SURVEYING EDUCATION:

CHALLENGES FOSTERED BY NEW TECHNOLOGY

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Abstract

Surveying practice has changed dramatically in the past 20 years and surveying education is experiencing a similar revolution. In years gone by surveying was closely associated with and taught in the Department of Civil Engineering. As other specializations developed within Civil Engineering, the surveying component has been significantly reduced in many programs and completely eliminated in others. Recent technological and professional developments have fostered a rebirth in surveying education as surveying and engineering professionals are called upon to participate in an ever expanding role of generating, analyzing, presenting and archiving information about the land, its boundaries and uses.

This paper briefly describes development of a 4-year surveying program at the Oregon Institute of Technology and high-lights continuing efforts to incorporate new technologies into the curriculum. The program has undergone significant changes in the recent past and continues to evolve in response to criteria imposed by the Oregon State Board of Higher Education, accreditation guidelines, requirements of modern surveying practice and advancing technology.

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Educational Challenges

Challenges in surveying education today include, but are not limited to:

1. Designing a curriculum which will provide each student an opportunity to acquire those tools requisite for a successful career.

2. Providing a learning environment (well equipped labs) which will help each student achieve his/her maximum potential.

3. Motivating students to learn concepts and to think clearly.

4. Finding a suitable mechanism for technology transfer via:

    A. Funded research: (OIT has no graduate program in surveying. Although research is encouraged, it is not mandated. Empahsis is on teaching.)

    B. Interaction with practicing professionals:
        1. Graduates.
        2. Coop.
        3. Summer/sabbatical professional experience.

    C. Continuing education:
        1. Seminars and conferences.
        2. Telecommunication technology.

An attempt will be made to focus on each one in light of recent technological advances and relate it to efforts at OIT to maintain a viable surveying program. However, before doing that, it is important to understand that the educational focus of the surveying program at OIT is different than what it might be at a research university. Although faculty are encouraged to be creative and innovative, the emphasis is on teaching/learning and applications of technology to existing professional practice.

The difference is significant. Research institutions rightly recruit and attract the most gifted persons capable of advancing the sphere of knowledge, but the educational focus in a polytechnic college relates more closely to providing an individual those tools which will help them lead a productive self-fulfilling life. Figure 1 is intended to show that surveyors interact with various disciplines at different levels. For some, a baccalaureate degree will permit them to operate effectively at the technician level and they will not aspire to more complexity or responsibility. Others will use a baccalaureate degree as the base from which to move into positions of professional practice and interaction with other disciplines.

