Boundary Work between Engineering and Engineering Technology: Knowledge, Expertise, and Power at Southern Polytechnic State University

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Gieryn coined the concept "boundary work" to refer to strategic actions that scientists took to demarcate themselves and their work from "non-science" groups and activities.[1] Boundary work is a series of processes and actions, by which groups create, manipulate, transform, dissolve, and reform their symbolic and social boundaries. This paper argues that group boundaries are created and maintained through a group's knowledge, expertise, and power. These elements help distinguish the group from others. Boundary work has been used to demonstrate the demarcation between science and non-science[2], the communication between difference social groups in knowledge production[3], knowledge boundaries as source and barrier to innovation across organizational groups[4], and the accumulation of social capital within a given field[5].

This study examines two academic degree programs in the fields of engineering at Southern Polytechnic State University[1] which share similar knowledge and similar expertise but different levels of external social power. With such overlap in knowledge and expertise, it is difficult to distinguish between the two even though the academic programs seek demarcation. Social and symbolic boundaries become blurred and external groups have difficulty in knowing the differences between the two.

SPSU is a unique case. It is unique not because it offers engineering and engineering technology degree programs; over 140 schools offer both academic programs. Its uniqueness is that the university offered only engineering technology programs for over 60 years and has added engineering programs only four years ago. In the other institutions that have both, the engineering program long preceded the engineering technology program. Engineering technology degrees at SPSU morphed over the years into bachelor degree programs that were "no different than an engineering degree, except for a course or two."[2] If one couples this development with a lack of clarification in the engineering industry between an engineer and an engineering technologist[6], one can understand why the boundaries between these two academic and industry fields become blurred and indistinguishable.

The present paper examines the boundary work between these two programs as they seek to co-exist at SPSU. The concept of boundary is used as a theoretical framework with which to examine historical and collected data. This framework pays particular attention to the use of knowledge, expertise, and power in the boundary work between engineering technology and engineering. The paper offers as data a brief history of engineering technology in the United States as well as the history of engineering technology at SPSU. This historical data demonstrates a continuing confusion about engineering technology and the role of an

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[1] SPSU is an unit of the University System of Georgia located in Marietta, Georgia. Its vision is to be a comprehensive university with a unique purpose. Through a fusion of technology with the liberal arts and sciences, we create a learning community that encourages thoughtful inquiry, diverse perspectives, and strong preparation of our graduates to be leaders in an increasingly technological world. The university – faculty, staff, students, and graduates – aspires to be the best in the world at finding creative, practical, and sustainable solutions to real-world problems and improving the quality of life for people around the globe.

[2] Interview with a 1980s graduate of the MET program from Southern College of Technology (SPSU's name from 1980 – 1996).

engineering technician or technologist in the engineering fields. Collected data will include the academic curriculum from SPSU's engineering and engineering technology degrees, program enrollment figures, responses from a survey of the engineering technology and engineering faculty members, and interviews with key administrations, deans, and senior faculty. The paper argues that the introduction of civil, mechanical, and electrical engineering programs at SPSU has caused a "boundary crisis" in the knowledge, expertise, and power of the corresponding engineering technology programs. The effects of this "boundary crisis" are materializing in the declining enrollments in the engineering technology programs that have corresponding engineering programs (Figure 1). This data demonstrates that the introduction of civil, mechanical, and electrical engineering has had a negative effect on the enrollments in the corresponding engineering technology majors. Civil Engineering Technology has decreased in enrolled majors by 62%, electrical engineering technology by 44%, and mechanical engineering technology by 30.4% during a five year period. Please note, however, that engineering technology programs which do not have a corresponding engineering major, such as computer engineering technology, have remained stable in their enrollment. This trend is not reflected in enrollments of engineering technology degrees across the United States. Since 2005, engineering technology programs have shown increasing enrollment.[7]

Figure 1: Fall Enrollment in Engineering Technology and Engineering Programs at SPSU from 2008 – 2012

ET Programs	**2008**	**2009**	**2010**	**2011**	**2012**
Apparel/Textile Eng Tech	32	38	42	45	41
Civil Engineering Technology	395	376	262	195	150
Computer Eng. Tech.	166	144	143	133	168
Electrical Eng. Tech.	366	372	309	243	205
Industrial Engineering Tech	135	152	178	180	199
Mechanical Engineering Tech	507	564	509	414	353
Telecommunications Eng Tech	31	31	32	34	28
	1632	1677	1475	1244	1144
Engineering Programs					
Civil Engineering	0	6	108	178	227
Construction Engineering	85	88	61	44	28
Electrical Engineering	0	6	103	223	318
Mechanical Engineering	0	0	138	316	529
Mechatronics Engineering	115	173	210	241	250
Systems Engineering	3	3	11	18	35
	203	276	631	1020	1387

SOURCE: SPSU Fact Book 2012

Figure 2 – Fall 2012 Enrollment in by Ethnicity and Gender at Southern Polytechnic State University

		Engineering Technology		Engineering	
		N	%	N	%
Ethnicity	Asian	86	7.5	122	8.8
	Black	265	23.2	268	19.3
	Hispanic	91	7.9	130	9.4
	White	602	52.6	750	54.0
	Other*	100	8.8	117	8.5
		1144	100%	1387	100%
Gender	Female	107	9.4	116	8.4%
	Male	1037	90.6	1271	91.6%

SOURCE: Institutional Research Office at SPSU
* include American Indians, Hawaiian/Pacific Islanders, and students who indicated a racial heritage of 2 or more races.

