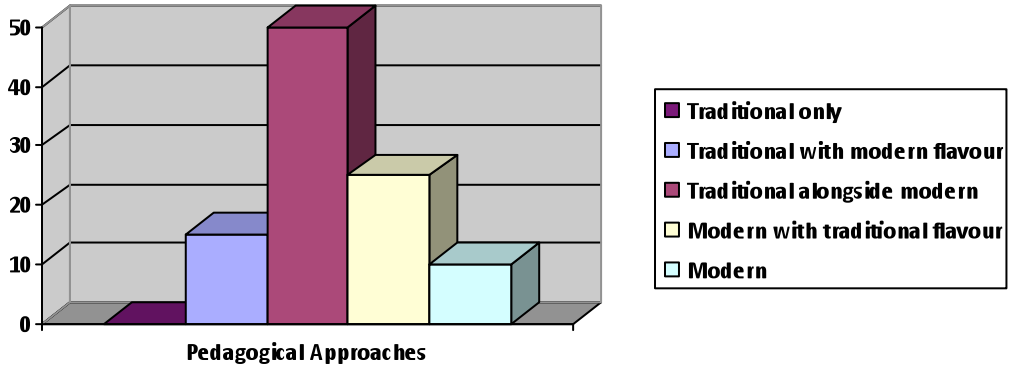

Figure 2 – Pedagogical Approaches used in University-based Surveying Programmes.

Traditional pedagogies here refer to the teacher-centred lectures with a large number of students having limited interactions with the lecturer. This approach is traditionally supported by smaller tutorial groups in which surveying related problems, developed by the lecturer, is worked through in a supervised setting. The tutorial problems tend to be restricted to forming solutions within the details covered in lectures and sometimes with additional references given by the lecturer. Some tutorial exercises include supervised practical exercises using simulations created by the lecturer and supervised by technical staff.

Modern pedagogies here refer to those approaches that are more student-centred and those approaches that take into consideration modern conceptions such as life-long learning and new efforts to make learning more authentic (more closely related to profession-based tasks).

Some of the specific pedagogical approaches used in surveying programmes are mentioned in this paper. These include lectures, tutorials, practical exercises, field courses, work-based learning, project-based learning / project-organised learning, problem-based learning and seminars. Figure 3 illustrates the extent to which the mentioned pedagogical approaches are used in the universities being studied. There is no claim that this is an exhaustive list but they are mentioned here because universities in the study use a variety of combinations that include all or some of those listed.