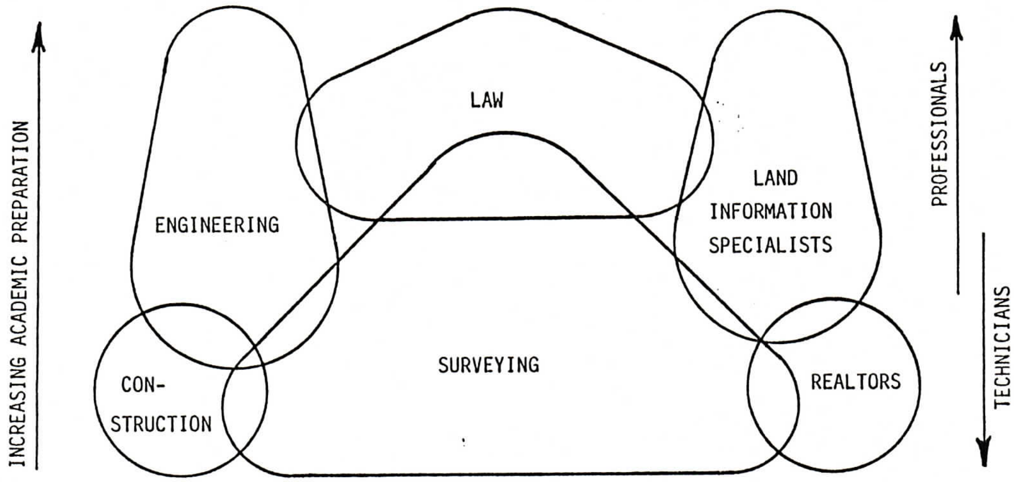


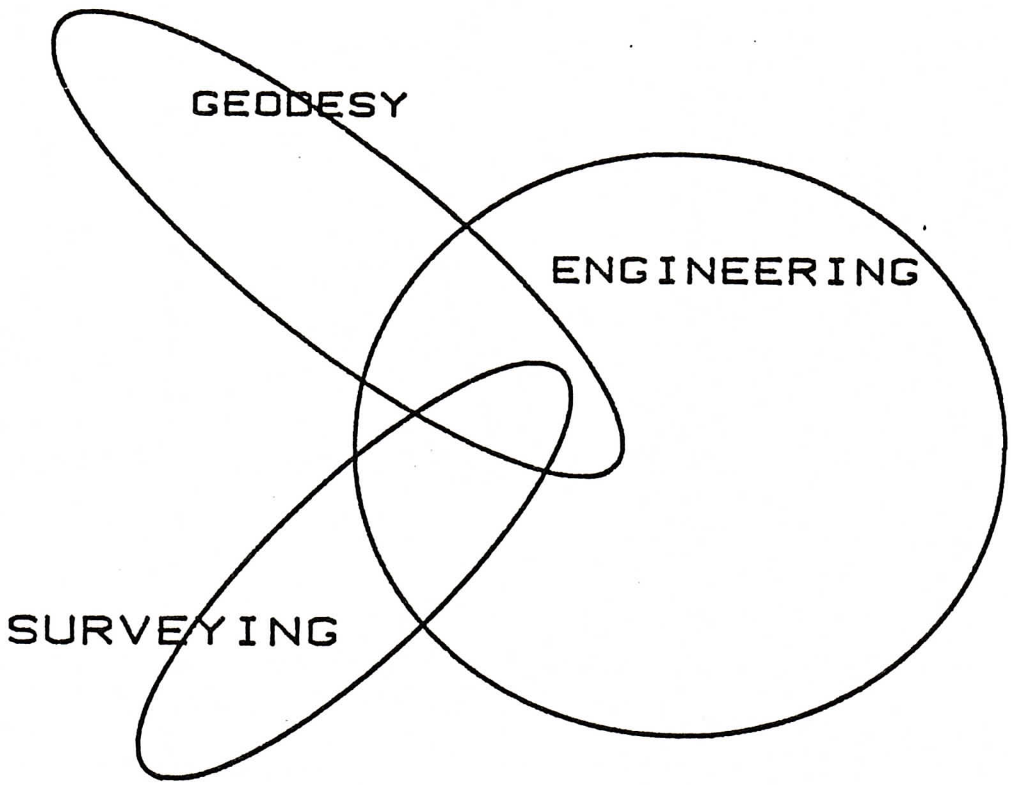
Figure 1. Interaction of Surveying with other Professions

With that in mind, another challenge (just as real, but not grouped with previous ones) is to provide each student a realistic picture of possible employment opportunities upon graduation. That is more difficult to do in light of the continuing discussion of the interaction between surveying and engineering. Some students are more capable than others and many have a preconceived idea of what their career holds for them. Others maintain an open mind to many possibilities and a small percentage choose to go on to graduate school. With technology changing as it is and given personal preferences relative to geographical areas and types of employment (government or private), it is difficult to advise a student correctly. To some the issue of whether surveying is a part of engineering is very real. To others it doesn't matter. Figure 2 is included to show one perception of the interaction of surveying/engineering/geodesy. Is it at least partially correct?

Placement of OIT surveying graduates is very good. In the past, many have gone to work for the Bureau of Land Management (BLM) and work primarily in cadastral surveying. One the other end of the scale, between 1984 and 1988 more than a dozen OIT students worked on a very precise (sub-millimeter) survey to place massive control magnets on the Stanford Linear Accelerator Center project. Landing the "right" job also depends largely on the aspirations of the individual and how they present themselves in an interview.

