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Land Surveying Education in the 21st Century

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Abstract

This paper presents a number of critical issues for the wider profession to work with over the coming years. These relate to where the profession is going, why it exists, what are its core values, and where it should go in the future. If these questions cannot be resolved, it will not be possible to educate future generations of professionals in a meaningful way.

A brief look at a previous surveying revolution is included to stimulate some thought and discussion about the nature of technological revolutions and their impacts. Some of the current problems and issues facing the education sector are presented, in the interests of supplying information for discussion.

A professional dialogue to resolve the many issues facing us, at least as far as developing some path to the future is concerned, is recommended.

Introduction

The purpose of the paper is to provide a brief discussion of some of the issues facing the educating of surveying professionals in the next several decades. Some of these issues come from the academic end of things, while others come from the profession, especially in the area of new technology.

There are no definite solutions to the question of how to educate surveying professionals. While there is certainly a core body of knowledge that a young person needs when entering the profession, how they obtain it is an open question. With the rapidity of change in both the academic sector and the profession, there are many ‘right’ answers to that question, but the answers will change over time. There are also some ‘wrong’ answers, and some ‘right’ answers that do not survive. We need to be aware of the choices that we collectively make, as a profession, and the consequences of those choices.

A Reverie

When in the midst of a time of turbulence and change, it never hurts to look at history to see if there have been similar situations before, and what happened then. In the surveying profession, we have been undergoing major changes over the past 50 years. Have there been times when this has happened before?

If you were a surveyor in those times, how would you deal with rapid and unprecedented change in what you do? How would you deal with changes to your whole world (and world view) as a consequence of the changes happening around you? If there was a time that had parallels to the current situation, we may be

able to see how things tend to turn out, and so be prepared for what happens in our future, by looking at the future of some professionals in the past.

Let us consider the year 1550 AD. There are the beginnings of the Renaissance in Europe. English has been established and the common language in England for only 100 years. We are at the end of the Middle Ages. Gutenberg's printing press is only 100 years old, and the Protestant Reformation is only just beginning. However, the changes are not particularly fast or widespread, and for many people, life continues on much as it has always done.

For a European surveyor in 1550, things hadn't changed much for many centuries. Most survey work was mapping, and there was almost no mathematics involved beyond arithmetic. Most of the work was artistic, in that a picture was created of the landscape. It was only in construction that detailed measurement really mattered, but in that case, the guildsmen had expertise in their own fields, and if that included measurement to their needs, they had that skill as part of what they had learnt during their long apprenticeships.

The most powerful surveying instrument is the groma, the Roman device for turning right angles. The Roman surveyors had based a lot of their work in straight lines and right angles, and this approach continued, where it was needed, with little change up to 1550. Surveyors, such as there were, could look back on over a millennium of continuity in methodologies, technologies, and almost everything else associated with surveying.

But if we move forward to 1650, a mere 100 years on, there is almost total change. In the preceding 100 years, the following equipment and concepts have been invented or discovered:

- Plane table;
- Theodolites;
- Triangulation;
- Trigonometric tables;
- Logarithms;
- Co-ordinates;
- Vernier scales;
- Telescopes;
- Slide rule;
- Micrometer;
- Barometer;
- Graphite pencils;
- Analytical geometry; and
- Mercator's projection.

And to top it all off, the first surveying textbooks have appeared. In a matter of a century, almost all the equipment and methods that shaped how most surveying would be done until around 1950 were developed.

In this 100-year period, surveying has changed almost totally. It is now very much mathematical, as angles other than 90° are now easy to measure, and so trigonometry is essential knowledge (it was needed much before then). Small, local surveys are now small business, rather than all the business. Geodesy is big and surveyors are now Earth-measurers (in fact, the French word, *géomètre*, means 'Earth measurer'), and their viewpoint is expanding to encompass the planet as a whole.

From being focused on local pictorial map production, surveying has moved to triangulation networks that tie together regions, nations and continents. There is the potential to knit together every survey, so that they all fit into the national system, which has benefits both ways. Maps can now be used as an information resource that can be measured to retrieve measured information, such as distances and azimuths, in addition to telling a story in a picture.