Figure 2 shows the breakdown of the 2012 enrollments by gender and ethnicity. This shift in enrollment appears to be occurring across the entire student population as there are no differences across gender and racial groupings, except for a smaller percentage of African American/Black students in engineering. This trend will need continuous monitoring. The average SAT scores of the majors in engineering and engineering technology did not differ either. The majors in engineering technology had a combined SAT (Verbal and Math) of 1104 while the engineering majors had a slightly higher SAT score of 1138.

Boundary Work

Boundary work between social groups is a well-established theme in sociology. Durkheim's concept of the division of labor[8] as an ordering effect on society separates groups into their social location boundaries and his Elementary Form of Religious Life separated the sacred and profane elements of society into bounded spheres.[9] Weber's classification of status based on wealth, prestige, and power demonstrates the effects of boundary making between class, religion, and race.[10] Bourdieu's concepts of habitus and field are used to create and normalize boundaries and distinctions between social participants and groups.[11]

Groups create, maintain, and transform their symbolic and social boundaries through the manipulation and control of knowledge, expertise, and power. Ash demonstrates how expert mediators were able to use their newly acquired theoretical knowledge of expertise to elevate themselves above the craftsmen of skill and place themselves in a position of power between these craftsmen and their former wealthy patrons[12]. By using knowledge, expertise, and power, the expert mediators created a new social group within the English economic system through the process of boundary work. Knowledge is an accumulated investment in particular ideas and practices by a group for the purposes of constructing a social boundary. Expertise or practice is a "shared routine of behavior"[13] and is knowledge that is "localized, embedded, and invested"[14] by the group.[3] Power in boundary work is a form of ideology where "groups struggle over and come to agree upon definitions of reality" where by groups determine their power through "unequal access to and unequal distribution of resources (material and nonmaterial) and social opportunities".[15] Boundary work is consistent with the structuration concept where "all action is embedded in the social structures that it simultaneously produces, reproduces, and transforms."[16]

Knowledge. Gieryn states that much boundary work deals with the issue of knowledge and knowledge based information.[17] This idea connects with Fleck understanding of the "thought worlds" of scientists[18] and Brown and Duquid's concept of "knowledge boundaries."[19] Gieryn's analysis of scientists and their actions to establish a "rhetorical boundary between science and some less authoritative, residual non-science" focuses on the scientists use of knowledge to demonstrate their superior practices, cement their authoritative power, and construct "a social boundary that distinguishes some intellectual activities as "non-science."[20] Through boundary work, certain knowledge is ruled out.[21]

Expertise. Carlile connects knowledge with expertise/practice by describing knowledge as "localized, embedded, and invested in practice."[22] Carlile suggests a pragmatic view of knowledge (localized, embedded, and invested in practice) and suggests that "knowledge that people accumulate and use is often "at stake." People and groups are reluctant to change their hard won outcomes because it is costly to change their knowledge and skills."[23]

Power. Boundaries and power operate in a recursive configuration where boundaries have material and non material effects on the distribution of power, prestige, and status[24&25] and

[3] Zietsma and Lawrence (2010) argue that boundary work and practice work are interrelated forms on institutional work that interact in a "recursive relationship" (191). This paper acknowledges this concept as enlightening and beneficial to the current study but chooses to fold practice work into the more encompassing concept of boundary work.

a group's power helps to maintain, strengthen, and expand their boundaries. Groups employ oundary work to exert or maintain power by 1) de-legitimizing other groups through expulsive techniques of rhetorical ideological statements, 2) establishing a monopolistic control over a knowledge domain through expansion, and 3) protecting their own autonomy when threatened by external forces.[26] Burri argues that boundary work is used by groups to "accumulate symbolic capital within specific social fields."[27] These exertions of power are particular noticeable during times of what Gieryn calls "creditability contests"[28] and Amsterdamska terms "the legitimatory discourse"[29] as groups attempt to justify their boundaries by laying claim to the authoritative and legitimate nature of their knowledge and practices.

As the credibility contests and legitimatory discourses play out at SPSU between the academic programs of engineering technology and engineering, the crisis centers on the two groups sharing the same bounded space; not physical space (though that is a constant concern between the groups) but the same knowledge and expertise "academic space." The defining difference between the two groups is the power bounded in each group. This power differential is largely influenced by external constituents who either 1) value engineering over engineering technology (engineering licensing boards; large corporate employers) or 2) do not understand the differences between engineering and engineering technology (parents and students) and thus opt for the more well known of the two, engineering.

Engineering Technology in the United States

During World War II, government and industry officials realized that the United States needed a cadre of technically trained support professionals to assist the design and programming engineering profession. Prior to this realization, the technician was housed and trained in the military through apprentice style methods.[30] In response, the federal government "created a series of programs to train technical assistants, and this release engineers, scientists, and industrial managers for higher level technical and supervisory activities."[31] Government and industry officials sought to create an occupational position between the craftsman and the engineer and from this emerged the concept of the engineering technicians or technologist, a term recommended by the American Society of Engineering Education.[32] Many of these educational programs were housed in the newly created technical institutes.