The overall challenge then is to assist each student in reaching his/her maximum potential and prepare them for a role of professional (and personal) service to society.

OVERLAP OF PROFESSIONS



ENGINEERING is a broad discipline which includes scientific and mathematical principles at various academic levels. It focuses on application of knowledge of our physical world for the benefit of mankind.

SURVEYING as a measurement science (and art) has much in common with engineering, but includes legal considerations relative to land boundaries. In recent times surveying is also becoming more closely associated with land information and management specialities.

GEODESY is the science of determining the size and shape of the earth. It includes measurement science (surveying) as one component, but the whole of geodesy is much broader and includes scientific inquiry at many levels.

The diagram above is intended to show that SURVEYING overlaps with GEODESY within the broad definition of ENGINEERING.

Figure 2, Overlap of Professions

Overlap of Engineering and Surveying

Activities related to or called "surveying" have been part of civilization throughout recorded history. In the past 500 years surveying has benefitted much from scientific developments in mathematics, astronomy, navigation, machining/manufacturing, optics, physics, geodesy, electronics and computers. Notable technological advances include Mercator's conformal map projection designed in the 1500's, invention of the telescope in 1609 by Galileo, publication of 14 place logarithm in the early 1600's, use of triangulation (and telescopes with reticles) to meausre earth arc distances by Jean Picard in 1669-70, publication of the law of gravitation by Newton in 1687, invention of calculus in the late 1600's, geodetic surveys conducted in 1735-1742 to prove the earth was flattened at the poles, establishment of the length of the meter in the 1790's, formulation of the technique of "least squares" by Legendre in 1806 and many other discoveries since.

Recent technological advances having a significant impact on surveying practice include electronic distance measuring instruments (EDMI), hand-held calculators, computers (including main-frame, personal, desktop & portables), automatic levels, inertial positioning systems and the one which captures the fancy of many, global positioning system (GPS) surveying. Using GPS, it is now feasible to bring accurate geodetic positions defined by the National Geodetic Reference System (NGRS) down from the mountain tops to monuments along highways and other convenient locations. The process of "working from the whole to the part" is well tested and proven efficient, but its implementation remains a challenge to the surveying and engineering professions.

As an applied science of mensuration, surveying has been closely associated with engineering, both military and civil. Kreisle (1988) describes development of "surveying engineering" in the United States. From before the American Revolution in 1776 until after the Civil War ending in 1865, mapping projects in North America were conducted by the military to establish transportation routes for our developing country. In addition, topographic engineers educated at West Point were among the early explorers who mapped the great expanses of the American continent prior to settlement (Bartlett, 1962).

Civil engineering is a title first used about 1750 by John Smeaton, an English engineer, and describes activities related to construction of transportation facilities and development of natural resources for the benefit of mankind. Surveying and mapping has been an important part of many early civil engineering projects in the United States such as development of ports for international commerce, inland waterways and canals, the National Road, and the network of railroads which eventually cris-crossed the entire county. More recently, civil engineers have been responsible for construction of dams & irrigation systems, the interstate highway system, high-voltage power lines, pipelines, airports and high-rise buildings. Civil engineers also participate in many facets of space exploration. The role of the surveying engineer as a measurement/location/navigation specialist has been very important in each endeavor.

However, in all fairness, it must be understood the engineering profession does not have an exclusive monopoly on activities of surveying professionals. The surveying profession in the United States also has strong roots in the concept of private ownership of land with regard to delineating boundaries. John Love (1688) describes the art of surveying and measuring land. His work is amateurish by scientific/enginering standards, but it filled the needs of many landowners of that day. George Washington earned a living as a young man surveying land in Virginia around 1750 and became famous as a military leader. He went on to become the first President of the United States. He was not an engineer. This is not to say an engineer can not also be competent in surveying land. But it does illustrate a long history of two distinct professions.