Mapping as a whole is now much more precise, and as a result sea navigation is improving dramatically, in both simplicity and reliability. It now becomes possible to consider a sea-based empire, and with that, a truly global empire. European nations no longer think in terms of an 'empire' purely within Europe and North Africa; they think globally. Spain created an empire in the New World; France acquired colonies in various places around the world; Britain created a global empire based on dominance of sea trade backed up with dominant sea power.

The changes in the period 1550–1650 literally revolutionized surveying and set it on course to its current situation. In spite all these rapid advances, there are still more to come. However, most of these technologies and techniques augmented processes set in train in 1550–1650. These developments were often quite drastic in the impact, but it tended to be more with detail and the efficiency with which existing processes were done.

In 1650, calculus is almost 50 years in the future. Clocks that are good enough to enable longitude to be determined anywhere are still 130 years away, as are erasers (a vital complement to graphite pencils). Least squares and the metric system are still 150 into the future. Photogrammetry and the telegraph are 200 years away.

Technologies like EDM and GPS are over 300 years away, but they belong to a different era. After the 1550–1650 surveying revolution, surveying evolved for the next 300 years. Developments came more slowly and were developments, rather than sudden change.

Contrasts

How does the surveyor of 1550 compare with the surveyor of 1650? What are their educational needs? What are their mindsets? How do they view the world about them? How do they think of the surveying profession's role in the world?

While we cannot go back and read minds, we can gain something from what surveyors did and wrote. The presence of textbooks indicates that there was a growing body of knowledge, from around 1550, that was becoming progressively more important as surveying progressed.

Surveying was a significant part of the scientific revolution happening at the same time. Surveying changes from artistically descriptive to measurement science oriented as mathematics and technology develop. Surveying enables a global view to be tied to a scientific view, through global measurement.

Surveying moves from being village-based to being planet-oriented. It moves from its basis in drawing to having a foundation in measurement, and to seeing the world as something that can be measured. In the late 1700s, Gauss based much of his work on probability on his own survey measurements, and it is no surprise that the first application of least squares was to surveying.

Moving Forward

From around about 1950, we have seen some significant changes occurring in surveying. While Wild developed the first glass-circled theodolite in the early 1920s, and photogrammetry was quietly developing during the period before World War II, the war stimulated production and distribution of these technologies. From 1950 EDM starts to be developed, and computers start to be used in surveying computations. The rate of theoretical development speeds up, to support the technological developments occurring, and we start to see the creation of dedicated surveying education programs in many places around the world.

The volume of material that needs to be understood by a surveyor keeps growing, as new technology spawns new methods, which provoke new theoretical developments, which in turn lead to new methods and technology, and so on. As a simple example, the observation that the signals from the Sputnik I satellite in 1957 displayed a strong Doppler shift was followed by the observation that the Doppler shift could be used to help determine the satellite's orbit, which in turn led to the realization that if the orbit was known, observing the signal could locate the observer, which led to the TRANSIT satellite navigation system. TRANSIT was found to be very amenable to translocation methods to improve precision for surveying applications, which led to the realization of how to greatly improve results from GPS, which then led to the theoretical understanding of how kinematic GPS could be made to work, which improved GPS productivity and applicability dramatically, when suitable receivers and software made it to market.

So in 2009, what do we see happening around us that might have parallels with the equivalent 1609 period? This might help us think about our future, and to consider multiple possible futures.

Recent Developments

One recent trend is the widespread availability of measurement devices. Once, most measurement devices were the domain of specialists. Engineers tended to worry about distances less than about a foot or so; various trades people, e.g., carpenters, masons, worked with distances up to about 100 feet; and surveyors and astronomers had the rest. Lay people generally worked in the range under 100 feet, and that was pretty much all everyone needed.

Today there are well over 10 million vehicle GPS navigation systems, and a great many more handheld GPS devices, including those in phones. There are over 30 million digital cameras sold each year. In the last quarter of 2008, Apple sold 4.3 million G3 iPhones, which include both GPS and a digital camera. Smart phones with G3 connections have access to cloud computing and storage, which makes them terminals into some very powerful computing resources. In short, measurement technology is now cheap and widely available to anyone who wants it.

