In Search of Integration: Mapping Conceptual Efforts to Apply STS to Engineering Education

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As David Edge points out in his introduction to the *Handbook of Science and Technology Studies* [1], the field of Science, Technology, and Society (STS) is a diverse enterprise that developed in response to a heterogeneous set of desires ranging from a more rational basis for science policy to the democratization of science and the reform of engineering and science education. In this paper, we focus on STS as it can be *applied* in the practice of engineering to foster both socially responsible and commercially successful innovation. In an academic context, applying STS to engineering practice frequently takes the form of *integrating* a sociotechnical systems perspective *into* educational enterprises such as the major design experience mandated by ABET. Leaving aside the practical challenges of such integration, we focus here on the history of attempts to apply STS to engineering education and begin the process of integrating disparate attempts to apply STS in engineering education. As far as we know, this is the first review paper on attempts to integrate STS into engineering education. Specifically, we report on the exploratory stages of a systematic, empirical analysis of publications using the search functions of the PEER document repository available at https://peer.asee.org. In addition to describing the design of our exploratory study, we focus on three periods of high activity plus some interesting features of the earliest period:

- 1996-1999: Making the Case for a New, Integrative Approach
- 2005-2006: The Importance of Integrated, Sociotechnical Education for Both Engineers and Non-Engineers
- 2010-2011: Demonstrating How Science, Technology, and Society Are Interwoven
- 2017-2018: Embedding Sociotechnical Thinking and Using More Sophisticated Assessment Methods

Exploratory Study Design: Text Mining ASEE's PEER Document Repository

As we define and use the approach here, text mining (1) uses quantitative analysis of a large corpus of publications to uncover "trends in topics over time" [2, p. 5] and (2) assumes that a spike in publications using a particular term signals an important development in the understanding of the topic in question. Although there are numerous limitations to such an approach, the existence of large electronic repositories like ASEE's PEER greatly reduces the labor required to identify significant changes over time. Given the importance of ASEE in engineering education, it seems reasonable to assume that the papers published through ASEE provide a representative, though certainly not exhaustive, view of engineering education in America.

We searched PEER for the phrase "science, technology, and society" in all articles published in the proceedings of ASEE from 1996 through 2018. The initial search yielded a total of 231 items categorized by year, division, topic, and conference. To work with a smaller and more targeted set of papers, we decided to focus on the three periods of high activity described earlier, plus the formative period 1996-1999 when there were very few papers total but which provide insight into the motivations and goals that brought STS into the discourse of ASEE.

Qualitative analysis of the raw search results revealed that some papers are more relevant for our purposes than others. We separated papers based on whether they treat STS as it could be applied in engineering practice. Most of the papers in the "not relevant" group focus on STS in a technological literacy context, that is, in courses designed for students and other groups who are *not* engineers or engineering majors. Many of the papers mention "science, technology, and society" as part of a reference or an author's credentials rather than as a discipline or a conceptual approach. In other cases, not-relevant papers covered topics that are relevant to the practice of engineering or to engineering education broadly but without attempting to inform engineering research and design. After eliminating the not-relevant papers from the relevant ones, we performed qualitative coding of all the papers in the four periods of high activity. Specifically, we looked for how the papers understood and portrayed STS, and what arguments they made about its application to engineering education. We compared the trends found in the relevant and not-relevant papers, as well as in the papers across the four time periods and analyzed the authorship trends in the papers.

Quantitative Results

The quantitative results informed our research in several ways. First, the frequency analysis by year allowed us to identify four time periods on which to focus our qualitative analysis. Figure 1 below summarizes the frequency analysis and highlights the periods in which STS is most visible in the discourse of ASEE.

