SURVEYING EDUCATION AND TECHNOLOGY: WHO'S ZOOMING WHO

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ABSTRACT

It is clear that technological changes are making a significant impact upon the surveying and mapping profession. What is now common practice becomes outdated in only a few years. The impact of technology and instrumentation upon surveying and mapping education will be explored. This paper will begin by defining the role of higher education in the surveying and mapping profession. The assertion here is that the historical role of higher education is on the brink of being compromised. This happens when technology becomes paramount and theoretical concepts become subservient to the tools. What we are experiencing is a nudge away from education towards training. In our stampede to get the newest and brightest, programs have embraced unique "partnerships". The fear here is the "small print" in the agreement and the quid-pro-quo that may be implied.

A decade ago, attending a workshop on how to use a total station was deemed to be technician training. In some circles today it is referred to as continuing education. Moreover, the din against the necessity for a degree to become licensed is often based, in part, on the perception of a lack of technical skills graduates may exhibit in the workplace. There is also an inclination within the profession to provide education to "the masses". The result may be one where educational programs become diluted and even devoid of theory where tools and techniques replace conceptual issues.

Education has been under fire for a number of years. There are those who call for a return to the basics – "reading, riting, rithmatic". Surveying educators should not abandon the new and go back to what we did in the past. But, they have to be careful about how to embrace this new technology. Understanding how a laser scanner works, its limitations and advantages, and its production capabilities are important. Knowing what button to push to begin the measurement process or icon to click in order to process the data is less important, especially since this technology has a shorter life cycle than the typical college student's tenure in a baccalaureate surveying program.

INTRODUCTION

Surveying has been described in many different ways, but one of the simplest is the art, science and technology of making measurements of phenomenon on, above and below the earth's surface and setting out points in their desired location. As one can see, technology, at least as used here, is intrinsically linked to the surveying/geomatics profession.

Technology has played an important role in surveying education, from the emergence of summer survey camps to requirements of internships in order to finish a degree in surveying. One can also argue that it has been codified within our licensing laws. This idea is based on the guild or apprenticeship principle that allows one to "pass through the ranks" along the road to licensure. Even in states where education is a requirement for licensure, the laws require additional experience before being approved to take the exam. Some laws are specific in that the applicant must have both field and office experience. The premise is that a working knowledge of the tools is expected for future professional surveyors. Indeed, the surveyor in his/her role as a professional needs to be cognizant of the tools available to complete a mapping project.

The idea of incorporating technology into a surveying curriculum is not even a debatable item, although there have been individuals in the past who have argued that equipment "gets in the way" of a surveying education. These views are in a minority since some practical applications are generally acknowledged as being important in the student's development. As one looks at the constituencies that educational programs are trying to serve, the question is never do we incorporate technology but rather to what degree of inclusion does a program take in technology. What we see in the surveying education landscape are many different models of inclusion. No one model is necessarily better than others. Instead, we must understand the nature of the incorporation of technology and be aware of how that integration affects the college graduate.

TRAINING VERSUS EDUCATION

Within the surveying/geomatics educational community, there are many different types of educational programs. This paper is concerned only with baccalaureate degree programs. It is assumed the graduate degrees are theoretical-based while those that are less than four years are technical. At one level, we find programs that are accredited by some national accreditation agency, such as the Accreditation Board for Engineering and Technology (ABET). Accreditation has both advantages and disadvantages. In the past, the rigidity of criteria led to an almost homogeneity of programs where ingenuity was often stifled. This occurred because of the heavy reliance on "bean counting" to ensure certain courses or topical areas were present in every program. But today, especially with the outcomes-based assessment instruments used in program evaluation, accreditation could foster experimentation as programs find their niche. As long as outcomes have been identified, can be measured, and are used in program assessment, programs are pretty free to devise the program as they see fit. ABET consists of some 30 professional and technical societies and these groups work with ABET in establishing program criteria. The American Congress on Surveying and Mapping (ACSM) and the American Society of Civil Engineers (ASCE) work together to develop minimum criteria for surveying programs. These program criteria ensure that some basic core competencies are included in each accredited program.