The College of William & Mary in Williamsburg, Virginia, was one of the most highly regarded educational institutions in Colonial America and is the alma mater of the third U.S. President, Thomas Jefferson. Following graduation from William and Mary, Jefferson studied law under Judge George Wythe, one of the most learned and respected Judges in Colonial Virginia. Although his father was a surveyor, Thomas Jefferson did not practice as a surveyor or as an engineer. However, he was learned in many branches of science and provided competent leadership on issues and policy related to land ownership and development. As chairman of the committee which drafted the initial plan for disposing lands of the public domain, Jefferson was probably responsible for the system of townships and sections making up the U.S. Public Land Survey System (Stewart, 1935). Land use patterns and development in the United States still bear the mark of Jefferson's insight and foresight.

Professional service to society also includes topics of geodesy. Having much in common with engineering and surveying, geodesy is more rigorous than either and overlaps with science, mathematics, astronomy and navigation. Early geodetic surveys in the United States include the survey by Mason and Dixon conducted in the 1760's which marks the boundary between Maryland and Pennsylvania. Local surveyors lacked the talent and equipment to fix the line to the satisfaction of contending parties so an appeal for help was made to the Astronomer Royal of the Greenwich Observatory in London (Wilford, 1981). Mason & Dixon were sent to make the survey.

Another geodetic survey of note was performed by Major Andrew Ellicott and Benjamin Banneker in 1791 to lay out the City of Washington D.C. Andrew Ellicott was a Maryland surveyor who, along with David Rittenhouse, extended Mason & Dixon's line to the southwest corner of Pennsylvania and Benjamin Banneker was a black self-taught mathematician, astronomer and surveyor who, among other activities, published a yearly almanac.

A problem facing the United States in the early 1800's was lack of reliable navigation charts. Here too, President Thomas Jefferson played a key role. In response to various proposals for mapping and charting the coast, President Jefferson recommended establishment of a "Survey of the Coast" to the Ninth Congress in 1806. A bill authorizing such a survey was passed by Congress and signed by Jefferson February 10, 1807. Ferdinand Rudolph Hassler, a Swiss born and educated scientist, was appointed the first superintendent of the survey and established a legacy of excellence for the agency we know today as the Coast & Geodetic Survey, or more recently as, the National Geodetic Survey (Stanley, 1976).

Established in 1802, West Point Military Academy was not the only institution to offer studies in civil engineering. With continued development of the United States, many colleges and universities offered studies, not just in civil engineering, but also in mechanical, chemical, metallurgical and electrical enginering. Surveying was an important part of most early civil engineering curricula and some even offered courses in "geodetic" surveying. Professor Edward Ingram (1911) writes in the preface of his book, "After a careful examination of existing books, the University of Pennsylvania has failed to find a satisfactory text from which to teach its civil engineering students the fundamental principles of geodetic surveying and the adjustment of observations . ." Other university courses in surveying included cadastral surveying and boundary line retracement in addition to measurement science, but the point is, they were in the Department of Civil Engineering.

However, as other specialties in civil engineering (structures, transportation, planning, hydraulics, water supply & treatment, materials, geotechnical, environmental studies and others) have risen to prominence other topics, especially surveying, have been reduced or eliminated entirely. Marks & Weeden (1985) did an extensive study of surveying courses (required and offered) in civil engineering programs in the US. Of the programs selected to participate 52 responded. Of those, 10% offer no courses in surveying, 38% offer only one course and 27% offer four or more courses in surveying. Looking at required surveying courses, 23% do not require any surveying course, 19% require two courses and none require three or more surveying courses. There are many other interesting statistics in their report, but the point well acknowledged by most is that surveying is being squeezed out of civil engineering education.

