



Mine Surveying Education - a model for the future

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by

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Abstract

The surveying and mining industries have undergone significant changes over the past thirty years. This paper looks briefly at the history of mine surveying from a practicing perspective. The changes in technology and practice will be examined with respect to the new skills and educational requirements that are now demanded. The skills and educational requirements to take mine surveying education into the 21st century are examined. In particular, the current course offerings at the University of Southern Queensland are discussed and provided as an example of a suitable educational model for mine surveying education in the future.

The Presenters

Bill Storey

Bill has been involved in mine surveying since 1965. His main involvement being with coal mining, having been employed for similar periods in both underground and open cut mining. Bill was also actively involved in Mines Rescue for 15 years of this period. Before joining USQ in 1994, he had held several "in charge" surveying positions and gained a reputation for work in building survey control for developing mines. Over the years Bill has been an active worker for the overall good of Surveyors and Mine Surveyors in particular.

Since joining USQ Bill has attained his degree and is now completing a Masters Degree in Engineering Technology (Environmental Engineering). Mine Surveyors have always had an affiliation for the environment and this appeared to be a natural direction for his post graduate studies, particularly in the area of Carbon Credits. Bill previously has been instrumental in promoting a more informed design of mine rehabilitation towards golf courses and other recreational activities. He was also heavily involved in the first EMOS ratified in Queensland.

Kevin McDougall

Kevin graduated from the University of Queensland in 1981 with a Degree in Surveying and then began work as a surveyor in a private practice. In 1984 he returned to university to complete an honours degree and then a masters degree. During this time he also ran a consultancy firm in surveying technology. Kevin began lecturing at the University of Queensland in 1985 and taught in both surveying and the land information systems areas.

In 1993 he moved to take up a position at the University of Southern Queensland. He was appointed Head of Surveying in 1995. Kevin is actively involved in the profession and has performed a range of consultancies in Australia and overseas. He represents the university on a range of industry committees and is currently the academic representative of the Surveyors Board of Queensland.

The Early Days

Over the last thirty years the mining industry has experienced most of the full historical cycle of the technological advances that have occurred within the surveying industry first hand.

Typically the mine surveyors in the 1960's had several sets of equipment to carry out the day to day duties. At this time most surveying was carried out in a similar way to Major Mitchell might have carried out his work in the mid 1800's except with slightly less rum and fewer convicts.

The day to day underground surveys were usually carried out using a vernier theodolite, (See figure 1), a Cooke Troughton and Simms, sitting on a ball joint attachment on the tripod. Readings were inverted and the telescope was subject to fuzzy things growing inside - on the plus side however it was easy to clean and adjust, although the replacing of the spider web on the eyepiece was usually a sticky affair. Other necessary equipment included a cloth tape measure, plumb-bobs and the necessary marks and paint (survey stations underground go on the roof).