One of the significant findings that bode well for surveying education has been the results of the NCEES (National Council of Examiners for Engineering and Surveying) test results on the

Fundamentals of Surveying exam. Over the last 10 testing periods (from October 2000 to April 2005) test takers with a 4-year degree in surveying or related area have a significantly higher success rate than other test takers [Dekle, 2005]. It is clear that as the exam has changed to a knowledge-based format in 1999 that a baccalaureate degree is one good indicator of success. For those without any degree, the success rate is lower than the average of all examinees. In general, test takers with a 2-year degree have a pass-rate slightly below the average for all test takers, but it is unclear whether the difference is statistically significant.

Some may have seen results that show success rate differences between baccalaureate degree programs that are accredited and those that are not accredited. No conclusions can be drawn from these observations for a couple of reasons. First, NCEES has found some errors in reporting accreditation status in recent years. Some programs have been counted as accredited that are no longer accredited while some programs were identified as non-accredited that have recently gained accreditation. Second, before a program can receive accreditation it must have graduates of that program. This is particularly important as ABET moves to the outcomes-based performance criteria. Thus, there are good programs that are not accredited but moving in that direction and it is unfair to draw any conclusions about their quality during the intervening period.

NCEES does not show reporting statistics by school any more. It is not their mandate to evaluate performance of individual educational institutions. Moreover, there are too many factors that can make the results volatile and misleading. Nonetheless, some reports have shown that performance in not uniform amongst all schools. Why does this apparent discrepancy exist? It is clear that many variables exist, but a cursory look at the different programs within the U.S. shows some issues exist that may affect the success rate.

First, some programs (this is most prevalent at the Associate Degree level) have a technical focus where courses are geared towards the practitioner’s needs. This conclusion was reached by looking at various program media, course descriptions and the identification of prerequisites. As an example, there are courses dealing with least squares adjustment without any college-level mathematics prerequisite. While it is true that course descriptions are notorious for their vagueness and hyperbole, any treatment of least squares without calculus is superficial. On the flip side, teaching the student to use a particular least squares adjustment program can be accomplished with little mathematic fanfare.

The second issue relates to the credentials of the faculty. Again, this is a double-edged sword. Credentialed faculty without practical experience may have a difficult time relating theory to practical applications. As an example, it may seem dichotomous to some raised on accuracy and precision to accept the position of a boundary monument as accurate, and even absolute, despite the fact that recorded distances and directions to and from the monument are not the same as measurements collected in the field survey. At the same time, instructors who do not have graduate degrees in surveying and mapping or related fields sometimes do not appreciate the breadth of the profession. Without an understanding of the fringe areas in the profession, there is a tendency to gravitate towards individual comfort levels.

Finally, program development has a huge imprint on the degree option. While some older programs may have grown from engineering programs, most created in the last three decades have been created because surveyors within the state have been involved and pushed for these educational programs. A curriculum is developed as a team effort consisting of forward looking professionals and academics (or sometimes an academic consultant). It is not uncommon to find these programs being established to address a legislative mandate such as a new requirement of having a degree for licensure. This author believes that this is the first step in a metamorphosis. Just as the larva is transformed to the butterfly, educational programs grow and mature, or they die. Creating a curriculum through teams like this inherently skews the content towards current practices.

Within ABET, there are four different accreditation commissions and surveying programs will fall within one of three of these commissions. In general, an accredited program will reside in either the Engineering Accreditation Commission (EAC), Applied Science Accreditation Commission (ASAC) or Technology Accreditation Commission (TAC). Currently there are 8 surveying/geomatics programs accredited by EAC, 7 accredited through ASAC, and 8 programs with TAC accreditation[1]. Not all of the TAC-accredited programs are at the baccalaureate level.