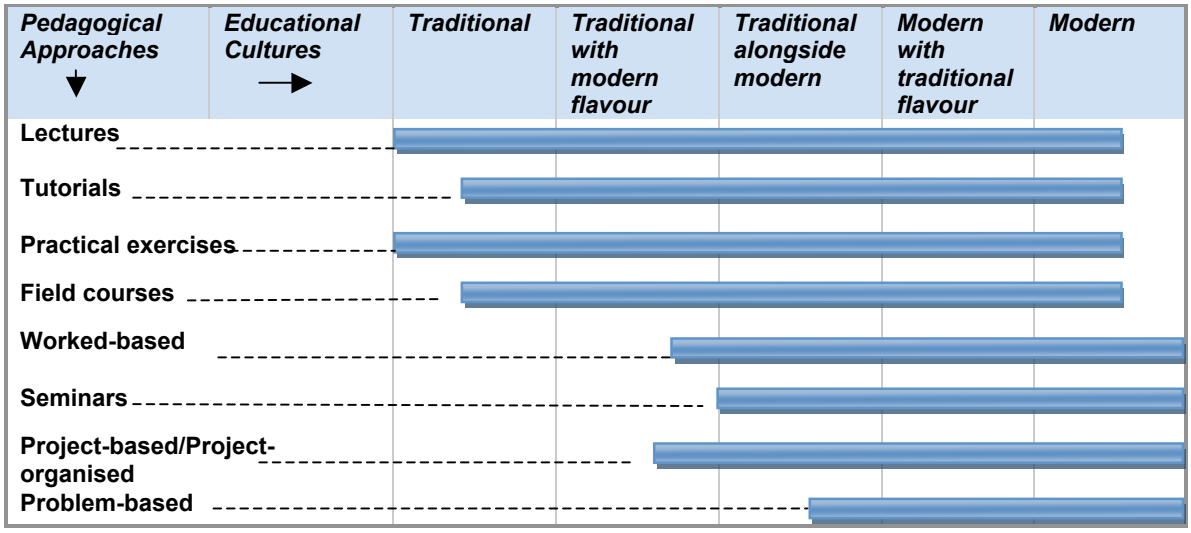

Figure 3 – Extent of use of pedagogical approaches in surveying education

3.1.1 Traditional lectures

Surveying cohorts in universities tend to be relatively small. This means that lecture groups in core subjects are generally not large and therefore can accommodate some amount of interactions between lecturer and students. Lectures, however, are typically geared towards covering a large amount of information or broad-based information in a short period of time. Though studies have shown that didactic approaches to learning are not best at producing authentic learning (e.g. Parsons and Hoxley, 2007), the method is an economic means of covering extensive content. Lectures are still considered appropriate in situations where there is a wide gap between the knowledge scope for the module and the students' current knowledge.

Not many courses are totally lecture based in surveying, and universities typically use a mix of instructional methods that aims at not merely covering the content but also at providing opportunities for students to engage with the material and apply the theory to practical exercises with the outcome of producing typical surveying artefacts. The use of technologies in lectures such as voting systems and Power Point is one way of enhancing student engagement in lectures.

3.1.2 Tutorial

Tutorials typically follow from lectures as a means of providing opportunities for students to engage with the materials covered in the lectures in a deeper way. Tutorial groups are typically smaller than lecture groups and in many cases the groups work through prescribed problems relating to the lecture topics and are closely supervised by a tutor. Surveying computation work sheets and theoretical problems are typically done during tutorial sessions. Some view the learning opportunities in tutorial sessions to have a wider offering than in lectures, yet due to high level control by academic staff, confines the learning within narrow

boundaries. Students can learn from a wider range of related experiences if they are allowed to draw on their own experiences and on reference materials not limited to those indicated by the academic staff. It is understandable that educational institutions do not make random decisions but operate in a systematic way. This, however, should not be a deterrent to exposing the students to a wider range of learning opportunities that may be gained through activities outside of the traditional arrangements.

3.1.3 Practical exercises

These exercises are organised in a variety of ways within the university curriculum. With pure surveying courses such as Plane Surveying, Engineering Surveying and Geodetic Surveying, the practical exercises are generally linked directly to materials covered in lectures and the problems are formulated by the academic staff, supervised by them and confined to time allocations organised within the timetables. The objectives are narrowly defined to meet learning targets that include use of equipment, application of measurement methods to solve stated surveying problems and analysis of outcomes. There is typically a range of surveying artefacts produced by students from these exercises. These may include processed surveying data resulting in useful information such as areas, volumes, deformation values, maps, plans, sections, terrain models, etc.

3.1.4 Field Courses

Practical exercises which are components of lecture-based modules are justifiably confined to short time frames with limited exposure for students. Some universities use field courses (residential field camps for a week or two) as an approach to consolidating and amplifying the instruction given in classrooms and the limited field exercises linked directly to the lectures. These field courses seek to give the students extended field surveying exposure where they will be required to put into practice surveying techniques in simulated surveying problem settings. It is during these field courses that many students make a useful link between theory and practice as it relates to use of equipment in solving relatively large scale surveying problems.

Even courses involving this type of exposure are considered to have limitations as there is the notion that authentic learning can only occur in a real work setting which offer experiences that cannot be fully planned for in a simulated setting. However, the experiences gained in a field courses do have value and can be counted as an important step in developing the technical competencies surveying students will need to develop to prepare them for professional work. Field courses also help in the development of team working and time management skills. The social interactions with clients, surveyors and other professionals on real jobs and all that comes in these settings can be obtained through a different type of 'field' exposure called work-based learning.

3.1.5 Work-based learning

A number of surveying programmes incorporate work-based learning in their curricula. In some of the universities being studied, this represents a prescribed period formally included in the curricula. In some instances an entire semester is dedicated to work-based learning away from the university with an organisation engaged in surveying work which is deemed to be relevant to developing prescribed skills and competencies in students beyond what can be offered within the university. This component of the study programme is an attempt to respond to the needs of the surveying industry, recognizing that industry experience is an integral link that validates and reinforces classroom learning. The process typically involves the selection of appropriate job sites for the development of measurable learning objectives to be achieved during the training period.