These technical institutes followed a series of boom and bust enrollment cycles.[33] From 1946-54, the programs surged in enrollment with the influx of WWII veterans and the GI Bill. From 1954-57, enrollment stabilized or decreased due to the movement toward humanities and arts by entering college students.[34] In the wake of Sputnik during the 1960s, a shift occurred in engineering programs toward the acquiring of more theoretical knowledge by incorporating additional science and mathematics courses "at the expense of design and application based laboratory courses."[35] This shift by the engineering programs created room for expansion of the engineering technology programs and a resurgence on their enrollment growth. The engineering technology programs responded by expanded into four year degrees and a new occupational position was created; that of the engineering technologist. Ungrodt writes,

> Some of the changes in engineering technology education have resulted from the changes in engineering education. The development of science oriented engineering curricula and the trend toward advanced level programs in engineering, as well as the rapid growth and

development of associate degree programs in engineering technology, have stimulated the development of baccalaureate programs in engineering technology.[36]

Confusion with Engineering

Engineering technology in the United States suffered from a lack of demarcation from engineering. Carr states quite frankly, that "the interface between engineering and engineering technology educational programs is not well defined. The career status of technicians, technologists, and engineers is not understood by educator or employer."[37] This confusion with engineering has not abated over the years. Engineering technology suffers, as an academic and economic discipline, from a lack of clarity about what it is, what its graduates do, and confusion about the boundaries between it and its more powerful and well-known discipline, engineering. Using the paper's theoretical framework for boundary work of knowledge, practice, and power, one can see the how the boundaries between engineering technology and engineering lack demarcation, to the detriment of engineering technology.

Knowledge. ABET, the national accrediting body for engineering and engineering technology programs, defines engineering and engineering technology in the following manner:
Engineering technology is the profession in which a knowledge of mathematics and natural sciences gained by higher education, experience, and practice is devoted primarily to the implementation and extension of existing technology for the benefit of humanity. Engineering technology education focuses primarily on the ***applied*** *aspects of science and engineering aimed at preparing graduates for practice in that portion of the technological spectrum closest to product improvement, manufacturing, construction, and engineering operational functions.*

Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind"

ABET, however, concludes these explanations by stating "Of course, there is much overlap between the fields. Engineers may pursue MBAs and open their own consulting firms, while technologists may spend their entire careers in design capacities."[38] A major problem with such definitions and explanations is that the position of technologists is not used by those in industry as we will see in the section on practice.

Many institutions that offer engineering and engineering technology programs use these definitions as a way of explaining the difference between the two programs on their departmental websites.[4] Robison writes "The statements defining and pointing out curricular differences do not adequately reveal the differences that exist between these educational programs. Only upon close examination of the content, depth and level of each curriculum are the differences between the two curricula apparent."[39] This inability of engineering technology to demarcate itself from engineering translates into difficulties when explaining what engineering technology is to prospective students and parents. Engineering technology's boundary confusion and overlap with engineering is apparent only to academic and accrediting insiders within the field and thus

[4] See UNC-Charlotte http://et.uncc.edu/about-us/engineering-vs-engineering-technology.html; Wayne State University, Pittsburg State University http://www.pittstate.edu/dotAsset/10561.pdf

"many students enter engineering or engineering technology without a clear perception of the differences between engineering and technology curricular and their respective employment opportunities upon graduation."[40]

Expertise: The term "applied" and "hands-on" are the traditional nomenclature of engineering technology. This applied nature of the technology programs manifests itself in laboratory experiences which play a major role in the educational process. Programs in engineering also contain laboratory courses but as Robison points out "those courses in engineering that contain laboratories show strong orientation toward experimentation or research. Technology education places laboratory emphasis on practical applications."[41]

Power: The component of power in the boundary work between engineering and engineering technology, however, does provide demarcation between the two fields, with engineering clearly demonstrating the power differential over engineering technology. In addition to engineering being well known by the general public, a tangible example of this power differential is the requirements for taking the professional engineering (PE) exam for state licensure as a professional engineer. In the state of Georgia (see Appendix 1), a person who has an accredited engineering bachelor's degree may sit for the PE exam after four years of acceptable engineering experience. A person with a bachelor's degree in engineering technology must have seven years of acceptable engineering experience before sitting for their PE exam. Furthermore, only 2/3 of the states in the U.S. allow individuals with engineering technology bachelor degrees to sit for their states PE licensure exam.[42]

Methodology

Data collection involved the historical information on the development on the ET programs at the institution, analysis of the curriculum requirements for the specific ET programs and their comparison with the engineering programs at SPSU, ABET criteria, and other ET programs, an online survey of the ET and engineering faculty members at SPSU, and interviews with SPSU faculty and administrators. Analysis of the historical data will focus on the study's three components of boundary work (knowledge, expertise, and power) and how the ET programs developed their curricular knowledge, emphasized their focus on applied expertise, and managed the power differential with their founder, Georgia Tech, as well as, the larger, more powerful reality of engineering. The curriculum analysis looks as the similarities between the civil and electrical ET programs and their corresponding SPSU engineering programs to demonstrate how close in knowledge and expertise these programs are.