There are a large number of other programs throughout the country that are not accredited for various reasons. These can be either baccalaureate programs, associate degree programs, certificate programs, or surveying/geomatics concentrations within some other department. Besides these degree option, there are also a plethora of other educational training opportunities that are available to the profession. These latter programs, and some of those leading to degree/certification can be characterized as technical training. These types of programs are very different than education.

The goal of higher education is to provide the student with the tools to solve problems they will encounter. They are taught to analyze and dissect problems, develop viable scenarios to solve the problem, evaluate the results and adjust the measurements if the findings are inconsistent with the reality, and to present a professional product to the client. The product should meet the needs of the client and it should be done in the most economical means possible while still making a profit for the employer. Training, on the other hand, attempts to show the student how to operate the tools – how to set an instrument up for measurement or what capabilities a particular software may have. Any theoretical treatment is ancillary and used only to stress concepts on how the tool operates. A diagram showing the geoid separation may be used to explain why the orthometric height is different than the ellipsoidal height, but any discussion on the theoretical concepts of heights is left out of the training program.

There is a need for both education and training, but the constituency that each aims to serve is different. In general, training is geared towards the technician, the individual who will be generating the actual work product. They generally have a narrow focus of activity. In the past, they were the rod person, instrument person, stereoplotter operator, CAD draftsperson, and to some degree the survey crew chief. They received directions from their supervisor and performed the task laid out for them. Education is centered on the professional who should have a vision of the larger picture. They have a knowledge of the technology, but maybe it is only

[1] Data obtained from ABET web site, www.abet.org, accessed 6/01/05.

superficial. Instead of being able to physically operate equipment, they understand the capabilities and limitations of the tools. They select the tools to use for the data collection and then dispatch the technician to perform the task.

The processes of education and training are also intrinsically different. Technical training is task oriented by its nature. Because of this, retraining is required once new technologies are introduced into the work environment. Successful businesses will often have in-house training periods set aside during the month to bring employees together for training purposes. This may include training on new equipment to safety training, all of which is important for the success of the company. Education should be goal oriented in that the individual develops a plan, allocates resources, executes the survey, and performs the quality control to confirm that the product has meet the expectations and needs of the client.

What is alarming is the growing development of programs with a concentration of "educating" students to the tools in surveying/geomatics. For example, right now the main industry buzz words are global positioning system (GPS) and GIS. What we are beginning to see are degree offerings in GIS/GPS. The development of GIS and GPS are changing our whole national fabric and they are important in many different industries/professions. But, they are tools which are becoming as ubiquitous as the ignition in an automobile. GPS, as an example, is being used in a myriad of applications from monitoring crustal deformation to keeping track of prisoners on work release. As an analogy, the level of understanding of electricity and electrical systems is different from the electrical engineer designing the electrical system for the Space Shuttle to the electrician who installs the electrical system in a house to the consumer who flips the light switch. So to does the degree of theoretical understanding vary with the tools like GPS and digital photogrammetric systems.

To the best of this author's knowledge, these types of programs are currently found at the associate degree or certificate level, although there have been some descriptions of baccalaureate programs that come close to embracing this training approach. The level of mathematics background in these programs is generally lower than one would find in conventional surveying baccalaureate programs. It appears that the treatment in the theory is at a technical level and the students are receiving a technician degree, whether it is a 2-year or 4-year duration.

CONSTITUENT PERCEPTIONS/NEEDS

When reading the trade magazines, and to a lesser degree professional journals, it is no wonder that many educators feel that they suffer from "post traumatic stress disorder". They hear some "nuts-and-bolts" surveyors demean the need for education to become licensed. Some believe that this requirement is a grand conspiracy in order to either restrict the number of entrants into the profession or as a job security program for teachers. Graduates are belittled because they may not be able to "hit the ground running". It is no wonder that they cannot be productive from day one since educators have filled their heads with worthless and useless knowledge that has no practical application in the real world.