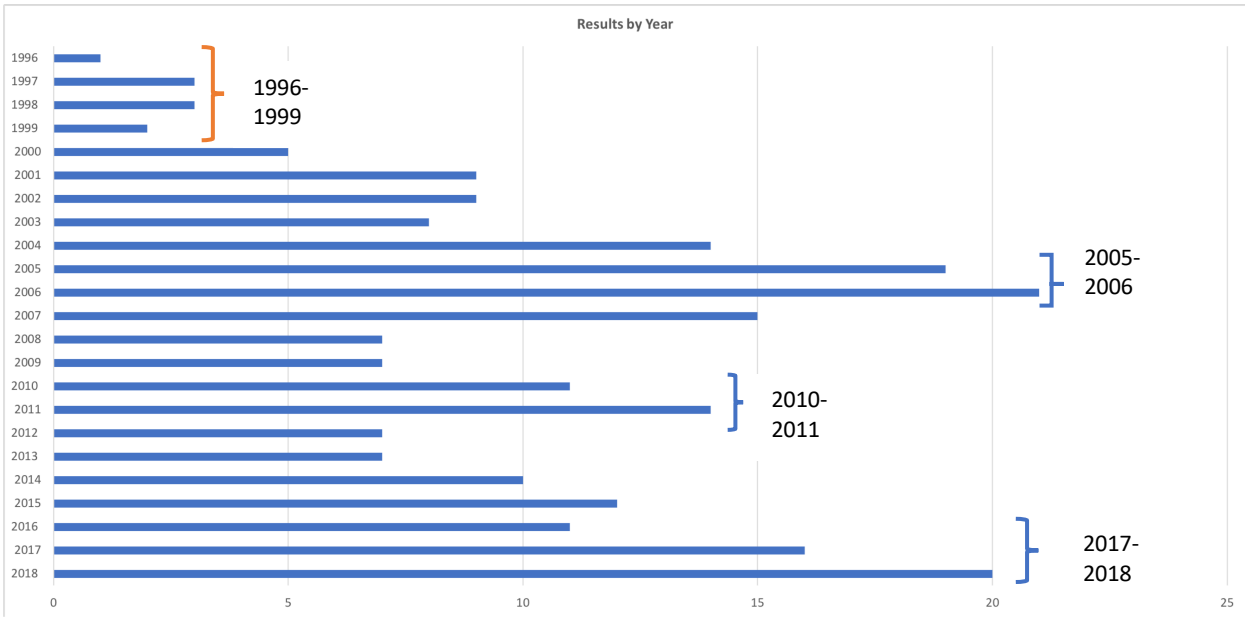

Figure 1: Numbers of papers mentioning "science technology and society" by year, with the emerging time period and the three time periods of high activity that we studied indicated

In this study as in most other contexts, STS is a spectrum of concern and activity, not a clearly delineated body of knowledge or activities. This spectrum is reflected within ASEE in the number of different divisions in which papers on STS have been presented. As Figure 2

illustrates, STS is taken up as a topic broadly across ASEE with greatest concentrations in (a) Technological Literacy and Technological and Engineering Literacy/Philosophy of Engineering (TELPhE) and (b) Liberal Education and Liberal Education/Engineering and Society (LEES). Seven other divisions have also participated significantly in the scholarly discourse about STS in ASEE:

1. Engineering Ethics
2. Educational Research and Methods
3. K-12 and Pre-College
4. First Year Programs
5. Multidisciplinary Engineering
6. Engineering Technology
7. Engineering and Public Policy

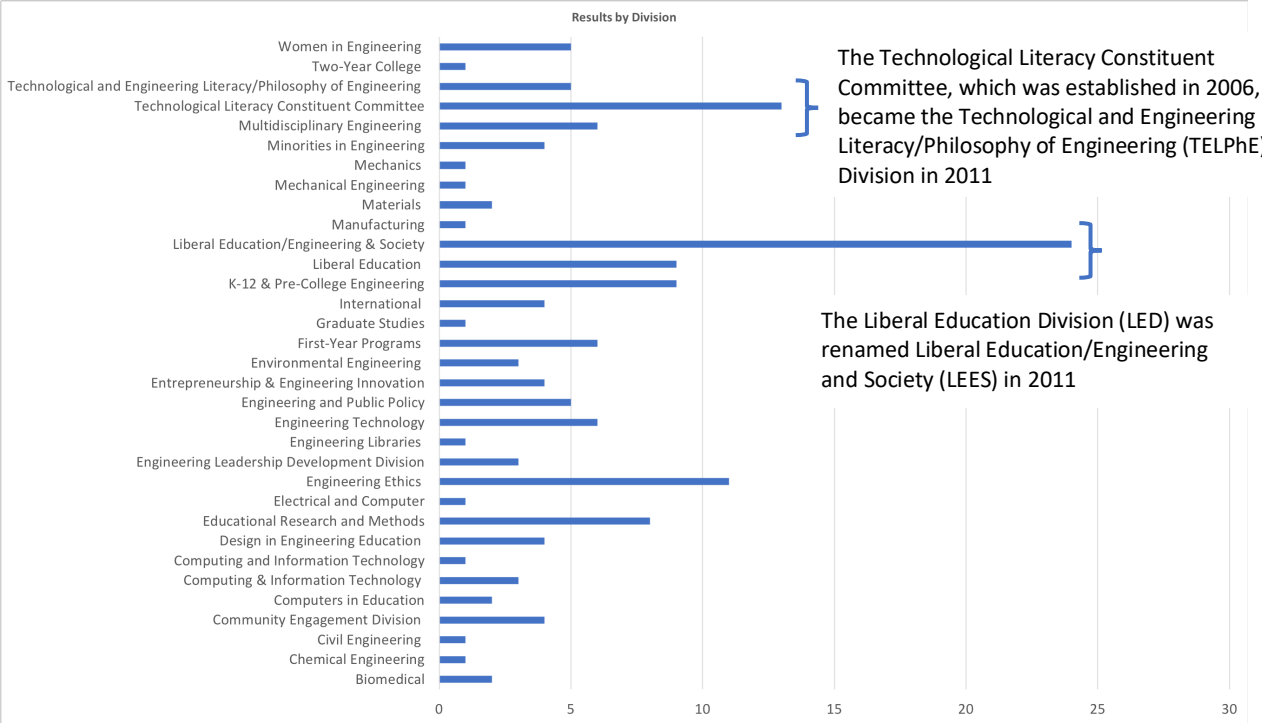

Figure 2: Number of papers mentioning "science technology and society" by ASEE division