Maybe that is the way it should be. After all, there is more to surveying than just engineering considerations. Recognizing the importance of competent boundary line determinations and conscientious in their charge to protect the public, most state registration boards have established a separate catagory for licensing the Land Surveyor. Sadly, educational requirements for surveying registration were not established or enforced at the same level as for engineering, giving rise to the disparity existing today. Some surveyors could (and do) qualify as engineers, but many can not. That does not say they are not good surveyors! Their sphere of practice may include issues of boundary law and management of land information quite beyond the scope of civil engineering.

On the other hand, it is not that legal issues and delineation of land boundaries is beyond the mental capacity of most engineers, but that many engineers who practice land surveying without the appropriate background in surveying have caused many problems by the things they didn't do right. Being an engineer does NOT automatically qualify one to be a competent surveyor.

Admittedly, that is only part of the problem. With separate licensing of land surveyors the criteria for registration are different. Due in part to lack of appropriate educational programs an accepted place to learn how to become a land surveyor was to work for one. The are many excellent surveyors practicing today who entered the profession via the apprenticeship route. However, if the same individual would have, by whatever means, acquired a stronger background in mathematics, science, physics, history, law and engineering, he or she would be in a much better position to take advantage of and provide leadership in the new technologies. Land surveyors too are causing problems by the things they don't do right. ENGINEERS NEED TO KNOW MORE ABOUT SURVEYING AND SURVEYORS NEED MORE EDUCATION.

The Challenge for Both Professions

The challenge for both professions is dramatically described by Palatiello (1988) in his article on "The Role of Surveying & Mapping Professionals in a Multipurpose Cadastre." The amount of money which will be spent and the job to be done are both enormous. Must one be an engineer to be capable of providing competent leadership to build a competent geodetic network and to manage the information which will go into a multipurpose cadastre? No. Are surveyors capable of providing that service? Not necessarily. Generally, engineers lack the surveying background and surveyors lack the education and experience to manage "high-tech" applications. Will the work be done by others by default? Sure.

Efforts in GIS/LIS and implementation of the multipurpose cadastre are being lead by people with a background in computer science, planning, and geography in addition to engineers and surveyors. The more things change, the more they stay the same. In the Land Ordinance adopted by Congress in 1785 (defining the US Public Land Survey System) it states that a surveyor from each state shall take an oath of office from the Geographer of the United States under whose direction the surveyor shall act (White, 1983). Even then the surveyor worked for the geographers? Engineering and surveying both have much to contribute to efficient construction and use of a modern Geographic Information System (GIS), but it takes our combined resources instead of exclusive claims to a given professional function. That cooperation requires a common committment to quality education and service to the public.

In Oregon, implementation of the multipurpose cadastre is being spear-headed by Dr. Ken Dueker, Director of the Center for Urban Studies at Portland State University. He is a very adept in the political process and is to be commended for soliciting input from the surveying/engineering community. Significant progress is being made relative to "working from the whole to the part" with planned installation of a Primary NAD 83 GPS Network to cover the entire state. Implementation at the county level is being debated between those who insist upon proven geometrical integrity of the local network versus those who insist upon local control and responsibility for the same. Given appropriate technical resources and educational background in each local office, it would not be an "either/or" discussion.

Lest I be misunderstood, let it be said I have utmost respect for many professionals who make valuable unselfish contributions to society and both professions. The collective progress is impressive. Surveying and engineering professionals are both highly regarded by society. However, as I write this, I am watching the Public Broadcasting System series entitled "Learning in America" (hosted by Roger Mudd and sponsored by Chrysler Corp) and realize the education problem is much broader than the small part I see. The challenges in surveying education are not unique.

Brief History of OIT Surveying Program

Oregon Institute of Technology (OIT) began in 1947 as a vocational rehabilitation school for veterans and has grown into a 2800 student body institute offering associate and bacculaureate degrees in engineering, health and business technologies. Two programs, nursing and surveying, are accredited as 4-year professional level programs.