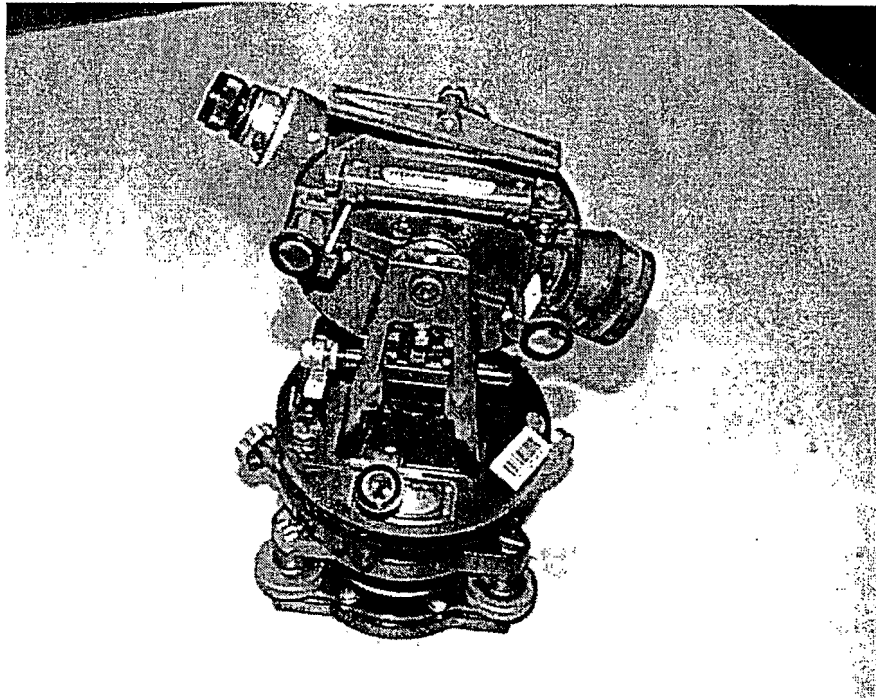


Figure 1 – Vernier Theodolite

Traverses underground and the surface work was usually carried out using a Watts No.1 microptic theodolite, (See figure 2). This was thought to be pretty flash gear at the time, the optics were excellent, the image was still inverted but it read directly to

twenty seconds and educately guessed to five seconds. Traverse measurements were carried out using a one sixteenth seven-chain band: it was regarded to be sacrilege to use this for any other measurements. This equipment was used with sighting tripods on the surface - no forced centring here.

The Watts was also used for tacheometrical surveys to pick up the surface features, it's amazing how quick you became at booking the three divisions on the staff, at the same time checking the accuracy, all without a calculator.

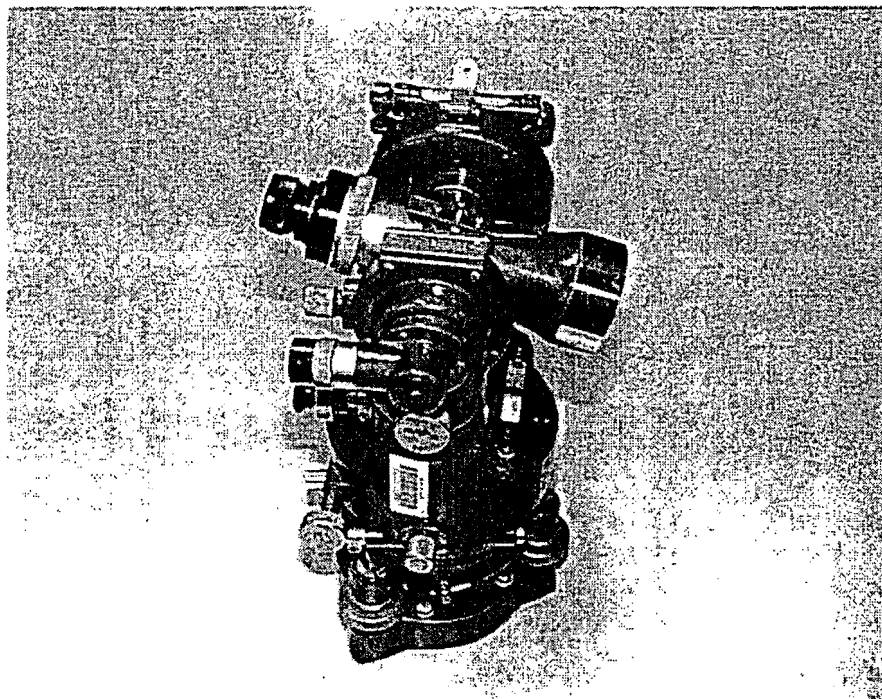


Figure 2 – Watts Microptic Theodolite

Levelling was carried out with an engineering level and staff, nothing has changed much in this area..

Office work was carried out using Log tables, Tacheometrical tables, slide rules for calculations and drafting equipment (pencils and parallel rules, etc) was used for production of plans. (See figure 3)



Figure 3 – Typical drafting and Calculating Facilities in the 1960's

At this time all measurements were in links and chains. Plans were generally at interesting scales such as 1 chain to the inch and 2 chains to the inch.