Among more specialized systems, the latest vehicle-based scanning systems can collect 1.5 million points per second, using six lasers. LiDAR collects 10,000 to 40,000 points per second, and with 200,000 to 400,000 points per square mile, can scan a square mile in between 5 and 40 seconds, at 10 ft spacing, with 4" to 6" vertical precision for \$100 to \$800 per square mile. The USDA Natural Resources and Conservation Service aims to get a 1m to 1.5 m resolution DEM of all of Wyoming for \$95 per square mile using LiDAR. Digital photogrammetry can produce well over 1,000 points per minute at centimeter-level precision. Airborne scanners, such as the Leica ADS40 can be used to produce precise digital maps at lower cost and in less time than a conventional aerial camera.

We are seeing the rate at which digital data can be collected increase at a rate that is unparalleled. At the end of its run, about 10 years ago, the HP-48GX could store about 500 kb of digital data and could work

as a perfectly good data recorder for more than a day's data collection from most surveying equipment. Its ultimate replacement, the HP-50g, can store 1 Gb of digital data (2,000 times as much), which is about 20 seconds of data collection from the six-laser vehicle-based scanner mentioned in the previous paragraph.

Field data collection systems like scanners tend to have terabyte drive units, as do airborne scanners and digital cameras. The data sets are very large, and beyond the capacity of any individual to work with in a meaningful way. As a consequence, the point cloud is now the data set, and the information we get from the software is a fitted surface. It is worth asking the question: where does such a measurement system end? Is it in the scanner, or does the measurement system include the software that creates the surfaces?

The incremental cost per measured point is rapidly approaching zero, and every measurement technology is shrinking, in both size and price. GPS may well end up being embedded in electronic objects in the same way that digital clocks were embedded in everything: "We've got to have a basic circuit board to work this thing, and there lots of room on it, so what else could we put on it? Why not a digital clock?" And every time we have to change the clocks back or forward...

It is perfectly possible that with the development of increasingly miniaturized measurement devices, that a the 'total station' of 2020 AD is the size of a cell phone, carries measurement devices to allow high-precision 3-D positioning and orientation, as well as distance measurements and photographic capabilities. With a high-speed link to the computing cloud, the device would act as a terminal to computational resources with hundreds of gigaflops and petabytes of storage (in effect, almost unlimited computing power and storage). With the ability to link to high-resolution satellite imagery and LiDAR DEMs, it will become possible to produce extremely detailed survey data in very short periods of time, with relatively little effort or expertise. Measurement will become something that anyone can do.

So, who has 'control' of spatial measurement in 2009? While some measurements are still the preserve of surveyors, more correctly this is 'measurement circumstances.' Everyone has control of spatial measurement, and at the same time, no one does. But we have to ask ourselves, what does 'control' mean? Does having 'control' matter? Is 'control' over spatial measurement even possible today?

Ubiquitous spatial measurement capability means that there is lower demand for professional services and less recognition of specialist skills in spatial measurement.

We can expect to see a great many changes in how surveyors work, in how they relate to the rest of society, and the role of surveying in the community. It is important that we get these things right! As was pointed out in relation to the Industrial Revolution: "Social relations are closely bound up with productive forces. In acquiring new productive forces, men change their mode of production; and in changing their mode of production, in changing their way of earning their living, they change all their social relations." (Marx, 1846)

"We are the Measurement Experts"

This is sometimes advanced as a definition of surveying and surveyors. While surveyors need to be measurement experts, this is almost a given. The question is what lies beyond the measurement expertise.

Using the idea of being measurement experts is a dead-end as a professional model. With measurement becoming something anybody can do, there is no real advantage to being an expert in measurement, unless it can be used for some other critical purpose.

Similarly, measurement expertise is a dead-end as an educational model. We need a foundation in measurement expertise, but surveying education needs to focus on what lies beyond that expertise.

An analogous educational model may be that for medical specialists. They all have to obtain a medical degree and the requisite residence experience, and on that foundation can specialize. So we can expect that all surveyors are measurement experts; but it is what they have beyond that level of expertise that makes them a surveyor. What constitutes the ‘beyond’ will be the basis for debate over curriculum.

