The Role of Civil Engineering Technology in the Global Picture

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Abstract

This paper discusses pertinent issues related to the field of civil engineering technology, and also attempts to answer some often asked questions regarding the purpose of civil engineering technology programs. The future of civil engineering technology relies on a clear definition of its mission and goals, and that these fit in well with adjacent fields of study. This paper presents a clear definition of the role, responsibilities, and rights of the civil engineering technologist.

Introduction

The turn of the century approaches along with the rapid development of new technologies and the maturity of fledgling civil engineering technology curricula conceived of some thirty to forty years ago. A few of the questions asked that cut right to the heart of the purpose of these programs need to be addressed to preserve their integrity and to ensure their proper alignment with adjacent fields of study and work. One such question, brought to light by the TAC of ABET accrediting criteria for civil engineering technology concerning the inclusion of certain types and amounts of civil related subject matter, is what is the role of the civil engineering technologist in the work place. Another such question relates to the role of civil engineering technology in the development of civil technology, methodology, and practice. Research funds are dispersed to institutions and industry with general categories ranging from 'pure' to 'applied' research. Where, in this scheme of research and development, does the responsibility of the civil engineering technologist lie? With a clear definition of the role, responsibilities, and perhaps the rights, of the civil engineering technologist made, we may then as a group address the legitimacy and necessity of having professional registration for civil engineering technologists. These issues are addressed in this paper in the hopes of shedding some light on the matter for the cause of preserving and clarifying the purpose of civil engineering technology.

Engineering Technology Vs Engineering

The first author of this paper has a civil engineering background, both academic and in practice. New to the field of engineering technology two years ago, several peers, who had been in the field of engineering technology for several years, attempted to explain the difference between engineering and engineering technology. Apparently, several fields of engineering experienced a divergence of theory and practice due to efforts placed toward getting to the moon. Fields of engineering integral to that effort developed a host of new theory and techniques necessitated by the new and unique criteria of launching a vessel through space. Thus, these fields of engineering experienced a real need to have curricula where efforts were placed toward research and development for the creation of new theory and techniques, and other curricula where efforts were placed teaching engineering practice and improving practice oriented technology. The divergence of theory and practice is perhaps most obvious in the fields of electrical engineering and electrical engineering technology.

There are, however, some fields of engineering that were virtually unaffected by the moon launch of the 1960's, and perhaps the most obvious of these is the field of civil engineering (CE). Yet, despite the lack of divergence between theory and practice in civil engineering, civil engineering technology (CET) programs were created along with all the other engineering technology (ET) curricula some 30 to 40 years ago. The initial CET programs differentiated themselves from CE programs by concentrating in a type of civil technology, the two most prevalent CET concentrations being architectural drafting, and surveying. What these programs essentially achieved was to develop civil engineering technicians with a particular qualification such as draftsman, or surveyor. Developing technicians, however was not the intent of ET programs, and the newly revised TAC of ABET accrediting criteria reinforces this, especially for CET. What is needed now is a clear definition of the purpose of CET programs and their relationship with CE programs.

Defining CET in the Work Place

The TAC of ABET criteria that became effective in the academic year 1997-1998, requires that CET programs include topics in statics, dynamics, strength of materials, and fluids for technical sciences, and engineering graphics, problems solving techniques, surveying, CE materials, engineering economics, soils and foundations, and a two course design and analysis sequence for technical specialties. In addition these programs must have required math through the second semester of calculus, and a heavy emphasis on hands-on experience by having a required lab for several of the technical specialty courses. The single biggest difference between CET curricula that meet these criteria and CE curricula is the absence of the third semester of calculus and a semester of differential equations in the CET programs. However, the TAC of ABET criteria does go on to say that depending upon the educational objectives of the program, including applied statistics, advanced trigonometry, and/or differential equations may be necessary. With one additional year of math, graduates of CET programs would have the same level of understanding and potential to do design and analysis in CE topics as would CE graduates.

The second large difference between CET and CE programs, is that TAC of ABET requires CET programs to have a large number of laboratory hours, preferably a required lab for every course in a technical specialty. The reality of this requirement is that CET graduates gain ample training in CE field and practice operations, whereas CE graduates gain more theory and are therefore better suited to move on to graduate programs and research and development. The question that rises in this authors mind, is which of these two types of graduates, if only one group were to be chosen, would be best suited to become professionally registered practicing engineers? This question will be addressed in more depth later in this paper.