Before long the industry decided to change over to measurements in feet and inches, with typically equally obtuse scales. This move was a little short sighted, as within a few years the country was soon to change over to metres and mine surveying followed.

The Electronic Age

By the early 1970's surveyors were to see the coming of the magical distance measuring instruments. With a Tellurometer, ancillary equipment and the ubiquitous car battery you were able to measure automatically between two inter-visible points. The age of the national survey grid upgrade was upon us - prior to this the mine might have used a local grid "borrowed" from someone like the railways. The emergence of the DI3 was soon to arrive, a giant leap for the surveyor, but unfortunately a small step for underground mine surveyors as electronic equipment use in underground coal mines was restricted due to the dangers of explosive gases. However at this time the mines were purchasing desktop calculators - the electronic age was truly upon us, the demise of the log tables was imminent.

In the early 1980's with the boom of coal mining and Open Cut mines in particular, mines had money to spend on such marvellous surveying equipment as Wild T1 theodolites with removable tribrachs - how easy traverses were now with forced

centring techniques. A Wild DI5 was able to be purchased to sit on the T1, talk about magic: it was found that you could shoot up to 6 km to a single prism. Various total stations soon followed this as technology improved and prices dropped. This technology soon allowed Resections and Trilateration to replace traverses in much of the surface mine surveying.

It was around this time that mine surveyors were introduced to other miracles of the electronic age, firstly hand held calculators - how could anyone have lived without an HP 41C? Then came the computer. Mines had monster computers that cost millions of dollars and lived in their own buildings. These weren't driven by cards similar to others generally seen at the time, they had large spools that spun around like a massive tape recorder - every major company had to have one of these (a bit like hospitals having that machine that goes 'bing'). Software packages that did everything except make the coffee were now on the scene. The computers did however allow the mine surveyors to produce heaps of data and beaut plans, although major number crunching jobs had to be scheduled over the weekend and the results picked up on Monday. Other packages for data manipulation, spreadsheets, word processing, etc were soon at their disposal.

Before long the personal computer was at our command, for only \$30,000 you could have a computer on your desk, which could almost go as fast as you could type - certainly if you typed as slow as most mine surveyors. This was a big inroad for data manipulation for surveyors; the mine surveyor was now able to transfer data between various disciplines at work. This really made life easy for Geologists and Mining Engineers who had quickly grasped the potential and ran with it, they let the mine surveyor do the work and they produced the final concepts and reaped the glory.

The "reflectorless distomat" and the "one man total station" came on the scene at the start of the 1990's and all of a sudden management was asking the pertinent question - "if we buy one, how many surveyors will it replace?" Most mine surveyors fought the urge to buy either because of this trend until the age of "voluntary retrenchment" was upon us.

In the last decade the emergence of GPS has expanded the potential for data capture, almost to the point where the surveyor can be made redundant. This time we must ensure that we are the experts in this field, although numbers of surveyors are certainly dropping again with this technology.

GIS has also been refined this decade whereby we as mine surveyors are able to better use the data we have captured allowing further refinement of our job description.

Technology advances in the last thirty years have certainly been outstanding for the surveyor and the mine surveyor in particular. We are probably now able to produce ten times the amount of accurate, useful data with one tenth of the work force and double the stress.

The Changing Educational Environment

Australian higher education, like so many other sectors of the Australian economy, has experienced significant change over the past 20 years.

The Dawkins reforms and the unification of Colleges of Advanced Education (CAE's) with the universities dominated the education system during this period. In addition, a user pays system (HECS) has been introduced in an attempt to share the cost of education.

These reforms have resulted in a number of important changes:

- (i) The competition for funding now dominates the activities of universities;
- (ii) The system is now geared for large-scale graduate production rather than the smaller elite;
- (iii) Many specialised courses and disciplines find it increasingly difficult to remain viable; and
- (iv) Universities have become more responsive and entrepreneurial, treating students as customers and industry as clients.