Employment Trends

In the information sector of the economy, the number of people employed there appeared to peak in the 1980s. At this point, information technology started to reduce the number of people employed in that sector. In the case of the primary (agricultural and mining) and secondary (manufacturing) sectors of the economy, the output of the sectors lost no value, possibly even increasing it, while employment levels declined. The reductions came about through efficiency and automation, and largely took place from the bottom: the lower-skills jobs disappeared first.

The same is the case in the information sector. We are seeing a decline in data entry people, as scanning takes over. There are fewer bank tellers, typists are much less common, and survey crews have been shrinking steadily for years. Information collection, manipulation, management and dissemination are being done by everyone now: you work the ATM, rather than deal with a bank teller; you scan your own groceries, bag them and pay by card. We are all the unskilled workers in the information sector, but we are either volunteers, or paying for the privilege!

Meanwhile, job requirements keep expanding and technological change gets faster. In most information sector positions, you need to have some kind of qualification to get a job. As was the case in the primary and secondary sectors, the criteria for entry keep getting higher, more expensive and more stringent. There are very few unskilled positions in these sectors, and those that exist tend to be providing basic services to the core business of the organization (e.g., custodial services), rather than being involved in the core business itself.

The Information Cycle

One way to think about information is to look at the way it moves around a cycle, as in the figure below.

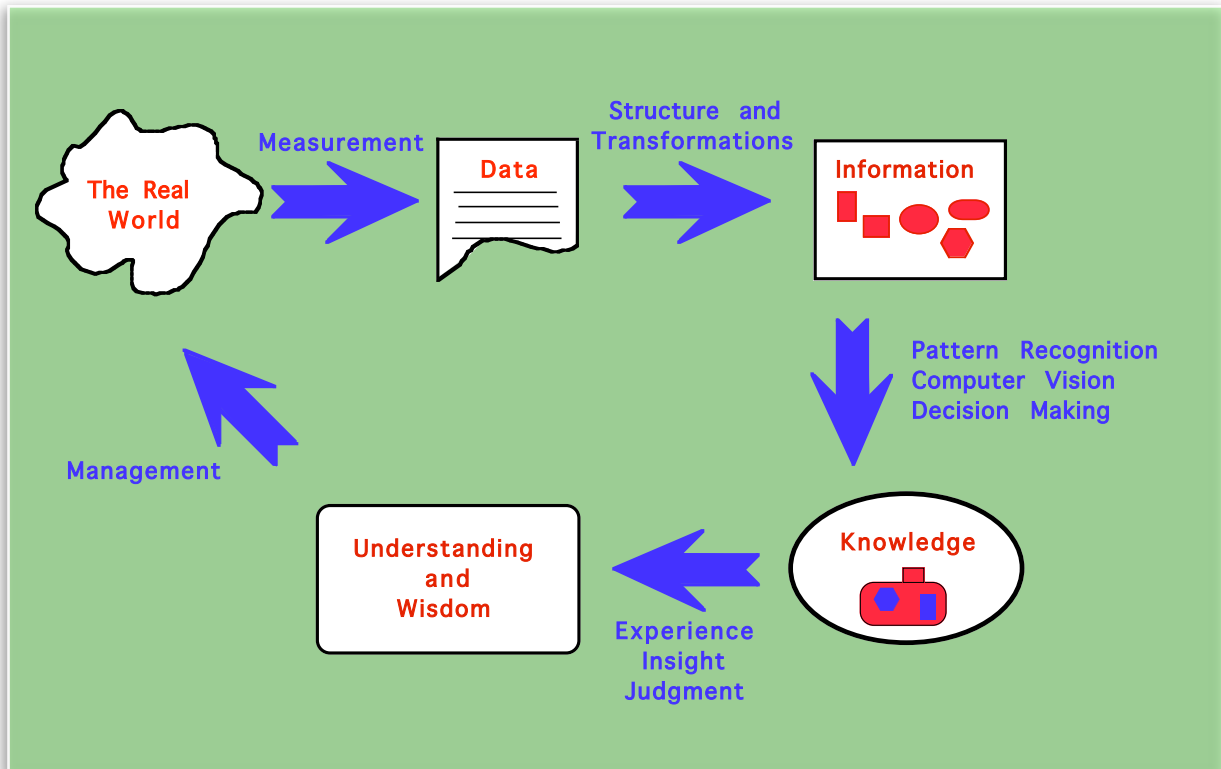
We gather data from the real world, in the case of surveyors by actual measurement. We then structure and transform this data into information. This would be a map of some description in the surveying case.