Assessment for work-based learning may be through a portfolio developed by the students, evaluation by appointed supervisor within the surveying firm/department using university-prescribed criteria, student written report, oral presentation by student and oral defence before academic staff and professional surveyors. Some of the activities that work-based learning attempt to engender include interaction with clients, engagement in real surveying problems ranging from cadastral work to engineering work, use of a variety of software packages in developing surveying products, time management and interactions with associated professions such as civil engineers and architects.

An example of work-based learning objectives from one of the universities in the study (University of Technology, Jamaica, 2009) is reproduced here to show possible benefits of this approach:

- To assist in the development of the students' technical and interpersonal skills by providing them with the opportunity to work in their specialized fields.
- To work cooperatively with the Surveying industry to provide a viable, economic and productive contribution to the company/surveying department providing student placements.
- Affording company/department representatives to assess potential graduates
- To develop work-readiness and employability skills required for professional development.
- To assist students in establishing or confirming their career choices.
- To expose students to a mix of cultures both small and large organizations locally as well as internationally.

3.1.6 Seminars

Seminars are becoming a feature of modern universities offering opportunities for students to meet in small discussion groups with academic staff and professionals. These meetings are sometimes a standard part of the study timetable particularly for senior students and sometimes they are arranged by lecturers for some aspects of their modules. Seminars are used in surveying programmes as an avenue for student presentations, particularly in areas related to professional practice, project work and research work. They are sometimes used to introduce students to examples of industry applications with presentations made by individuals drawn from industry.

3.2 Pedagogical innovations in surveying education

Innovations in teaching and learning have in recent years been strongly influenced by constructivist[2]-based philosophies that emphasise learner-direction in learning and group interactions. Two particular pedagogical approaches that appear to be on the increase within surveying programmes will be discussed in this section. These are Problem-based Learning and Project-based Learning.

3.2.1 Problem-based learning

Problem-based learning (PBL) was the first major attempt to adopt a student-centre approach in areas with professional requirements and very substantial bodies of knowledge to be learned. 'PBL is a way of constructing and teaching courses using problems as the stimulus and focus of student activity Boud (2006). It is a way of conceiving of the curriculum as being centred upon key problems in professional practice. The aim is to equip student with the skills of self-direction in problem solving and the ability to journey systematically from problem, through deconstruction, to decision, implementation, analyses and justification and reporting. This pedagogical approach is used extensively in the Aalborg University (AAU) programme as it forms one of the primary means of delivering the curriculum. In a few of the other universities studied PBL is used less extensively and particularly with students in senior years in modules that 'naturally lend themselves to problem-solving'.

3.2.2 Project-based learning

Project-based learning, also referred to as project-centred learning (Crosthwaite et al., 2006) can be viewed as a predominately task-oriented approach to learning that involve an individual or group activity within a specified timeframe, with set parameters and criteria, resulting in a product, presentation, or performance (Savin-Baden, 2004). However, project-oriented learning as used at AAU embraces a much wider concept. At this University it is used as an approach to organising the broad curriculum (Kolmos et al., 2004). Project work within this context has a major focus within a given subject-related framework or theme determined for each educational sequence (e.g. semester).

Various aspect of this instructional approach is widely used in engineering education and in other situations where case study methods provide a useful focus in teaching/learning. As used in electrical engineering (Crosthwaite et al., 2006) and surveying (Enemark et al., 2002) project-centred curriculum provides a structured sequence of professional practices simulations 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).

3.3 Relevance of pedagogical methods used

[2] Constructivism is a philosophical view that individuals play an active role in constructing their own understanding through cognitive processes and their interactions with others.

Pedagogical approaches are considered to be closely linked to how students approach learning and this is believed to have an effect on how well prepared they will be for their post university professional engagements (Barnett and Hallam 1999). The adoption of pedagogical approaches that foster authentic learning is viewed by many (e.g. Parsons and Hoxley 2007) as more effective at preparing students for professions. Herrington et al. (2009) stated that the practice of authentic learning in higher education pedagogies is "arbitrary and undefined." They further stated that as "technology continues to open up possibilities for innovative and effective teaching and learning opportunities, students and teachers are no longer happy to accept familiar classroom-based pedagogies that rely on content delivery and little else". It is this direction of thought that has led to pedagogical innovations in higher education.