Thus far, we have offered no real definition for CET other than to offer the perceptive difference that CET programs are practice oriented, as opposed to CE programs which are more research and development oriented. At this point it seems CET and CE programs have more in common than they do in difference. In fact, the practice of engineering has been undergoing significant changes due to the progress of technology, and to the changes of business practice the world over

(Haddad, 1996). The curricula for these programs have been under attack from industry, engineering societies, the federal government, and the schools themselves (Curry, 1991). The complaint is that engineering curricula has not kept up with the changes and as a result are turning out students ill prepared for work in today's technical work place. A recent survey done with the intent of gaining some insight on how to reform engineering education, found that the majority of new graduates felt there was considerable knowledge required by their jobs that was not part of their undergraduate education (Maul, 1994). The result of this fact is that industry has inherited the considerable cost of additional training to give new hires the skills they need to be productive (Dahir, 1993). Efforts to reform curricula to better meet the needs of industry has been attempted at some schools by adding requirements to the curricula (Denning, 1993). This is a flawed attempt however, due to constraints placed on curricula from accreditation boards, state governments, university and college core requirements, and the students themselves. In order to achieve accreditation, engineering curricula must have sufficient levels of theory, design, and appropriate labs. In order to cover all the material needed and still meet university requirements, engineering curricula have approached 140 to 150 credit hours in some cases. Pressure from students and state governments, as well as university councils have encouraged curricula to be approximately 128 credit hours. However, all this effort has been to give students more instruction, not more of what industry desires in the students. Thus, the era of high technology has increased still more the level of confusion as to what the roles are of the CE and CET graduates (Braddock, 1995).

Industry has identified several qualities they would like in new engineering and engineering technology hires. This list includes communication and interpersonal skills, analytical ability, self-confidence, personal initiative, willingness to change, problem solving ability, teamwork skills, and ability to establish operation procedures, creativity, and the ability to be immediately productive in a new job assignment. One solution attempted to create a new graduate with the above listed qualities, was to expand the curriculum by adding a 5^{th} year of additional course requirements (Curry, 1991). However, this solution increased credit hour requirements, providing more instruction and not necessarily what industry wanted in the students, and meet with little success. Another approach to this problem has been to redesign curricula to incorporate a "hands-on" approach to design instruction, as exemplified by the MIT engineering curricula (Durfee, 1994). "Hands-on" design happens when students work on realistic, or preferably real-life, design problems with outcomes going beyond drawings and reports, to involve presentation of working prototypes. This has proved to be a beneficial approach to solve the problem, and can be taken even further, to include training in more of the skills listed in the industry desired skill base earlier. While some of these skills overlap, combined they create a large and varied skill base required in students. Educators are faced with how to give students the training they need within a reasonable number of credit hours. While curricula must provide sufficient breadth of material to give students the technical and design skills necessary to be immediately productive as graduates, sufficient depth must also be provided through training in cooperative problem solving, communication, and other skills to ensure long term success in student careers (Miksad, 1996).

Our framework, which constitutes our current approach to engineering and engineering technology, has been based on several questions: What is the engineering profession? What is ET? What is engineering and ET education? What is the university role? What is engineering work, and what is ET work? It is obvious that our answers to these questions, however vague they were, are at this point invalid. We need engineering and ET curricula capable of preparing students for the new world, incorporating design and practical experience, effective interaction with others, as well as training in all the other desired skills. Now, we have the bases for a clear definition of the role CET, not as a stand-alone program, but in concert with defining the role of CE, for the next century. Covering adequate skill training or adequate levels of both breadth and depth in one curriculum is not realistically feasible within a reasonable number of credit hours. It is possible however, to provide better that adequate levels of breadth and depth, if carried across two curriculums, one with a practical focus, and one with a theoretical focus. Thus a CET curricula should emphasis training in the skills that would create excellent field or practicing engineers, prepared to be immediately productive in an industry work experience, and CE curricula should emphasis training in skills which would create researchers and developers of new theory. It should be noted that training in skills outside of the curricula focus should not be neglected, but included as a secondary emphasis, such as having "hands-on" design instruction in engineering curricula, or having a laboratory assignment applying a design concept in a CET program.