These kinds of beliefs are indicative of the differences in perception in outcomes between the educator and the constituents that we are trying to serve. Many feel that they have an inherent right to licensure because of longevity. This is the guild approach to professional attainment where an individual learned their craft from established artisans. On-the-job training, many contend, has served the profession admirably over the years and it should be sufficient for licensure today. The fact is that exhibiting excellence as a technician does not automatically qualify one for professional licensure. The surveying and mapping community must recognize that having a cadre of competent technicians is essential for the continued viability of the profession. Recognition should be displayed both in listening to the opinions that technicians may have to more meaningful compensation for services. Respect is not a value automatically conferred upon an individual by passing a test. Instead, it is earned by hard work, honesty, diligence to detail, and treatment of others.

A corollary argument to on-the-job training that has been presented by some is that the licensing exam is not based upon what the normal surveyor does, but reflects information learned in colleges and universities. This argument is true in that the exams have migrated to a knowledge-based format. But, arguably, the exam still contains a wealth of questions that are based on practice and not knowledge learned in school. The argument has gone to the extreme where a few individuals have argued against the inclusion of certain topics, such as GPS, because their company does not use this type of equipment. To carry this line of reasoning to its natural conclusion, exams would have to be tailored to different types of companies, depending on their normal scope of work. It also reflects the perception of the test-taker as to what constitutes education.

The difference between education and training is evident in many of the continuing educational courses we see offered today. A large proportion of these courses are technical training, teaching how to use a specific instrument or software. A course on how use a particular software to perform a least squares adjustment with state plane coordinates is considered more important than understanding the theory of map projections and the statistical foundation of the least squares method. One is practical and the other esoteric. Practicality is equated to education while the mysterious is deemed trivial and unimportant in daily practice.

Many educators maintain, and this author concurs, that an employer should hire college graduates for what they want 3-6 months from the date of hire. For example, if they need a crew chief then the college graduate should be prepared to act in that capacity in that 3-6 month time frame. This is applicable for graduates who are beginning to work for a company for the first time. For those students who have interned with the company before graduation, this time frame may be accelerated, depending on past experiences. It is the contention of many educators that the degree educates the graduate for what they may encounter 3-5 years after graduation and not for what they will find upon leaving the academy. The role of internships is to prepare the graduate for work upon graduation.

INCORPORATING TECHNOLOGY INTO THE CURRICULUM

As indicated earlier, there have been some educators who held the belief that technology or instrumentation may get in the way of education. There are two aspects of this philosophy. First, the student is often more enamored about how the instrument works than on the theoretical concepts of what the instrument measures. Second, teachers may abdicate their educational responsibility through benign neglect by giving the students what they want instead of fighting the battle of encouraging the student to learn the concepts. There are so many different things tugging at the professor's robes like publications, research, advising, professional obligations, etc. What is the harm in relaxing the educational requirements a little? Additionally, some faculty believe that the instructor's responsibilities involve presenting just that information students need to solve the problem. For example, the geodetic problem of computing the space rectangular coordinates given the latitude, longitude and height is straightforward. The inverse problem is not simple for the computation of the latitude, and to some degree the height. Therefore, geodesists through the ages have devised a myriad of approaches to solve this inverse problem. Some professors may show the formulas to solve the problem using one approach while others may show a few different methods with the underlying theory. Thus one can see that there is a lot of disparity in the treatment of the subject matter. Both approaches, along with the many different scenarios between the extremes, have merit. This author contends that presenting a series of steps to solve the problem without the theoretical underpinning is dangerous. Students do not understand the assumptions made to arrive at the answer. The solution becomes a simple recipe or "black box" operation. "The greatest danger in modern technology isn't that machines will begin to think like people, but that people will begin to think like machines" (anonymous quote).

Technology is very important and what the profession is facing in the future is the integration of technologies. Thus, the graduate of the future needs to have a better understanding of these technologies, some of which are not even developed today. Some prognosticators believe that the trend in the future is data fusion. In some sense surveyors have been doing this from the beginning. A boundary survey requires looking at the evidence in the field gathered from measurements and legal research and arriving at a conclusion that can be defended. Thus, new and old measurements, oftentimes inconsistent, are brought together and evaluated. With some of the newer technologies, the process is similar, but the volume of data will be significantly greater. For example, we can now collect upwards of 100,000 samples from laser altimetry/lidar data. As we begin to merge this new surface data with archival digital terrain model (DTM) data, we must again resolve discontinuities that may be found when matching the two data sources. An understanding of laser altimetry and DTM data is a prerequisite in this evaluative process.