An online survey was sent to all ET and engineering faculty members and can be found in Appendix B. The survey was anonymous and the respondents were only asked to identify themselves as faculty members in ET, engineering, or both. The open-ended questions focus on the similarities and differences between the engineering technology and engineering programs at SPSU, the impact on ET from adding engineering, and the future of the engineering technology programs at SPSU. The survey was emailed to 42 faculty members. Twenty-four faculty members responded; nineteen from the ET faculty, three from the engineering faculty[5], and two who teach in both programs.

Semi-structured interviews were conducted with key personnel from the SPSU faculty and administration. The study interviewed the following personnel from SPSU: the vice president for academic affairs, the dean of the school of Engineering Technology and Management, the dean of Engineering, the department chairs from Civil, Electrical, and Mechanical Engineering Technology, a longtime faculty member from the ET faculty, a faculty member who now teaches in both the ET and engineering programs, and the director of strategic marketing who conducted a marketing programs for the ET and engineering programs.

The questions asked during the semi-structured interviews are similar to the open ended questions asked in the faculty survey. Consistent with the qualitative data analysis recommended by Agar and Siedel[43], the data analysis, with the assistance of the computer software, NVivo, involves a recursive series of noticing, collecting, and thinking about the data. This type of analytic process was not focused on gross analysis and summarization of a category of the data. Rather, it emerged out of preliminary coding and followed the prescription of working with "a little bit of data, and a lot of right brain."[44] The theoretical boundary work of knowledge, expertise, and power provide a framework for these themes and categories.

Findings

Development of Engineering Technology at SPSU

The history of the engineering technology program at SPSU mirrors the developments in engineering technology at the national level. SPSU was founded as the Technical Institute in 1948 as a division of the Engineering Education department at the Georgia Institute of Technology (GA Tech). It was founded in response to the national concern of needing professional technicians to work with engineers in developing the infrastructure and technology of the post-war world.[6] L.V. Johnson, first director of the Technical Institute which would become Southern Polytechnic State University, proclaimed that industry needed these graduates, "Georgia Tech is providing the officers of industry and we (industry) can train the privates of industry, out great need is for the sergeants of industry."[45] The Technical Institute offered its first programs in 1948 to 116 entering students at the Naval Air Station in Chamblee, Georgia. In 1949, its programs were accredited, the institution changed its name to the Southern Technical Institute, and it graduated its first class of engineering technicians. In September 1952, the awarding of associate degrees was approved by USG Regents. In 1954, the Technical Institute was voted into the American Society for Engineering Education. Unlike other technical

[5] In response to recommendations of a reviewer of the paper, the researcher made contact with several engineering faculty members about the low response rate from the engineering faculty. The consistent response from these inquiries was that the engineering faculty saw this issue (dropping ET enrollment) as an ET issue and not an issue for the engineering faculty.
[6] See the 1944 "Report of the Sub-Committee on Technical Institutes of the Engineer's Council for Professional Development." The report indicates that industry required and "can employ at least three times as many technical institute graduates as they can four year engineering college graduates." (3).

institutes in the 1950s, the institution experienced steady growth from 401 students in 1952 to 1194 students in 1958.

In the late 60s when Georgia Tech, along with other engineering schools, was shifting its engineering programs to a more theoretical perspective, the Southern Technical Institute responded by offering bachelor degrees in engineering technology. With this move came a significant event. The Institute was removed from under the Georgia Tech Division of Engineering Extension Division and move under the Georgia Tech College of Engineering.[46] In 1970, it was granted the right to offer bachelor degrees by the Georgia Board of Regents and began graduating its first class of engineering technologists.

In 1980, it formally separated ties from Georgia Tech, changed its name to the Southern College of Technology and became an independent state institution within the University System of Georgia. The Southern Tech faculty has opposed this name of "college" and had proposed the name of Southern Institute of Technology. The administration and faculty at Georgia Tech, however, felt that such a name was too similar to theirs. Georgia Tech objected to the name to the Board of Regents, again demonstrating their continued power over engineering education in the state of Georgia. At this time a significant event occurred. In 1984, The USG Board of Regents was considering expanding engineering education in the state system. Southern Tech lobbied heavily for the opportunity to "upgrade its Engineering Technology programs to offer full engineering degrees" which "set off a firestorm of controversy among the Regents, Chancellor Crawford, and Georgia Tech."[47] No action was ever taken on the matter, again demonstrating the power of Georgia Tech over engineering education in the State of Georgia. This event strongly impacted the curriculum development of the engineering technology programs at Southern Tech. A long time ET faculty member clearly makes the connection, "They *(the ET and engineering programs at SPSU)* are basically the same. SPSU ET programs only existed because the BOR would not allow SPSU to have engineering for fear of competition with Georgia Tech." As a result, the ET faculty began to develop degrees which "copy engineering programs at other schools resulting in similar subjects being covered by both."