Surveying educational institutions have had to respond quickly to both the significant developments in technology as well as the structural reforms that have been thrust upon us by successive governments.

The impact on surveying institutions has been varied with some institutions blossoming in this more competitive environment whilst others have struggled to maintain staff and student numbers. Successful marketing by disciplines such as Business and Commerce has drawn students away from the Sciences, Engineering and Surveying.

Past Mine Surveying Education

In 1965 mine surveyors were employed as potential mine managers. As such they were expected to be the epitome of the multi skilled worker. The mine surveyor had to carry out all of the "typical" survey duties as well as bore logging and correlation; mine design and mine safety design.

In 1965 few opportunities were offered for the school leaver towards university education, as only a small percentage of school leavers would be offered a place at University. Hence, there were few mining personnel with degree qualifications.

The mine surveyor was required to complete a TAFE based certificate and then pass registration qualifications set up by the Department of Mine Qualification Board.

These registration qualifications were comprised of further exams set by the Board with emphasis on Mathematics and the Law, a practical exam and an oral exam. At that time it was a known fact that only something like one out of seven candidates would actually pass this qualification round.

The TAFE mine surveyors course in 1965 was completed with night classes, was taught by practicing professionals and was thorough and excellent academically. Most students then studied further for their Undermanager's and Manager's Certificate if they so wished.

Equipping Surveying and Mine Surveying Graduates for the Next Millennium

Education, like the changing professional environment of mine and land surveying, must adapt to meet the challenges of the future. Until the 1980's, surveying was defined as the "art" of measuring natural and man made features on the earths surface (Trinder & Han 1999). As we move towards the next century the technological advances have been so dramatic that the skills of measurement is rarely seen as an art form.

The reduction in the time taken to complete once complicated field tasks has been dramatic. The array of technological measurement tools available to both the mine and land surveyors is staggering, both in sophistication and of course cost. With this change in process has come a change in the emphasis from the collection of data to the processing and management of information.

The skills required by the mine and land surveyors for the next millennium include:

Excellent Communication Skills: the ability to effectively listen and communicate with both operational staff and management, prepare and present reports;

Information Technology Skills: with virtually all survey data being captured digitally it is essential that surveyors be conversant in end user computing, data processing, manipulation and management;

Foundation Skills: these comprise of a solid mathematical grounding with an emphasis in practical problem solving, development of a scientific knowledge base and skills for assessing and analysing data;

Data Measurement and Processing Skills: an understanding of the principles of measurement, automated measuring and positioning systems, data processing theory and operations;

Data Presentation Skills: the ability to present and transform data for a range of clients including the interface of other information systems, graphics presentation;

Management Skills: increasingly the surveyor is required and expected to be able to manage projects and people;

An Understanding of the Operational Environment: an appreciation and knowledge of the safety, economic, social and environmental issues that affect the industry; and

Professionalism and Life Long Learning: the importance of professionalism and professional conduct together with recognition of the need for continuing professional development.

This list of skills is not exhaustive but it clearly indicates that the graduates of the courses in the next century will be much differently equipped than their counterparts of 20 years ago.

Designing Surveying Courses for Both Industry and Graduates

Universities are acutely aware of the need to balance the sometimes-competing demands of industry with the need to ensure that the essential academic foundations are provided. Students are also more discerning in their selection of courses and are increasingly aware that they are now "paying customers".

Industry continues to play an essential role of providing advice on the skills that they require of graduates emerging from universities. This is usually in the form of advisory committees or accreditation bodies. However, some sectors have expected universities to complete all of the training and have ignored their responsibility to provide on going training when graduates reach the workforce.

The design of courses must now also increasingly meet the demands of our "paying customers" who want a career pathway to follow and flexibility of study. Articulation of surveying courses such as those provided by USQ allow students to progress upwards to higher qualifications with little or no penalty. Flexibility is provided by reducing the prescriptive nature of the course and by providing flexibility in both progression and the mode of study, such as distance education.