Pattern recognition, which may not be the best term, is the next stage. Surveyors really only go there when dealing with problems in boundary determination, or other complex problems, but it is something that we need to deal with, as it is becoming increasingly automated. Photogrammetric scene analysis, data mining, and certain aspects of decision-making and computer vision are becoming more common with spatial information, and should be something that surveyors deal with, rather than hand off.

Pattern recognition allows the creation of knowledge about aspects of the real world, and when this can be combined with experience, insight and judgment, we may attain understanding and wisdom. This allows us to manage the real world, hopefully in a wise manner. This is the nature of the cycle.

An example of this cycle in action, albeit rather abbreviated, was the support team for the Mars Rovers. The rover would upload each day's and send it to Earth, where it was automatically placed on the JPL servers. This was downloaded by the group at OSU working on this, who had a series of automated

systems to extract as much as they could from these data. They would map the rover's progress, calibrate its wheel rotation data, extend its map of the surrounding area, try to pick out interesting objects, and provide location data along the path for other scientific teams. All this information, combined with the existing experience with the rover, provided knowledge about the rover's operation and helped in managing what to do next. All this had to be done overnight, so that decisions could be made at JPL and the general instructions for the next day could be uploaded to the rover.



The questions we need to ask are: where in the cycle should we be working? and what skills will we need to work there? The answers will determine the nature of the profession, as well as the nature of the education required to enter the profession.

Another example of understanding the information cycle is as follows. A survey firm that specialized in high-precision work, especially in support of the steel industry, was asked by the engineers at one steel plant to come and measure a trench they had dug. The trench was within a building, and they wanted to place a pipe (with associated structure) in the trench. They asked that the survey company come and give them a number of cross-sections of the trench, so that they could see how the pipe might fit.

The survey firm owner asked them more about the nature of the problem, and ascertained that they needed more than the cross-sections (which was all they had asked for). He asked if they had a CAD file of the pipe and structure that they could send him, and sent a crew with a laser scanner to do the data collection. The laser scanner mapped the trench with a very fine mesh and the firm produced a 3-D model. This was combined with the 3-D model of the pipe and structure, and they produced a movie showing the pipe being placed in the trench, at which point the places that needed removed showed up in different colors. Of course, volume measurements and detailed locations of the parts needing modification were also produced.

The engineers were blown away! They didn't know you could move things in AutoCAD. The product they received gave them the answer to their actual problem far better than they could conceive that it could be answered, in part because their surveying mindset was still in a much older 'cross-section' mode, and they presumed that what they knew about surveying was all there was to it.

The moral of this story is that you need to go beyond the client's self-defined expectation. Don't give them the data and measurements in the form of a map. Solve their spatial problem.

This requires that you move into the client's knowledge domain and understand their real needs, not what they think they need. It also means that you adapt or engineer your information, or your information collection, to meet their needs. To do this, multi-disciplinary skills and teams are required.

We are our Information Products, not our Services

It has been suggested that surveying is a service industry or discipline. I would argue that it is an information industry or discipline, and always has been, for the following reasons.

Services are, by definition, transitory: the service doesn't last much beyond the time of service. You buy a meal or a haircut or pay to get your house cleaned, and not long afterwards you have to do it again. In ancient times, the temple priest would consult with the gods to give you advice for your current situation, but different situations needed different advice. But surveying is not like that.

Surveying produces a very definite product, which lasts beyond the time of the service provided. Since the product is primarily information, it may be intangible, but like all information it lasts. When a surveyor determines the location of a boundary, the information product is not the monuments in the ground, nor even the plat of the survey, but the relationship between the two. This relationship can survive the destruction of the ground marks, and even that of the original plat. Further, this information can be duplicated and disseminated without subtracting from the original, an important characteristic of information. Information is also very difficult to destroy, although its intangible nature makes it easy to overlook.