SPSU and its engineering technology programs not only mirrored the development of engineering technology programs at the national level, it also suffered from the same external confusion of what its programs were about and who its graduates were. Bennett writes

> Opening any new educational institution is difficult, and the Technical Institute was fortunate to be under the auspices of an established and respected institution. But success would require more than simply attracting students. It was also necessary for Technical Institute officials both to define the profession of "technician" for which they were preparing students and then sell the concept to industry, prospective students, and wary Regents.[48]

It suffered from being seen as a trade school throughout the 1950s and even produced a short film in 1952 to explain the "technician in industry." The institution sought to define its technician graduates as "one who is able to work with the ideas and materials of his profession and to put these ideas and materials into concrete form. Training was less manual than in a vocational school and less theoretical than in an engineering curriculum."[49] During the 1960s, several steps were taken to distinguish Southern Tech from the vocational technical institutes such as adding calculus as a required course for all but one major because "many in the local area do not realize that Southern Tech offers a full college program and is not just another vo-tech." The university has taken many PR and marketing steps to correct this misconception and the situation has improved. However, some faculty feel that the introduction of engineering "has gutted ET since people have a familiarity with what an "engineer" does and are unfamiliar with ET. People very likely do not distinguish between Chattahoochee Tech and Southern Polytech".

Throughout its existence, SPSU has struggled against the more powerful entities of engineering (i.e. Georgia Tech, Society of Professional Engineers), especially in the areas of program offerings and professional licensure. A two track system for professional licensure (The PE (professional engineer) exam) was established with ET graduates having to obtain more years of professional engineering experience before they could take the PE exam. Bennett writes, "At the ECPD (Engineer's Council for Professional Development) Board of Director's meeting in October 1979, it was becoming apparent that 'old core societies' for professional engineering were determined to keep engineering technologists a minority within the professional engineering fields."[50] In 1984 Georgia General Assembly, a House bill that would have excluded engineering technology graduates from Southern Tech from taking the PE exam was narrowly defeated by the Senate. Bennett notes, "However, it demonstrated the continued problem of identity and understanding which had plagued the discipline of engineering technology for decades" and admits that "one of the longest struggles which Southern Polytech has faced is that of identity."[51]

Creating a Similar Knowledge Boundary

As SPSU's engineering technology programs developed over the years, the curriculum began to emulate an engineering degree program rather than a standard engineering technology degree. Appendix C illustrates the similarities between the civil and electrical ET programs and engineering programs at SPSU. Not only do the ET students receive instruction in the same engineering components (statics, engineering graphics, strength of materials) as engineering students, the level of instruction is also similar. The chair of the institution's mechanical engineering technology program comments, "When we teach thermo or statics, we do not use the algebra-based textbook for ET students. We use the calculus-based textbook used in most engineering programs." One faculty member wrote, there is an "attitude of 'let's prove we are as good as the engineers."

In its current iteration, civil, electrical, and mechanical engineering technology degree programs require both calculus II, differential equations, and physics II. These math and science courses are the same courses required by the corresponding engineering programs at SPSU and ET and engineering students sit alongside each other in these courses. Though many other engineering technology programs require calculus II and differential equations, these courses are designed specifically for the ET program and are not the same courses taken by the institution's engineering students.[7] The ET curriculum requirements at SPSU far exceed the standard criteria for accreditation of engineering technology programs by ABET[8] which is a strong source of pride for the ET faculty at SPSU. One ET faculty wrote

> Our programs are much better than other ET programs. Most of our current ET programs are very close to good engineering programs (eg. the level of theoretical difficulty of advanced courses) and they are not close to other ET programs. Other ET programs may not train the students for engineering positions but the managerial or more technical positions. Our program trains them to be engineers.

The elevation of the ET degrees to equivalency with outside ENG degrees corresponds to Gieryn's boundary work concept of expansion where "expansion of authority or expertise into domains claimed by other professions or occupations, boundary work heightens the contrast between rivals in ways flattering to the ideologists' side."[52] Clearly, the knowledge component of the boundary work of engineering technology is the curricular requirements. These requirements and their expected instruction level are the means by which ET makes its boundaries similar to engineering.

Demarcation of Boundaries through Expertise

The level of expertise is where the ET programs at SPSU have long distinguished themselves from the engineering degrees at Georgia Tech and other strictly engineering schools. A long tenured full ET professor states, "our ET graduates are trained for industry and they come out the door running" and industry is concerned about "who gets up to speed faster and it is normally our graduates because of their educational experiences in the labs with hand-on, applied education." This "applied engineering" and getting graduates ready for industry are the hallmarks of SPSU. The institution and faculty have used this component of boundary work as a means of exercising Gieryn's concept of expulsion where "boundary work excludes rivals from within by defining them as outsiders."[53] The expertise of "applied" and "hands-on" educational experience has allowed the ET programs at SPSU to demonstrate their superiority over engineering. An ET faculty member writes

> They (ET degrees) train the students for real engineering jobs. They have hands on courses and students also learn computer packages and programs necessary for the jobs. Employers do not need to train the graduates. The graduates have found real engineering jobs because they have learned both theoretical and hands on stuff. The professors not only have teaching experience but also the industry experience which adds to the quality of teaching. Engineering programs have a long way to go to perfection. They do not teach skills to students.