Surveying has been prominent at OIT since the first 2-year technology program was implemented in 1949 and accredited by the Engineer's Council on Professional Development (ECPD) in 1953. OIT's 4-year surveying program, implemented in 1966, was the first in the United States. The first class graduated in 1968 and the program was accredited by ECPD in 1970 as a "Bachelor of Technology in Civil Engineering Technology" (BT-CET). In 1978 all degrees on campus were changed from "Bachelor of Technology" to "Bachelor of Science."

The surveying program continued to prosper and student enrollment was at an all time high in the early 1980's. In order to identify the degree content, the word "surveying" was added to the transcript, BSCET (Surveying), but not to the diploma. A continuing problem however, was that the various state boards of registration repeatedly questioned the content of a 4-year "technology" degree. When told of our desire to call it a "Surveying" degree, one engineer asked in all seriousness, "How can you find enough material in surveying to make a 4-year degree out of it?" In an effort to have the degree title reflect curriculum content, we prepared justification and filed a request with the Oregon State Board of Higher Education to change the degree title to "Bachelor of Science in Surveying." That change was approved in April, 1983, and remains in effect today.

ABET Accreditation

In the late 70's and early 80's discussions were taking place on the national level relative to appropriate accreditation of surveying programs. The result was creation of the "Related Accreditation Commission (RAC)" under the Accreditation Board of Engineering & Technology (ABET). The new commission exists on the same level as the "Engineering Accreditation Commission (EAC)" and the "Technology Accreditation Commission (TAC)." The intent in setting up the new commission was to establish criteria just as rigorous as the engineering (EAC) guidlines, but to accommodate material unique to the surveying profession. The OIT surveying program was one of two programs evaluated under the RAC guidelines in 1984 and was granted that accreditation. It has maintained that accreditation ever since (Burkholder, 1987).

Since changing the degree title our enrollment is down. What factors contribute to the decline? Is it part of a national trend? Is it because a BS Surveying degree has too narrow a focus? Is it because we raised the math and science requirement to satisfy accreditation criteria? (It is NOT because placement is down. During the past 5 years placement has been very good.) Is it because nation-wide we are still trying to determine our professional identity. (I will naively believe that is part of it.) Other factors include the "glamour" associated with computers and electronics and comparative pay scales for graduates. Although not bad, the pay scale for surveying graduates should be better than it is.

In 1987 the Oregon State Board of Higher Education issued an edict that all colleges in the state system would switch from a calendar of 3 terms per year to one of 2 semester each year. The transition was to become effective Fall term 1990. As a result, all programs in the system were subjected to careful study to identify obsolete material and to incorporate new material as appropriate. That task was nearly complete when political pressure caused the decision to be reversed in December, 1988.

So, we will stay on the quarter system after all and we are now working to incorporate planned improvements into three ten-week terms per year. The BS Surveying program as approved by the campus Curriculum Planning Commission on May 12, 1989 is shown in Appendix A. Final approval will be made later by the State Board Office.

The revised curriculum was designed to meet ABET/RAC criteria. The focus is surveying; admittedly at the expense of several engineering type courses. For example, the surveying curriculum no longer has Strength of Materials or Fluid Mechanics in it. Are those courses important? Certainly, but just as civil engineering is squeezing out surveying, surveying is squeezing out civil engineering? Not that either set out to exclude the other, but both are faced with a common dilemma of finding that best combination of courses to meet the needs of the profession, the student, and society.

Challenges Revisited

Returning to the challenges listed in the first section of this paper, the first is that of designing an appropriate curriculum. Given the previous discussion it is difficult to know which way to go. Should the program focus strictly on land surveying, engineering surveying, geodetic surveying or a combination of all three? Looking at the scope of professional practice and interaction of many professions we must include parts of each. The specific process follows that suggested by Adler & Bossler (1988) in which they state "it is almost invariably a case of evolving a new curriculum from an existing program in order to arrive at the 'best under the circumstances'."