There continues to be numerous criticisms of the didactic approach to teaching and learning. Some of the criticisms are that the didactic approach: presents knowledge as fragmented bits of information (Shepard, 2000), discourages students from adopting a deep approach to study (Entwistle, 2003), limits learners' conceptualization of what counts as learning thereby inhibiting their ability to adapt knowledge to new tasks and situations (Duit and Treagust , 1998), is unsuited to achieve life-long learning objectives (Raidal and Volet, 2009), etc. In support of learner-centred approaches Duit and Treagust (1998) stated that learning of structure is more productive than mastery of facts and techniques. Some believe that pedagogies that embrace learner-centered, constructivist philosophy offer greater engagement of learners and influence their sense of belonging and their motivation and achievement (Askham, 2004). Social learning activities as are used in PBL are considered to be effective at developing self-direction and deep approaches to learning (Vermunt and Verschaffel, 2000). As a result of these findings, changes in curriculum and instruction from teacher-centred to learner-centred approaches have been encouraged by many researchers (e.g. Thomas, 2002,). These findings, however, do not validate the total rejection of the teacher-centred approach since, according to Elen et al. (2007), when appropriately combined the approaches jointly contribute to teaching quality.

The debate appears to be about how to resolve two competing philosophical views about how education should be approached. At one extreme is the view that a discipline is a body of knowledge best presented under formal direct instructions and at the other is the view that a discipline is a practical manifestation that is best taught through experiences based on the procedures of the discipline. Universities have used several approaches that fall within the two extremes. In a discipline such as surveying, which has clear practical and technical functions, it is important that discipline-knowledge is effectively covered. However, the modern demands on the surveyor require a professional with competencies that allow him/her to adapt to new situations in multi-disciplinary contexts.

It seems reasonable to think that a mix of pedagogical strategies may be an effective way to engage students in the learning process, while ensuring that important content is covered with appropriate guidance. The concept is supported by Schweitzer and Stephenson (2008) who believe that a variety of formats encourage diverse learner aptitudes. Decisions to innovate educational strategies should never be taken lightly since as Frand (2000) stated, innovation is not necessarily synonymous with improvement.

Having explored issues of curriculum architecture in surveying education Table 1 illustrates a likely match between expected surveying competencies and pedagogical approaches.

Skills type	Learning objectives / Industry competencies	Recommended pedagogical approaches
Discipline specific	Theoretical principles in surveying and related spatial sciences	Technology aided lectures, group work, printed and internet resources
Discipline specific	Theoretical application of principles	Tutorials, group work, lectures, printed, internet resources &PBL
Discipline specific	Computational skills	Tutorials, group work & field courses
Discipline specific	Drawing and designing skills	Supervised labs, group work & industry attachment
Discipline specific	Practical skills using equipment in executing surveying and related tasks	Field exercises, field courses, industry attachment, group work, PBL & project-based learning
Discipline specific	Professional ethics	Guest lectures (professionals) & industry attachment
Generic & discipline specific	Team work	Group work, project work, industry attachment, field courses, seminars
Generic & discipline specific	Management of resources	Lectures, industry attachment, seminars, group work & PBL
Generic	Communication skills	Seminars, oral presentation & PBL
Generic	Inter disciplinary skills	Seminars & industry attachment
Generic	Problem solving	Problem-based learning
Generic	Analytical skills / Critical thinking	Problem-based learning, PBL, research, seminar, industry attachment
Generic	Problem solving	PBL, project work, field courses
Generic	Analytical skills / Critical thinking	Problem-based learning, project based learning, research
Generic	Life-long learning skills	Self-directing activities such as PBL, group work, research, self assessment etc.

Table 1 – Matching pedagogical approaches to surveying skills and competencies.

4. CONCLUSION

Learning experiences in surveying education programmes are generally an amalgamation of: theoretical principles taught in lectures and tutorials, computational techniques developed in tutorial sessions and in group work, field applications in field simulations and work-based exposure, reporting and analytical development through oral presentations and written reports and computer labs providing exposure to the various surveying and surveying related software packages and critical thinking skills through research and problem orientation. New pedagogical approaches are being explored by some universities but the impact of the innovations as well as the traditional approaches is yet to be understood on a deep level.

It is understandable that there have been and will remain differences in curriculum structures and content due to variations in the role of the surveyor in different contexts. However, universities are encouraged to critically analyze their existing educational structure to ensure that there is a clear link between curriculum goals and the pedagogical approaches employed.

Surveying education is going through a period of transition and the current trend points to a reinforcing of the technical components of surveying to meet market demands while strengthening the spatial management and life-long learning aspects. Whether the marriage of surveying with the newer areas of geosciences is consummated or kept as related but separate courses of study, education plays a crucial role in shaping the modern surveyor/geomatic engineer.

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