[7] See Purdue's ET program at http://www.tech.purdue.edu/MET/academics/undergraduate/MET/plan-of-study.cfm or UNC-Charlotte's ET programs at http://et.uncc.edu/undergraduate-programs/electrical-engineering-technology/4-year-academic-plan-of-study.html.

[8] ABET, the engineering accrediting body for U.S. programs, has separate commissions (the Engineering Accrediting Commission and the Technology Accrediting Commission) with separate criteria for accrediting programs in engineering and engineering technology. See ABET 2012. Criteria for Accrediting Engineering and Technology Programs, Website: www.abet.org.

Another ET professor wrote, "The truth is our students have been working as engineers in industry for decades. I would put these students up against any Georgia Tech student when it comes to working in industry as an engineer. Engineering Technology is basically just a different way to become an engineer." For most of its educational history, the ET programs were able to fashion boundaries which were equivalent in knowledge and provide demarcation from "research engineering" through expertise.

A New Reality

The boundary management of maintaining an equivalent knowledge boundary to engineering and demarcating between "applied engineering" and "research engineering" through the boundary work of expertise was more manageable when engineering was located only at Georgia Tech and other institutions. But when engineering programs were introduced at SPSU, the distinction between ET and ENG boundaries became blurred and the boundary work component of expertise no longer sufficed as means of demarcation. A faculty member expressed the sentiment of the majority of responders,

> the programs are way too similar in the way they are currently taught. Entrance requirements for both programs are also the same. Too many students with poor math preparation are being accepted into engineering programs. The engineering programs are using the same terms to describe their programs that have been traditionally the domain of ET programs for decades. This leads to a lot of confusion.

As engineering entered the domain of engineering technology at SPSU, the boundary components of knowledge and expertise became blurred. The knowledge component already was virtually equivalent as demonstrated previously. But now the boundary component that the ET programs had used to demarcate themselves was being usurped by the new engineering programs who sought be less research oriented and more applied.

At this point, Gieryn's concept of protection of autonomy emerged as the two groups fought over the concept of "applied" and "hands-on." The boundary work concept of protection of autonomy is a series of "strategic practical action"[54] that "are mobilized in the service of protecting professional authority against outside powers . . . that endeavor to encroach"[55] upon a group's established authority. A faculty member comments,

> At the moment engineering technology programs are stronger. The programs are around for so many years. They have established a good reputation in industry. We first started the best labs and now Engineering programs are simply piggy back on us. . . . They *(engineering)* have the engineering technology programs as their models and they have kept changing their programs to get closer to the engineering technology programs.

SPSU's director of marketing was asked to develop a marketing program which would help prospective students distinguish between the ET and ENG degree programs. During a meeting with the programs' deans argued over the use of the words "applied" and "hands-on."

> A debate ensued about who owned the word "applied". The ET dean said, "You can't use "applied" because of the ABET decision on such and such a date." The engineering dean replied "But, we are applied. You (ET) are more hands-on. We are more applied." They were using words that sounded different to them but pretty much mean the same thing to anybody else.

Power as Demarcation in the New Reality

Engineering Technology programs nationally has always measured themselves against engineering, though the reverse is not as apparent. Engineering always has maintained the more powerful position. But for most of its history at SPSU, the ET programs have been the premier programs and they have carved a separate reality inside the larger engineering reality. In the larger reality, engineering has the clear power differential and institutions such as Georgia Tech are more prestigious and can easily exert their power over that larger reality. But within the smaller reality at SPSU, the ET programs were powerful. This reality allowed them to develop a knowledge component that separated them from the average engineering technology program and one that made them equal to engineering programs, "an attitude of 'let's prove we are as good as the engineers." They distinguished themselves from engineering programs through the boundary work concept of expertise by educating graduates with applied and hands-on skills who could "step out of the classroom and go to work as an engineer."

Now the smaller reality has changed and engineering has been introduced. The university has tried to maintain an equal power differential between the programs.[9] The university is committed to maintaining its heritage as a leader in engineering technology programs. The deans sit on the same floor in the same new academic building in matching office suites. The ET and ENG programs share the same classrooms and laboratories (though this sharing is a point of contention). The marketing program was to be for both degree programs and not just for the new engineering programs. Yet ET programs have experienced significantly declines in enrollment (see Figure 1) and ENG programs have surpassed the ET programs in enrollment in the areas where there are both ET and ENG programs (civil, mechanical, and electrical). The introduction of engineering program has brought the larger reality into the smaller reality in the form of a competing discipline. Konon notes that "Disciplines are political institutions that demarcate areas of academic territory, allocate the privileges and responsibilities of expertise, and structure claims on resources."[56] The ET faculty's efforts to create and maintain boundaries similar to other engineering programs are now working against them. Now, these knowledge and expertise boundary components only serve to blur the boundaries between the two disciplinary groups. The third component of our boundary work framework, power, has become the means of demarcation.