More broadly, a map is a very similar product. It is an abstract representation of the real world; measurement data that have been selected, structured, ordered and presented to deal with a specific problem or need. While selling the map to the client is a service, the product itself is the information in the map.

As an example, the key task of the ancient Egyptian surveyors was to re-establish field boundaries after the annual Nile flood had obliterated them, and so re-create the original relationships of those boundaries, despite the destruction of their tangible representations. The boundary information, the information product, continued to exist; the service was replacing the boundary markers each year.

Surveying is by far the oldest information profession, discipline or industry¹. We now live in an 'information society,' and operate in an 'information economy.' The world has finally caught up. But what do we mean by 'information society' and 'information economy'?

Essentially, an 'information society' and 'information economy' operate primarily through the use of 'tokens.' Rather than deal with real objects, we create 'tokens' that are used as representations of whatever it is we want to deal with. In many cases, this is very useful. We don't trade land, we trade deeds and mortgage documents. We don't buy and sell what we need using bullion or produce, we

¹ By contrast, the 'oldest profession' is very much a service industry, in every sense of the word.

exchanges pieces of paper or use electronic tokens via plastic cards. On the downside, we often don't think about individual people, but work with social security numbers and statistical aggregates representing the 'average person.' When confronted with an actual individual, we often work with tokens of their individual totality: their psychological, behavioral, political or consumerist characteristics. Stereotypes are another form of token.

So the information that surveying produces is a token. That token may be the map or the plat or something similar. Since there is usually some spatial measurement involved in developing this information, and spatial measurement is now available to all, there is the risk of surveying becoming irrelevant in an information environment (which will include the information society and information economy).

Surveying fits neatly into the information sector of the economy for several other reasons. For many years, employment levels have been declining. At the same time, entry-level requirements are rising, and job requirements are expanding, as more technology is deployed.

As an information industry, we find that adding value to data is profitable, but measuring it isn't. The incremental cost of measurement is heading to zero, and almost anyone can measure things, so measurement is becoming something of a commodity. Commodities tend to move to negligible profitability over time. For example, the price of wheat is such that there is not a large profit margin in it, and the same goes with coffee beans. But Panera and Starbucks generally do quite nicely, because they add value to the basic commodity. Panera does bread and related products with consistent quality and flair, and you go to Starbucks for the ambience. It has been argued that other coffee houses (and even Dunkin' Donuts) have better coffee, but clearly a lot of people will pay a significant premium for the added value, even if that value is largely intangible.

Come the Revolutions, Comrades...

Surveying is clearly in the midst of another revolution, probably as dislocating as the one 1550–1650. If such a revolution takes a century to work through, we are right in the middle of it! Which means that there is plenty more to come.

There is a larger information revolution happening as well, as we shift to an information society (we are well into having an information economy). Can we make this transition successfully? While surveying is an information industry of long standing, can we make the shift to a world we are no longer a rarity in dealing with information? How do we make these shifts in the profession?

One important consideration is education: how do we prepare the next generation of surveyors to both carry the torch and move to the future? To do this we need to examine the education side of the process.

Education Issues

All US surveying programs are at state universities. Almost all state universities are short on funds, not just now, but almost chronically. However, there seems to be remarkably little imagination used to see about raising funds. It is always easier to cut the costs you can see, rather than chase the income you don't currently have.

Within universities, surveying programs are often not popular. Many people don't understand such programs, their importance to society, nor the role of surveying in society. To be fair, many surveyors aren't very sure about these. Surveying programs have high costs: it takes about a million dollars to create one from scratch, because of the equipment requirements. Surveying programs often have relatively low

enrolments, especially compared to their costs. They tend to produce very little research income, because there isn't a lot to be obtained.

Surveying programs are difficult to staff well. There are very few US surveyors with PhDs who are prepared to become faculty. Many US surveying faculty come from overseas, but it seems odd that a country of about 300 million people can produce only about a dozen surveying faculty with PhDs. There are probably more in Australia, and maybe even in New Zealand (which has about 1% of the US population).