The University of Southern Queensland (USQ)

Established in 1967, USQ has built a reputation for offering quality academic courses which are recognised worldwide by other higher education institutions and internationally accredited by many professional bodies. The University's vision is to be highly regarded for excellence in teaching, to be a leader in distance and international education, to pursue high level scholarship and research, and to be sensitive and responsive to community needs.

USQ graduates record higher than average employment rates in most disciplines. Recent independent surveys suggest they have a very high overall satisfaction with the

standard of courses and support offered to them. *In the most recent national surveys by the Graduate Careers Council of Australia, USQ graduates continued to rate the teaching at USQ in the top quarter of Australian universities – one of only 12 universities to achieve a five star rating.*

The Toowoomba campus, located on spacious, landscaped grounds, offers excellent facilities. Students have 24 hour access to well equipped computer laboratories and access to CD-ROM and Internet resources through a well-stocked library which emphasises client support. USQ enjoys a current enrolment of approximately 20,000 students, including 6,000 on campus and 14,000 studying by distance learning. More than 600 academic and 850 administrative staff are employed.

The international program is expanding rapidly, with 4,300 students from all over the world currently enrolled in our courses. 900 students from 35 nations study on campus, and a further 3,400 study in their home country by distance learning. The relatively small on campus student population means that USQ students are less likely to be lost in a large group. Friends are made easily and teaching staff are readily available to provide assistance to students.

The Engineering and Surveying building was built two years ago and is equipped to the highest standard of facilities. All rooms are air-conditioned and the Surveying discipline ensured that their amenities were first class (see figure 4). From the ground floor, where the survey store is situated, through the third floor where several computer labs are set upright up to the roof which is set up particularly for geodetic observations, the new building serves the surveying discipline well.



Figure 4 – New Surveying and Engineering Building at USQ

The Surveying and Land Information at USQ

The Surveying and Land Information Discipline is part of the Faculty of Engineering and Surveying which also encompasses the other disciplines of Civil, Environmental, Agricultural, Electrical and Mechanical Engineering. Over the past five years the Discipline has progressed substantially in the development of its courses and teaching program.

The Surveying and Land Information Discipline has grown significantly, both in student and staff numbers and now has the largest number of surveying and GIS students of any University in Australia. This growth is shown graphically in Figure 5 and illustrates that the growth has been of the order of 60% over a five-year period.

Figure 5: Growth in Student Numbers 1994-1999

Figure 6 illustrates the diverse range of our student population in terms of age group. As opposed to other universities the majority of our students are non-school leavers with most students in the 20 – 35 year age group.

Figure 6: Age Distribution of USQ Surveying and GIS Students

USQ Courses

USQ offers a unique range of surveying and geographic information systems (GIS) courses. The Faculty offers courses at associate degree, bachelor's degree, graduate diploma and masters degree level by full time, on campus study and part time, external study. In addition, academic staff of the Faculty serve as research supervisors

for students enrolled in the doctor of philosophy course that is offered by the University.

The recent course developments were initiated in 1993 with the introduction of the Bachelor of Technology in Surveying in response to the demands of industry. This was followed in 1996 by the introduction of the Bachelor of Surveying degree and a Bachelor of Technology in GIS. Both of these courses have been well received.

In 1997, again in response to the demand, a postgraduate course namely, the Graduate Diploma in Geomatic Studies (GIS) was introduced, followed by a research masters program in 1998. An Associate Degree in GIS will now also be offered in 2000 to complete our suite of undergraduate degrees.