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[9] Not all ET faculty members believe this to be true. One faculty member wrote, "Most ET programs have seen enrollments slashed, with the exception of IET. Many more new students, especially freshmen, choose E, with more impact on the programs where PE licensure is more critical. E programs have been allowed to cherry-pick ET faculty without regard for the impact on ET programs. The E school is allowed to veto new programs proposed by the ET school, while the ET folks are told to mind our own business if we don't like something E is doing."

Now the larger engineering reality has infiltrated the smaller reality and the power differential associated with the larger engineering reality begins to emerge as the means of demarcation. Carlile writes, "Even when actors have equal ability to use a common knowledge to effectively share and access each other's domain specific knowledge, power is still being expressed."[57] Carlile was speaking about actors sharing knowledge and expertise information across boundaries, but here we have a case where the boundaries are equivalent, the knowledge and expertise common knowledge are the same, the actors have equal ability to share and access that common knowledge, but the power being expressed is coming from an external reality.

> The definition can't just be words either. It must be reflected in policies and entrance requirements. Honestly, most faculty in the programs couldn't really tell you the difference between the programs. They often use generic terminology such as 'highly mathematical' and 'research focused' **but the students are not ignorant. They see what they perceive as identical programs and they go down the path that is most familiar.**

With the introduction of engineering and infiltration of its power differential, a shift has occurred in the boundary work of ET. They have shifted away from expulsion and expansion modes of boundary work toward the mode of protection of autonomy. Gieryn states that when protection of autonomy is the goal of a social group "boundary work exempts members from responsibility for consequences of their work by putting the blame on scapegoats from outside."[58] Comments from several of the ET faculty members reflect this sentiment.

> There is a false perception that ET is less than 'real' engineering. Students are often advised to 'move up' to engineering or, worse, to move down to ET. The truth is our students have been working as engineers in industry for decades. I would put these students up against any Georgia Tech student when it comes to working in industry as an engineer. Engineering Technology is basically just a different way to become an engineer.
>
> Based on the comments made by students, not us: The professors of ET programs are more experienced and they teach engineering courses much better.
>
> We have new, mostly not-yet accredited E programs with nothing to distinguish them from many other programs and among the most highly reputed, accredited ET programs.

The changes proposed by the ET faculty as a mean of delineating between the two programs are 1) establishing entrance or admission requirements to the programs, 2) the engineering programs need to become more theoretical rather than applied, and 3) a repackaging of ET pedagogy through project based education. The ET faculty members are quite adamant that they will not lessen their rigorous curriculum and most are determined to see that "SPSU engineering technology will continue to have a strong mathematical as well as theoretical foundation and continue to build even more on its practical hands on skills." The resistance to alter the program significantly or in words of many ET faculty "dumbing down the curriculum" is understandable as Carlile suggests, "knowledge takes investment-time and resources to acquire-it should be seen as "at stake," indicating the significant cost associated with giving it up and acquiring different knowledge."[59] The ET faculty members have spent years developing their knowledge and expertise, manifested in their own skills and the ET curriculum, and to abandon it, even in face of declining enrollments, would be difficult.

Implications

This study contributes to the better understanding of the interplay between engineering and engineering technology in the field of engineering studies. Engineering technology is an understudied discipline within the field of engineering studies, yet, with over 140 institutions offering degrees in engineering technology, the discipline plays a significant and valuable role in the engineering education and engineering industry within the United States. Though this study's findings are limited to the engineering and engineering technology interplay at SPSU, future studies need to expand the research to include other institutions that offer ET.

This study's use of the concept of boundary work does suggest that the boundaries between engineering technology and engineering need better demarcation. The national trend in engineering technology is to move toward becoming another pathway to engineering[60] and away from the engineering technician/technologist terminology. The Engineering Technology Council has adopted a new slogan that seeks to designate that a degree in engineering technology is an educational pathway to a career in engineering, thus abandoning the concept of an engineering technologist. This new pathway concept will only increase engineering technology's need to develop knowledge and expertise as well as other boundary components in its boundary management that will help construct a viable academic and social space within the field of engineering rather than lead to further confusion. Assuming that engineering will not lose its power differential over engineering technology, the knowledge and expertise components of boundary work become significant for engineering technology. Locally, the engineering technology programs at SPSU are trying to redefine their knowledge and expertise through the revamping their curriculum and pedagogy to a more project based approach to engineering.

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Appendices

Appendix A. Licensure by Examination in the State of Georgia

An applicant may qualify for certification as a Professional Engineer by meeting the educational, experience and examination requirements specified in one of the following subsections of O.C.G.A. 43-15-9:

O.C.G.A. 43-15-9(1)

1. has obtained certification by the Board as an Engineer-in-Training having graduated in an approved engineering curriculum of not less than four years; and
2. has acquired not less than four years of acceptable engineering experience (which may include up to six months experience credit for co-op work); and
3. has made application to the Board and submitted the requisite, non-refundable, fee of $30.00 to the Board (made payable to the Secretary of State); and
4. has made application to NCEES and submitted the requisite fee to NCEES; and
5. has passed a written examination in the principles and practice of engineering (professional engineer examination).