Using mobile mapping systems, like laser altimetry, will present new challenges to educators. If one looks at a lidar system, we see that it is made up of three components: a laser scanner, GPS, and an inertial measurement unit (IMU). A fourth component, a timing system, is used to relate the measurement epoch from each of the measurements of the individual components. The professional needs to be able to understand how each measures separately and then how the system behaves when all of the components are tied together into a system. It can be easily seen that other sensors could be interchanged with, or added to, the lidar configuration. The professional is concerned with the relationship between sensors, the transformations required to bring the different measurement frames together, and other issues that will help yield acceptable results for the desired project. The technician will undertake the survey and, hopefully, will collect all of the necessary data for subsequent processing.

In a typical surveying program, students are exposed to a number of different instruments and software systems. In many cases, the software holdings are more diverse than most, if not all, of the other programs within a college or university. For example, students may be required to use software involving CAD (oftentimes AutoCAD), field-to-finish surveying processing of total station data (this may run as an add-on to AutoCAD as an example), digital leveling processing, GPS processing, GIS processing, remote sensing processing and softcopy photogrammetry. If a program has a laser scanner, add its processing software as well. Most programs require a programming language like Visual Basic or C++ and/or symbolic mathematics software. Finally, a program needs to add ancillary software like word processing, spreadsheets, data base management and project management software. This is a formable task for both students and faculty alike. To train the students on how to use these software packages educators have been forced to nudge out other topics, often times that involves theory. The danger here is that the output is a graduate with better technical skills gained at the expense of understanding concepts.

IMPACT OF TECHNOLOGY IN EDUCATION

Incorporation of technology has a number of advantages that makes it, at a minimum, palatable and, at the other extreme, exciting. Educators at all levels have used practice and rote to help students learn concepts. The educator John Saxon differentiates between practice and drills. The former is "thoughtful, considered repetition" while the latter is "blind, mindless repetition"[2]. Technology has the effect of automating these tasks, a beneficial outcome for drills but a potential problem for practice. Incorporating technology in the classroom will let the students learn what is happening in the profession today. In this sense it will better prepare the graduate for what they will encounter upon graduation. This may help improve the marketability of the graduates.

In the past, meaningful data collection has been a tedious and sometimes arduous task. Trying to fit laboratory experiences into neatly packets of 3-hour slots at the same time every week is difficult. During this 3-hour block, the instructor gives the students instructions for the assignment, equipment is dispensed to the student crews, the students deploy at the designated sites, the survey is done, students collect the equipment and head back to the classroom and finally clean and put the instruments away. One can see that productivity in actual surveying is rather small. But today, these assignments can be done quicker and to a higher degree of accuracy. Productivity increases because the measurement process is more efficient. In addition, more data can be collected which has the potential of exploring more scenarios than were available in the past. This can be invigorating for both the faculty member and the student since practical state-of-the-art equipment can be used to solve academic problems.

[2] "The NCTM denigrates the idea of practice, which is thoughtful, considered repetition, and confuses it with drill, which is blind, mindless repetition", http://www/illinoisloop.org/quotes.html, accessed 6/01/05. The NCTM is the National Council of Teachers of Mathematics.

Finally, providing hands-on training is one of the most commonly used methods of teaching and many schools will emphasize this in their literature. Mark Twain is quoted as saying: "If you hold a cat by the tail you learn things you cannot learn any other way". Student retention of instruction using hands-on methods is much higher than by lecturing, reading and even demonstration.