Defining CET in Research and Development

The earlier discussion suggests a practical focus for CET programs and a theoretical focus for CE programs, and defines CET graduates as engineering practitioners and CE graduates as engineering researchers and developers. Is there room within these program definitions for CET to take part in research and development? This author suggests that CET has a definite role to play in research and development. Indeed, the beneficial results of pure research could not be realized without CET fulfilling its responsibility as the final implementer of theoretical research.

There is wide range of research and development, with "pure" research at one extreme and "applied" research at the other. Pure research happens in fields such as mathematics, physics, and chemistry. Pure research poses questions such as what happens to a molecule of a certain type when heat is applied to it, or how do these molecules behave if firmly rubbed together. This information is then used at the next level of research in fields such as material science, while still classified as pure research, it applies what was learned before, such as to see if the molecules being researched earlier could become useful as a unique material. Thus materials are developed with characteristics such as being heat resistant, wear resistant, extremely malleable, or very lightweight. Fields of engineering can now apply these materials toward a useful purpose, such as using heat resistant tiles on the space shuttle, lightweight alloys for strong but lightweight structural members for bridges or buildings, or wear resistant engine parts for greater durability. The final step in realizing the benefits of a material with unique characteristics is to develop technology to make the material in a useful form, and then to apply it to a particular use, and thus we have applied research. CET sits at the end of the spectrum that applies useful developments in a practical way. They are the final link in a chain that connects rubbing molecules together, to constructing a bridge span made of super-lightweight reinforced concrete. It is important to note that if any link in the chain is missing, then the connection is broken. Thus CET plays just as important a role as any of the other fields that represent a link.

The above discussion demonstrated taking pure knowledge and eventually finding a useful application for it. The original questions created from some form of intellectual curiosity. Though some research does become initiated this way, and eventually find a practical form, it is more common for the questions to be created based on a practical need. Thus the necessity for a large bridge span, requiring a lighter weight material, would prompt questions such as how to create a lightweight reinforced concrete, leading to investigations involving lightweight aggregates, and lighter alloys for reinforcing. Therefore, it is also important to note that questions and information go back and forth along the chain linking pure and applied research.

It is common for research funds to be dispersed to both institutions and industry, within a category that defines what is legal to research under the description of the terms and intent of the research funds. Funds for pure research generally go to the pure sciences, and funds for applied research tend to go toward the applied sciences or engineering and engineering technology. While this is not necessarily bad, it does tend to inhibit communication along the chain. In order to secure funding for research, institutions and industry are more apt to redefine a research question then to request the input of the most appropriate field. Competition for funds and for credit has inhibited the sharing of questions and information between the fields, which greatly inhibits realizing the benefits of any research. It is easy for CET to be excluded from the research process because they have a practical emphasis, and also because they exist at an extreme edge of the research process. It is important to note that several important research questions arise from necessity at this end of the spectrum, therefore defining upcoming pertinent research, and also this end of the spectrum applies developed concepts, therefore realizing the benefits of research. CET is therefore both instigator and applicator of research.

Not only does CET have a large responsibility to fulfill toward research and development, but also they have the right to give and solicit information from the other fields on the chain connecting concept to application. How much more effective the whole research process would be if teams of researchers worked toward practical solutions with each team member representing a field pertinent to the line of research. Like business found that marketing, engineering, manufacturing, sales, and customer service as a team were much more effective in creating a quality product due largely to increased levels of communication and effectiveness, research and development could greatly benefit from the team approach involving chemistry, physics, material science, engineering and engineering technology.

CET Professional Registration

The content of CET programs was discussed earlier in this paper. In that discussion it became obvious that CET programs accredited by the new TAC of ABET accrediting criteria were more similar to than different from CE programs. These CET programs also have several more laboratory hour requirements then CE programs do, giving CET graduates ample training in field and practice operations. This makes CET graduates very suited to become immediately productive as field and practicing civil engineers in training upon graduation.