O.C.G.A. 43-15-9(2)

1. has obtained certification by the Board as an Engineer-in-Training having graduated in an an approved engineering, engineering technology, or related science curriculum of not less than four years; and
2. has acquired not less than seven years of acceptable engineering experience (which may include up to six months experience credit for co-op work); and
3. has made application to the Board and submitted the requisite, non-refundable, fee of $30.00 to the Board (made payable to the Secretary of State); and
4. has made application to NCEES and submitted the requisite fee to NCEES; and
5. has passed a written examination in the principles and practice of engineering (professional engineer examination).

Appendix B. Online Survey of ET and ENG Faculty at SPSU.

1. Are you a member of the engineering technology faculty, the engineering faculty, or both?
2. What are the similarities between engineering technology and engineering programs at Southern Polytechnic State University?
3. What are the differences between engineering technology and engineering programs at Southern Polytechnic State University?
4. What are the differences between engineering technology programs at Southern Polytechnic and other engineering technology programs across the nation?
5. How would you differentiate between engineering technology and engineering at Southern Polytechnic?
6. How has the introduction of engineering programs at Southern Polytechnic affected the engineering technology programs?
7. What will the engineering technology programs at Southern Polytechnic look like in five years?

Appendix C. Comparison between Math, Science and Engineering Courses of the Civil and Electrical Engineering Degree and Engineering Technology Degree requirements at Southern Polytechnic State University

ET

CHEM 1211K*	Principles of Chemistry I	4
MATH 2253	Calculus I	4
MATH 2254	Calculus II	4
MATH 2306	Ordinary Differential Equations	3
PHYS 2211	Principles of Physics I*	4
PHYS 2212	Principles of Physics II*	4
ECET 1011	Fundamentals	3
ECET 1100	Circuits I	4
ECET 2110	Circuits II	4
ECET 1200	Digital I	4
ECET 2210	Digital II	4
ECET 3220	Digital III	4
ECET 2300	Electronics I	4
ECET 2310	Electronics II	4
ECET 3410	High Frequency Systems	4
ECET 3400	Data Communications	4
ECET 3500	Survey of Electric Machines	4
ECET 3620	Signals and Systems Analysis	4
ECET 4610	Control Systems	4
ECET 3600	Test Engineering	4
EDG 1210	Survey of Engineering Graphics	2

Electrical Engineering

CHEM 1211K	Principles of Chemistry I	4
MATH 2253	Calculus I	4
MATH 2254	Calculus II	4
MATH 2255	Calculus III	4
MATH 2306	Ordinary Differentials Equations	3
MATH 2260	Probability and Statistics	3

PHYS 2211K	Principles of Physics I	4
PHYS 2212K	Principles of Physics II	4
CSE 1301E	Programming and Problem Solving I	4
ENGR 2214	Statics	3
EE 2301	Circuit Analysis I	4
EE 2302	Circuit Analysis II	3
EE 2401	Semiconductor Devices	3
EE 2501	Digital Logic Design	4
EE 3501	Micro Embedded Systems	4
EE 3605	Electromagnetics	3
EE 3401	Engineering Electronics	4
EE 3702	Communications Systems	3
EE 3601	Electric Machines	3
EE 3701	Signals and Systems	3
EE 4201	Control Systems	4
EE 4701	Professional Practice	3

B.S. in Civil Engineering Technology	B.S. in Civil Engineering
CHEM 1211	CHEM 1211
	CHEM 1212
PHYS 2211	PHYS 2211
	PHYS 2212
MATH 2253 Calculus I	MATH Calculus I
MATH Calculus II	MATH Calculus II
MATH 2306 Differential Equations	MATH 2306 Differential Equations
	MATH 2335 Numerical Methods
EDG 2130 Civil Graphics and Computer Drafting	EDG 2130 Engineering Graphics
	ENGR 3305 Data Collection and Analysis
ENGR 2214 Engineering Mechanics/Statics	ENGR 2214 Engineering Mechanics/Statics
ENGR 3131 Strength of Materials and Lab	ENGR 3131 Strength of Materials and Lab
CET 3210 Cost Estimating and Scheduling	ENGR 3324 Project Cost Anaylsis
CET 4110 Ethics of Engineering	ENGR 4402 Engineering Ethics
CET 3410 Soil Properties /Site Exploration	CE 3703 Geotechnical Engineering and Lab
CET 3210 Structural Mechanics	CE 3204 Structural Analysis
CET 3230 Concrete Infrastructure Design	CE 3203 Design of Concrete Structures
CET 3130 Applied Fluid Mechanics and Hydraulics	ENGR 3343 Fluid Mechanics
CET 4410 Foundation and Retaining Wall Design	CE 4105 Foundation Design
CET 3220 Applied Structural Steel Design	CE 4103 Design of Steel Structures
CET 3510 Traffic Analysis and Road Design	CE 4174 Transportation Engineering
	CE 4178 Highway Design and Construction
CET 3310 Water Treatment and Distribution	CE 3702 Environmental Engineering
CET 3320 Waste Water Collection and Treatment	CE 3703 Environmental Engineering II
CET 4310 Stormwater Management and Erosion	CE 4703 Engineering Hydrology
SURV 2221 Surveying I	SURV 2221 Surveying I
SURV 3421 Geographic Information Systems I	