There are several disadvantages that reliance on technology brings to the educational setting. As instruction becomes technic-centered, there is a loss of healthy skepticism of the results. "The answers must be correct since they came out of the instrument" becomes a common mantra. When learning software, we are usually consumed at arriving at a solution, oftentimes without understanding what the solution means. A photogrammetric space resection program may appear to run because coordinates for the location of the camera exposure station are displayed. But, if the values for the Z-coordinate are negative then it should be clear that this is an impossible solution. On the other hand, a geodetic transformation showing a negative Z-coordinate for the location of a GPS satellite could be perfectly acceptable.

As new software and hardware systems are developed and incorporated within an academic program, the faculty find that they are spending more and more time and energy learning how to use these systems. Moreover, the degree of sophistication is also increasing thereby making these systems more powerful and versatile. The toll is that the faculty member's time is directed from other areas that would help advance the science of surveying. Teaching students how to use these instruments and software systems also takes time away from other topics. Often what is sacrificed are the theoretical concepts and principles.

Technology begets technology and programs begin to feel that maintaining state-of-the-art systems is critical to the mission of the program. There are only two ways that one can obtain the hardware/software and this is through purchase or donation. Manufacturers are often very generous with academic institutions with educational discounts. Still, most programs have difficulty in obtaining funding from within the institution for equipment acquisition. Established programs with strong alumni ties and good relationships with the state professional organization and other friends and supporters of the program can often generate funds from these sources. Others may rely on grants and other gifts. None of these scenarios is dependable and available every year. Once equipment is purchased, maintenance funds can almost be as difficult to procure as acquisition funds. In addition, the typical life cycle of the technology is much shorter than it was just a decade ago. For example, Konecny [1985], using the economic theory of Kondratjew, showed that technology within photogrammetry can be defined in 50 year periods or blocks. First and invention is made and 10-15 years later the first practical instrumentation hits the market. The technology is then used for 20-25 years in normal practice. Then, for the next 25 years or so the technology shares the market with newer technology that will eventually replace the older methods. But, these time frames are not as relevant today since newer products are brought to the market much faster and technology is replaced at a more rapid rate.

The second approach is to procure equipment through donations. At one time, manufacturers were quite liberal in their donation program. Today, they have started to be more selective for some very good reasons. In the past, one or two new theodolites or total stations would be of great help to a surveying program. This was particularly true during the period when transit and scale reading theodolites were the mainstay. Following what Konecny [1985] reports, newer technologies were slowly incorporated into normal practice. This allowed the new technology to be slowly incorporated into the curriculum. It gave the program and faculty time to evaluate the new technology and see how it would enhance their teaching methods. Today this approach is no longer valid. To be useful in today's environment, a typical surveying program will need 5-10 instruments. Manufacturers see the merit in getting their equipment in the hands of the student and therefore they may be willing to help fewer institutions by giving each more than they may have in the past. As more and more surveying programs are established, there is more pressure placed on the manufacturers to help out these fledging programs.

Donations in the past have helped in the short term but technological advanced required programs to seek out newer donations later on. Manufacturers support education for a number of reasons. First, they feel it is important to give back to the profession and to invest into its future. A strong and growing work environment opens new business opportunities. Secondly, there are tax incentives that may be helpful to the company. Finally, there is the business decision to get their name and product into the hands of the students. This is an investment since they know that in the future these students will have some say in the decision making process on what kinds of equipment and software to purchase. In order to meet the demands for up-to-date equipment by surveying and mapping programs, some vendors have embarked on a new concept of loaning equipment to the schools. Conceptually, new equipment is provided the program at the beginning of the school year where is it used and then picked up by the manufacturer or their agent at the end of the school year. The equipment is then sold to the practitioners as used equipment. This is really a win-win-win situation for all parties.

While a program like this appears to help all parties, educational programs need to be aware of the agreements that they may enter into. For one, there may be some quid pro quo or other hidden costs to the agreement. As an analogy, soft drink vendors often enter into retail agreements with academic institutions. The vendor pays the school a fee for the exclusive right to sell only their product. As with surveying and mapping vendors, there may be some requirement and/or expectations between parties and these need to be acknowledged up front.