There have been three surveying programs in the US that have undergone splits in recent years: Maine, Florida and Ohio State. In each case the apparent causes were different, but the way the faculty tended to divide was that those who had a surveying background (i.e., an undergraduate degree in surveying) tended to go one way as a group, while those who had come into the discipline from other fields, i.e., through specialization in some specific area, tended to go the other way as a group. This led to the splits largely dividing the generalists (the surveyors) from the specialists. These kinds of splits are often over turf issues, and lead to 'silos' of expertise. A more current example is CaGIS (specialists in cartography and GIS) voting to leave ACSM (the generalist body), albeit by a narrow vote. Even the 'separating-out' of the Member Organizations within ACSM is another example of specialization taking precedence of a more general viewpoint. This will lead to significant difficulties in education in trying to get surveyors into faculty positions, as well as looking to develop multi-disciplinary teams and groups. You can't be multi-disciplinary in a silo, and increasing specialization without equivalent generalization is a recipe for disaster. The medical and legal professions avoid this, and we have to avoid the same trap.

Students no longer have the same approach to their education as was the case only a few decades ago. Very few are truly full-time students, dedicating their lives to full-time study (and whatever else students got up to) for four years. Most have some time working each week. So there is limited time available to focus on the educational program, and the way that students progress through the programs is now highly individualistic. Few will complete a degree in exactly four years, and in the prescribed manner. Individualized programs are the norm, weaving education through a busy life. Distance education is increasing, so that education can be done concurrently with work.

Economic necessities mean that many students try to rush through their program, graduate and get employment, as they have student loans to repay, and had relatively scarce financial resources when they started college. Unfortunately, the rush to get through the minimal program to get a job means that students tend to short-change their future (and that of the profession) to get through present difficulties. That MSPS devotes such effort to funding scholarships, and is able to disburse such significant funds to so many students is an indication that the profession recognizes the critical importance of education, and is trying to alleviate the financial burden. MSPS may well lead the nation in its support of education.

The nature of students these days seem to be to regard education as some odd abstraction of reality that is tolerated in order to get the meal ticket at the end. The passive nature of education, the simplification and superficiality of much of what is presented to them, from elementary school on, tends to disconnect them from the education process. By the time they get to college, most students have figured out how to work the system to get what they *want* (the grade), and their approach has become almost automatic. But the superficiality forced into them by the educational system means they never really consider what they *need* from education, beyond the meal ticket. So the education system is actually seriously under-utilized by its main users, who simply have no idea of what they need (short term or long term) that the education system can provide. The superficiality continues after graduation, when the ultimate examples of superficiality in professional life today, the NCEES examinations, are administered to determine if they are superficially professionally competent.

The intersection of rapidly advancing technology and education raises some important issues. As measurement changes, for surveyors and everyone, there may be questions raised about the role of technicians in the profession and industry, as well as the role of 2-year programs. If we see a changing pattern of employment, we may need to re-think how this operates. However, other industries' histories suggest that entry-level requirements at the technical level will rise, and there may need to be changes in the way that 2-year programs operate. There will definitely need to be changes in how 4-year programs operate. However, there is still some time before these changes will have a significant impact.

With the ability to do computing anywhere, via cloud computing, together with distance education, the question has to be asked about where information processing and education might take place. If education is being delivered on-line, then the educator, as much as the students, can be remote from the campus. Similarly, why does surveying information processing have to take place locally? Off-shoring is a definite possibility with both these activities.

Recruitment Issues

Surveying has poor 'brand recognition,' especially given the important role that surveying plays in the economic and social fabric of nations. There are many reasons for this. One is that there is deep confusion within the surveying profession over why the profession exists. Another is that there is no truly agreed definition of what constitutes 'surveying,' and particularly what is and isn't surveying. US surveying has no equivalent to Len Beadell, the famous Australian surveyor who quietly inspired many Australian kids to look favorably on surveying as an interesting and adventurous career. This was helped greatly by the higher standing of surveyors in the general community.

Similarly, US surveying has no one like James Herriot, and no equivalent to legal and medical dramas on TV, to portray the profession in a strong light. It might be worth the profession's while to fund a really good film adaptation of Len Beadell's life story, or a composite of several surveyors' careers.