CE programs have been under fire for some time now for producing graduates ill prepared for practicing engineering work (Curry, 1991). CET programs have filled this void by producing graduates who are well prepared for practicing engineering work. Some CE programs have tried to overcome this by incorporating a “hands-on” approach to design instruction, giving the students more of what industry needs in them. Still, the vast majority of CE programs continue to have few laboratory hours and an emphasis on theory leading to students better prepared for graduate school than for practicing engineering work.

In the attempt to define CET’s role and work, it was found that industry desires a large number and wide range of skills in students. One type of curriculum cannot feasibly supply adequate opportunity for training in all the desired skills to students within a reasonable number of credit ours and time frame. However, CET and CE programs can supply adequate levels of training in the desired skill base if training were carried across the two programs. CET and CE programs are then essentially covering the same skills, emphasizing some skills in one program more then others, each program approaching from opposite sides and overlapping somewhere in the middle.

In the discussion defining CET’s role in research and development we found that CET has an important role in the raising of pertinent research questions for a practical purpose, and in putting research to work through providing practical applications. The importance of the link held by CET in completing the connection from pure to applied research and to practice is similar to the role CE plays, which is essentially bridging pure and applied research, and helping CET to bridge research to practice.

Nowhere does this author find support for CE graduates being more qualified to become professionally registered then CET graduates. If one group had to be chosen, then it makes more sense for the group well prepared for engineering practice to become the professionally registered engineers, and the other group to continue into research and development. However, it is important that the links between pure and applied research and to practice remain intact, lest divergence of efforts in research and development and practice create barrier to progress in the field. Therefore, in the best interests of CET and CE and the betterment of the civil field, it would seem best for each program to keep its focus, become ABET accredited, and to each pursue professionally registered alumnae.

Conclusion

The conception of CET programs some thirty to forty years ago coincides with the divergence of theory and practice in several engineering fields caused by efforts placed toward the moon launch. Engineering fields integral to that effort needed to create a new curriculum to essentially continue traditional engineering theory and practice, while the established curriculum chased new theory and techniques necessary for space considerations. However, civil was not a field integral to the space effort and thus the CET curricula created did not have great divergence with the existing CE programs. Indeed the mission of both CET and CE programs has remained unclear.

The discussion presented in this paper demonstrates that CET and CE programs are essentially tied at the hip. While CET programs retain a practice focus, and CE programs retain a research and development focus, there is significant overlap in the fields. This is not necessarily a bad thing. The industry desired skill base for new graduates is too much for one type of curriculum to provide, and therefore CET and CE can help each other by carrying the load across two curriculums. Sharing the burden enables both curriculums to effectively train students within a focus, and industry enjoys the product. One type of graduate will be more prepared to be immediately productive as a practicing engineer in training, and the other with more theoretical and design skills.

CET must also be an integral part of research and development. CET has a responsibility to fulfill in the creation of pertinent research questions and to putting research to work by providing practical applications. This is important, first because CET is an important link in connecting pure and applied research and engineering practice, and secondly because the progress of either CET or CE is dependent on progress in the other. Research cannot sufficiently advance without a matching level of established technology, and advanced technology will not be created without matching efforts in research and development. Therefore, not only are CET and CE tied at the hip, but so too are progress, research, technology, and engineering practice.

Oh Yes, About that Moon Launch

The space program didn't last all that long, about ten years give or take a few. Nixon essentially killed the program because it couldn't be economically justified any longer. We accomplished the goal of walking on the moon and there was no longer a national goal to work toward. We could not find a justifiable reason to continue the program. It has been said many times that necessity is the mother of invention, and the space efforts of the 1960's lacked necessity.

What is the necessity that will truly launch humanity into space? Most necessities are economically driven. What economic reasoning would necessitate a space program? This author suggests that the need for resources is the necessity that will economically justify a space program. Resource gathering is mining, and mining is civil engineering in its most basic form.

When necessity arises, and the space program revives, civil's will be in its midst. It is therefore necessary now, for CET and CE programs to join efforts in preparing themselves for this. Both types of programs lag behind other fields in computer programming ability and analytical ability such as advanced operations research techniques and non-linear considerations, among other things. Instead of competing with each other as to who is greatest in the field of civil, we need to work together to bring the field up to speed. Then we will be prepared to go mining in alien environments when the need arises.

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