Creating these partnerships with manufacturers may also have additional consequences. First, scheduling may be an issue. This includes when the equipment/software will be delivered and subsequently picked up. A delivery time during the first week of school, or later, gives the faculty member very little time to learn how to use the system, particularly if the equipment is new to the school. While getting the newest version of a system is great, faculty must understand that there still may be bugs in the system and the time it takes to incorporate the new tools into an established curriculum may be longer than anticipated. Second, the partnership could end up defining the program in ways that were not intended, especially if the partnership makes the vendor an exclusive provider. Third, there is a danger that faculty could compromise their objectivity. Fourth, the partnership could be exploited as an advertising opportunity by the vendor. Finally, there is the danger of becoming dependant upon the provider that could cause problems in the future when personnel change either at provider or within the academic institution.

ACADEMICS AND THE SURVEYING PROFESSION

Whether one likes it or not, the educator's impact upon the profession is profound. Students will be influenced, both positively and negatively, by their experiences in our colleges and universities. This effect is long term since today's struggling student will be tomorrow's mentor and lighthouse. But, as experience has shown, perception of their college experiences change over time. A curriculum that has a strong foundation and challenges students to excel will generally be considered as valuable by both graduates and their employers. Over the years, this author has heard a number of concerns by students about classes they take. They talk about the rigor of the course, the depth and breadth of coverage, and the relevance that courses have in their professional lives. But upon graduation, most wear their degree with a sense of pride and accomplishment. Robert M. Hutchins stated: "It must be remembered that the purpose of education is not to fill the minds of students with facts…it is to teach them to think". Thus, education is for the long term whereas training is undertaken for more immediate results.

Educators should not be apologetic for their role within the profession. While there seems to be a constant barrage of opinions against the requirement of education for licensure, professionals, and educators in particular, need to begin to look forward to requiring more education for licensure. The American Society of Civil Engineers has supported requiring a baccalaureate degree plus 30 additional hours and appropriate experience for professional licensure [ASCE, 2004]. NCEES is also contemplating similar requirements. As pointed out by Phillips [2005], engineering educational requirements have remained stagnant or fallen whereas minimum requirement for other professionals has increased. It should be acknowledged that the body of knowledge of our profession has grown considerably over the years. In 1900, engineering required more formal education than other professions. By 2000, medicine, law, pharmacy, architecture, occupation therapy and accounting require more than a bachelors degree for entry into the profession. Additionally, Phillips [2005] shows that the credit hours for the BS degree has steadily declined.

This author believes that an equally strong argument can be made for the surveying profession. A part of this need can be attributed directly to the incorporation of technology into the curriculum and the subsequent de-emphasis of the theory. There is also a trend in higher education to reduce the number of credit hours for a degree. This is a direct consequence of competition. As the cost of higher education rises, the push to reduce the number of hours becomes stronger, from both students and their parents as well as the administration. The consequence is further denigration of theoretical concepts.

CONCLUSION

Education and technology – what is in charge? It is clear that technology and surveying and mapping are tied together. Surveying education must strive for the proper balance between practicality and theory, between industry's immediate needs and the student's long-term development, and between expectations of many different constituencies. The current balance may be more heavily influenced by the tools and equipment. Paul Sally Jr., a professor in mathematics at the University of Chicago states: “This notion that one has to ‘interest’ students in mathematics in order to make them do it has gone much too far, to the point where real mathematics in many cases has just disappeared entirely from the course. They’re just a discussion of what mathematics does and beautiful pictures and imprecise ideas”. Surveying education is looking in this same direction.

Surveying education without a strong theoretical foundation is doing a disservice to the profession. Instead of trying to determine how a curriculum can be built around today’s technology, educators need to work at finding how technology can be used to augment and enhance the theoretical concepts. Surveying education should not be a series of courses on how measurement tools are used. At the same time, we must recognize that the need for technical training is also critical to the growth of our profession and that educational programs that address this technical need should be established.

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