The profession has some role model issues. There are very few female students, despite women making up about 50% of the population, and about 50% or more of the general student population. Surveying has very few minority students, despite them being about 30% of the population, and very few dyslexic students, even though there may be up to 20% of the population with such problems. We are tending to ignore or are missing at least 70% of the potential student pool. This drastically reduces the profession's potential to recruit the 'best and brightest.' We need to find ways to get the message out to all these potential students, and we need to have a sound, united story to tell them.

Definition Issues

Herbert Simon, the Nobel laureate, economist and system theorist, noted in 1996 that "The meaning of 'knowing' has shifted from being able to remember and repeat information to being able to find and use it." How are we shifting our ideas about 'knowing,' both in education and the profession?

ABET, which is a national body that accredits engineering, surveying and similar programs, redefined its accreditation so that it now focuses very much on outputs and the 'find and use' approach to knowing. many surveying programs are ABET-accredited, through one of three accreditation commissions.

NCEES is the body that develops examinations for professional registration in surveying, engineering and related areas. NCEES's approach to 'knowing' is purely 'remember and repeat.' Which is the model we want for surveying, now and in the future, as an information profession?

This difference between ABET and NCEES reveals to two totally different interpretations of what surveying is. Is it any surprise that the profession is not sure itself, and cannot project a credible idea of what it is to potential recruits?

The surveying profession is also uncertain what it means by 'profession.' There has been a fair amount of debate about this in the professional publications, but we can say that a profession is characterized by:

- systematized theoretical knowledge in a specific field, with demonstrated proficiency in that area, based on extensive education beyond the community norm;
- ethical standards that are reasonably explicit;
- professional closure, i.e., entry to the profession is restricted to those with the qualifications;
- indeterminacy of knowledge, because a significant proportion is based on experience, rather than theoretical knowledge; and
- public service and altruism.

If surveyors are to be measurement experts in a time where measurement is increasingly complex, the level of education has to be raised. If the profession wants to be able to add value to its products, it has to be able to work closely with other professions, which means that its members need to have equivalent educational standing, as well as some background in other professions.

Skills Required

Part of the purpose of a college education is to prepare the graduate for a productive professional life to the coming 40 years. This means that the education program has to focus on the kinds of skills that will be needed over the coming several decades. Technology has a half-life of about five to seven years. This means that after about five to seven years, about half the technology now in use will be obsolete. Theory, on the other hand, has a half-life of about 15 to 20 years. This means that over a 40 year period, about 75% of the theory that exists when a student graduates will have become obsolete by the time they retire. The problem for educational programs is providing a foundation for what is likely to come in the future, using what's available today. At the same time, there is a need to work on breadth and possibilities, rather than the one single path through the educational process.

The important points upon which to focus are on professional skills ahead of simple technical skills. Measurement is becoming progressively simple, but understanding it isn't, so a sound foundation in measurement theory is critical. However, this has to be based on over-arching concepts, not on a lot of highly specific and disconnected detail. There needs to be a focus on decision-making processes and problem-solving, together with the background to understand other professional's problems and spatial information needs. It is critical that graduates are able to support decision-making processes with a very wide range of spatial information, and to become an important part of the decision process themselves, in support of their information.

And After College

A college education is a first step on the road to a professional career. Because a profession involves knowledge based on extensive experience, it is incumbent upon professions to strongly support the post-graduation development of their newest recruits. There is a need for a 'professional experience curriculum' for after college, so that a new professional can gain the right experience as effectively and efficiently as possible. MnDOT has such a system for its new surveyors, and perhaps we need to look at how we can implement something similar across the profession.

There is also a need for continuing education, so the professionals can stay up-to-date as the technology continues to flood us, and the surveying revolution of 1950–2050(?) continues. ‘Lifelong learning’ is getting a bit hackneyed, but it is a critical issue for all professionals.

What Is To Be Done

There are major choices ahead of us as a profession, and as educators. Neither the profession nor the education sector of the profession can work in isolation from the other, not expect to survive without the other.

The primary issue to resolve is what the profession is about, why it exists, what it stands for , and how it should adapt to the revolutionary changes happening around it. If we can’t agree on this, at least to some extent, it is impossible to educate the next generation of professionals.

If we can’t agree on where we are going, we will end up somewhere else, and it may not be pretty.

So we need to develop a professional dialog about these many issues, so that we can place our profession and ourselves in the best position for the future.