Although I sympathize with the suggestion by Adler & Bossler (1988), that "educational requirements for registration in surveying be reconsidered and a degree in surveying & mapping or mapping and information science from a university known for its all-round excellence be in itself acceptable as fulfillment of the educational requirement for a modern surveyor," our program and our institution do not have the power or prestiage necessary to be "self-accrediting." Therefore, we have opted to stick with the RAC guidelines.

A proper learning environment is another challenge in surveying education. Students attend college for many reasons, but one reason students attend OIT is the highly touted 95%+ placement of graduates. True, they also come to gain a marketable skill which will lead to a satisfying career, but often they don't know or understand what it is they want other than a degree and an implied guarantee (not from the college, but from society) that now the world owes them a high standard of living. Some become disillusioned when they realize learning takes a lot of effort and that the high standard of living too must be earned.

Any one of several cliches might apply, but I like the quote by John W. Gardner, Secretary of Health, Education & Welfare from 1965-1968, when he said, "The ultimate goal of the educational system is to shift to the individual the burden of pursuing his own education." To that end, students still look for role models and react quite differently when walking into an office where a sign proclaims:

> "I'd like to help you out.
> Which way did you come in?"

as opposed to another office containing a sign which says:

> "Listening to you is the most
> important thing I will do today."

Learning is joint venture between faculty and student which thrives in an atmosphere of curiosity and mutual respect. Just as little is gained by saying surveyors can't be engineers or that engineers don't know how to perform good surveys, an attitude of contempt between faculty and student is just as damaging (even if it can be justified). Too often we teachers find ourselves caught up in our own problems and not taking the time to listen.

Another challenge is motivating a student to devote the effort necessary to do his/her best. One could complain about the lack of preparation in the high school experience and I have done that. However, rather than just complain, I made an appointment with our District Superintendent, Dr. Earl E. Ferguson, President of the American Association of School Administrators, 1986-87. It was an interesting discussion and I came away with a greater appreciation of educational challenges at the high school level. Many dedicated teachers do an excellent job in our nations high schools, but performance in the classroom is affected by values of society and the home life of each student. High schools are required by law to "teach" all students and that adds to their challenge. Again, Roger Mudd's PBS series "Learning in America" helped put education in perspective and I have a greater appreciation for the unsung efforts of many high school teachers.

In spite of the apathy, many students are turned on by learning new things and applying new technology to solve surveying problems. We've had GPS equipment on campus several times and student interest is very high. Even with the satellite window in the wee hours of the morning, they were willing and anxious to take the equipment out, set it up, and collect data on campus control points. Those are the times and students which make teaching enjoyable.

An exciting part of teaching at the college level is that students are still learning to think for themselves. Often young people discover the advantages of and feel comfortable parroting ideas, phrases and actions of older people. Some never do get around to "rebelling" to the extent that they are willing to think for themselves. It is indeed a challenge to participate in mental exercises with students in which preconceived ideas are disgarded and new ideas can be discussed in terms of current givens. Not that the old way is bad of itself, but the benefit comes from seeing a person arrive at a firm conviction because they have thought a problem through and reached a viable conclusion. The greatest fear I have as a teacher is that someone will believe something because I said it. I would far rather have them evaluate it for themself and reach a conclusion for which they can take the credit.

Of course, we do not have to reinvent every wheel. In teaching computer programming I share a list of "rules" I have found to be beneficial:

1. Never accept anything except clear, distinct ideas.

2. Divide each problem into as many parts as are required to solve it.

3. Thoughts must follow an order from the simple to the complex and where there is no order, we must assume one.

4. We should always check thoroughly in order to assure that no detail is overlooked.

I wish I could take credit for the rules of logic, but I was impressed to find them attributed to one, Rene Descartes, French philospher and mathematician who lived between 1596 and 1650 A.D. Was he programming a computer then? Yes, the one between his ears.

Another rule of logic was brought home to me in a new way when a student asked, "How can a good decision be made based upon a bad assumption?" That too points out the importance of correct logic.