Course	Years of Study	
	Full-Time	Part-Time
Bachelor of Surveying	4	8
Bachelor of Technology (Surveying)	3	6
Bachelor of Technology (Geographic Information Systems)	3	6
Associate Degree in GIS	2	4
Associate Degree in Surveying	2	4

Table 1: Course duration by modes of study for USQ Surveying courses

The USQ surveying education model provides the basic educational requirement for each level of the surveying and mapping workforce with and clearly defined articulation pathways for those wishing to upgrade their existing qualifications. All of the courses are offered in both the internal and part-time external mode. The integration of these modes of study provides students with significant flexibility.

Specialisations in Mine Surveying at USQ

Over the last thirty years the technology required by Mine Surveyors has taken a quantum leap. Mine Surveyors today need to understand the new surveying techniques, have excellent computer knowledge, have excellent communication skills, have excellent management skills, be conscious of their safety and economic requirements and be aware of their legal obligations. They need to be both professional and to be seen as Professionals. They need to be similarly equipped academically to compete professionally with their peers.

It is with is mind that the University of Southern Queensland has offered an extension of their Bachelor of Technology (Surveying) course to incorporate specialised subjects to fulfil these requirements.

The Bachelor of Technology (Surveying) already incorporates teaching of the necessary technologies required for surveying professionals with particular emphasis being placed on computing and surveying skills. We also ensure the graduate is well versed in management and communication skills as well as being aware of their environment both ecologically and legally. The Bachelor of Technology (Mine

Surveying) incorporates three specialised elective subjects to ensure rounding off of the Mine Surveying requirements.

Mine Surveying is a profession that has drifted to remote areas following the mining operations, to this end distance education is the obvious alternative for prospective students. As USQ teaches in both internal and external modes, students are at liberty to switch between modes depending on their needs and their domestic situations. We teach students from all over the world, but most of our students come from the Pacific Rim. We often find external students take a year off work to finish their final year, and likewise internal students revert to external mode if they are able to find employment before they finish their course.

Emphasis on Quality and Flexibility at USQ

The benefits provided by the flexible and industry ready approach by USQ are significant for both the employers and the students.

For employers the benefits include improved level of staff skills and knowledge, the ability to retain staff as they upgrade their skills, industry prepared graduates and access to effective continuing professional development.

The benefits for students include professionally accredited qualifications, local national or international employment opportunities, wide range of career pathways, excellent employment rates, flexible study options, continue to study if offered full time employment, move between on campus and off campus study at any time and ability to change courses or discipline of study easily.

All USQ engineering and surveying courses are recognised by the relevant professional bodies. The Bachelor of Surveying degree is accredited by the Boards of Surveyors throughout Australia and is also recognised internationally.

The Faculty recently introduced a quality assured management system and has achieved third party certification to ISO 9001 for its teaching programs. Study materials produced by the Faculty are available for scrutiny by employers, practising engineers and academics and annual surveys of graduates and students ensure that the quality of service provided is maintained at a high level.

The most recent career destination survey was completed and analysed in June of 1998. At the time of the survey none of our graduates surveyed were seeking full-time work. One graduate had returned to full time study, whilst the remaining 28 graduates were gainfully employed. This represents an employment rate of 97%, which is extremely high for any profession.

The high quality of our graduates is further evidenced by the continued demand by employers for our graduates. Many of our undergraduate students do not get the opportunity to complete their studies on a full time basis as they take up positions part way through their courses and then complete their studies externally.

Conclusions

Over the past thirty years mine surveying, and surveying in general, has taken a quantum leap. The Mine Surveyors of today need to understand the new surveying techniques and technology, have excellent computer knowledge, communication and management skills, be conscious of their safety and economic requirements and be aware of their legal obligations. They need to be both professional and to be seen as Professionals. They need to be similarly equipped academically to compete professionally with their peers.

The University of Southern Queensland offers a unique suite of courses that are well articulated and readily accessible to students where they work. The Bachelor of Technology (Surveying) at the University of Southern Queensland already incorporates the teaching of the necessary technologies required for mine surveying professionals and offers a further specialisation in this field. USQ is embracing the change in technology and providing a quality range of teaching programs that will take surveying into the next millennium.

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