The final challenge to be considered here is that of technology transfer. The topic is a big one and can not be covered adequately. However, I do want to point out that educational challenges fostered by new technology carry over into continuing education and professional development. As mentioned earlier, there is much distrust in the professions between civil engineering and surveying. But, there is a large area of common interest and much we can learn from each other. New technology requires each of us to continue learning and applying technology to solve problems in creative ways. I don't have an answer as to the best or even an appropriate way to affect technology transfer, but I am convinced education and a willingness to listen to and learn from each other will go far in helping us meet our obligation of competent service to society.

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APPENDIX A

OREGON INSTITUTE OF TECHNOLOGY

SURVEYING Curriculum - Approved by CPC May 12, 1989

Freshman Year:

			F	W	S
CET	111	Intro to Civil Engineering Technology	3		
Mth	104	College Algebra	4		
Wr	121	English Composition	3		
Sp	111	Fundamentals of Speech	3		
		Health Elective	2		
PE	190	Physical Education	1		
Sur	161	Surveying I		4	
Mth	105	Trigonometry		4	
Wr	122	English Composition		3	
CET	112	Computer Aided Drafting (CAD)		3	
PE	190	Physical Education		1	
Sur	162	Surveying II			5
Mth	251	Analytic Geometry & Diff. Calc.			4
Sur	175	Plat Drafting			3
CET	215	Contract Documents			3
PE	190	Physical Education			1

16 + 15 + 16 = 47

Sophomore Year:

			F	W	S
Sur	163	Surveying III	5		
Sur	241	Law I	3		
Mth	252	Integral Calculus	4		
CET	131	Statics	3		
Psy	201	Psychology	3		
Sur	242	Land Descriptions & Cadastre		3	
Mth	253	Multivariable & Vector Calculus		4	
Ph	201	General Physics * (Ph 221)		4	
Cst	110	BASIC Programming **		3	
		General Elective		3	
Sur	243	Boundary Surveying			4
Ph	202	General Physics * (Ph 222)			4
Wr	227	Technical Writing			3
CET	221	Engineering Geology			3
Sur	264	Surveying Software Applications			3

18 + 17 + 17 = 52

Total hours for Associate Degree = 99

* Calculus based Physics 221 & 222 recommended but not required.

** Students with demonstrated proficiency in BASIC may choose different programming language subject to Advisor approval.

OREGON INSTITUTE OF TECHNOLOGY

SURVEYING Curriculum - Approved by CPC May 12, 1989

Junior Year:

			F	W	S
Sur	351	Construction Surveying	4		
Ph	203	General Physics * (Ph 223)	4		
Sci	215	Topics in Astronomy	3		
Ba	321	Financial Accounting	3		
		Sur/CET Elective	3		
Sur	335	Computer Applications to Surveying		4	
Ba	340	Industrial Economics		3	
Mth	411	Statistics		4	
Sp	321	Discussion Processes		3	
		General Elective		3	
Sur	352	Control Surveying			4
Sur	338	Subdivision Planning & Platting			4
		Economics Elective			3
		Math Elective			3
		Social Science Elective			3
			17 +	17 +	17 = 51

Senior Year:

			F	W	S
Sur	451	Geodetic Position Computation	4		
Sur	425	Photogrammetry	4		
		Social Science Elective	3		
		Humanities Elective	3		
		General Elective	3		
Sur	452	Cartographic Applications		4	
Wr	327	Advanced Technical Writing		3	
Ba		Ba Elective (BA 381, Real Estate Law rec.)		3	
		Science Elective		4	
		Humanities Elective		3	
Sur	466	Survey Law II			3
Sur	454	Astronomy & GPS Applications OR **			4
Sur	415	Forest Road Design **			
		Math Elective (or Sur 465)			4
		Humanities Elective			3
			17 +	17 +	14 = 48

Total hours for B.S. Surveying degree = 198

* Calculus based Physic 223 recommended but not required.

** One of two courses required. Other may be used as elective.