Unsurprisingly, all papers do not fall neatly into the categories of "relevant" (applied STS) and "not relevant." One example of difficult to categorize papers is introduction to engineering courses that combine non-engineering majors with engineering majors. For the reasons discussed above and because courses and other educational experiences vary considerably and often in subtle ways, the categories "relevant" and "not-relevant" are somewhat arbitrary and artificial. As the analysis that follows shows, however, they did help us unearth some interesting trends and distinctions, as illustrated in Figure 3. Specifically, we see that (1) the net percentage of relevant papers is uneven but relatively high in the early period (1996-1999), (2) the percentage of not-relevant papers is particularly high in 2005 and 2006, and (3) the net percentage of relevant papers is highest in 2017 and 2018. Additionally, the net percentage of relevant papers

is steady in 2010 and 2011, though not-relevant papers outnumber relevant papers in 2011, the year TELPhE became a division.

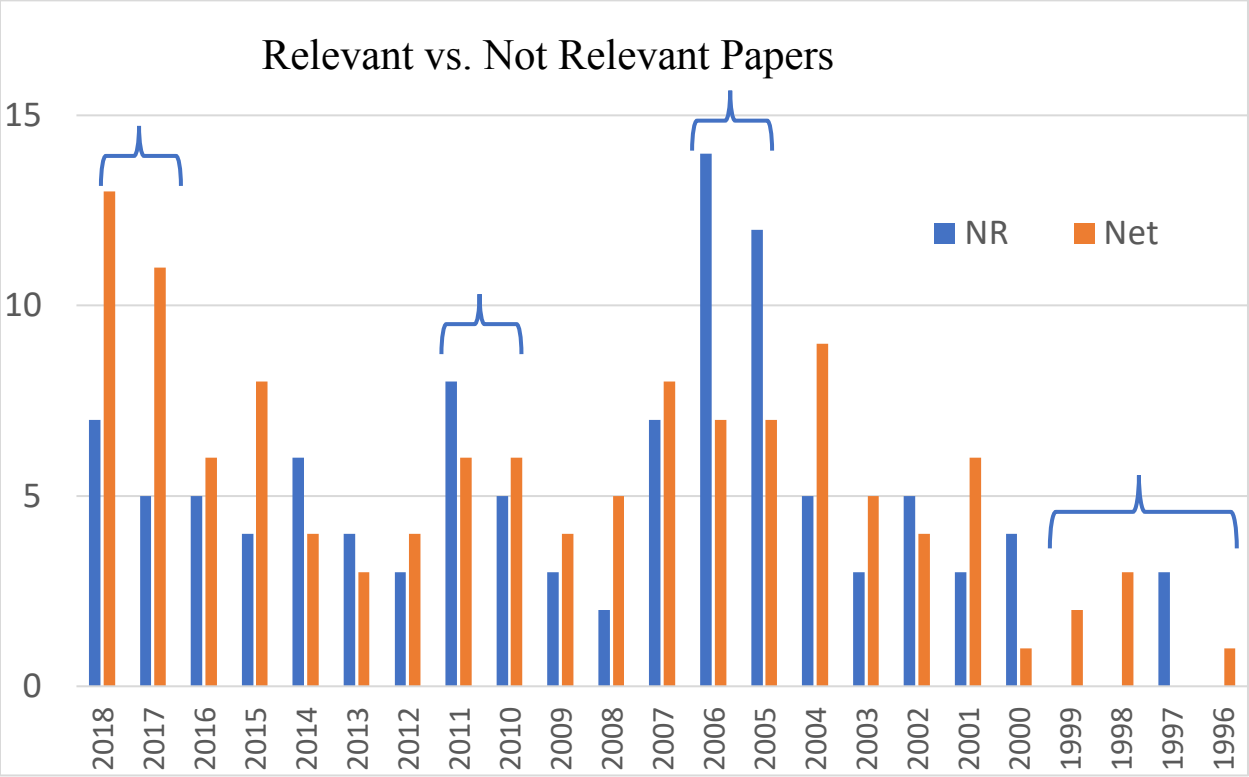

Figure 3: Numbers of papers mentioning "science technology and society" that we deemed relevant or not relevant to our study, i.e., papers that practice applied STS or do not. Our four time periods are marked with blue brackets. NR indicates papers deemed not relevant. "Net" refers to papers that are relevant for our purposes.

To give a sense of the relationship between the relevant papers and the total number of papers retrieved by the search, we calculated the number of relevant (i.e., applied STS) papers as a percentage of the total number of papers retrieved by the search in a given year, as depicted in Figure 4.

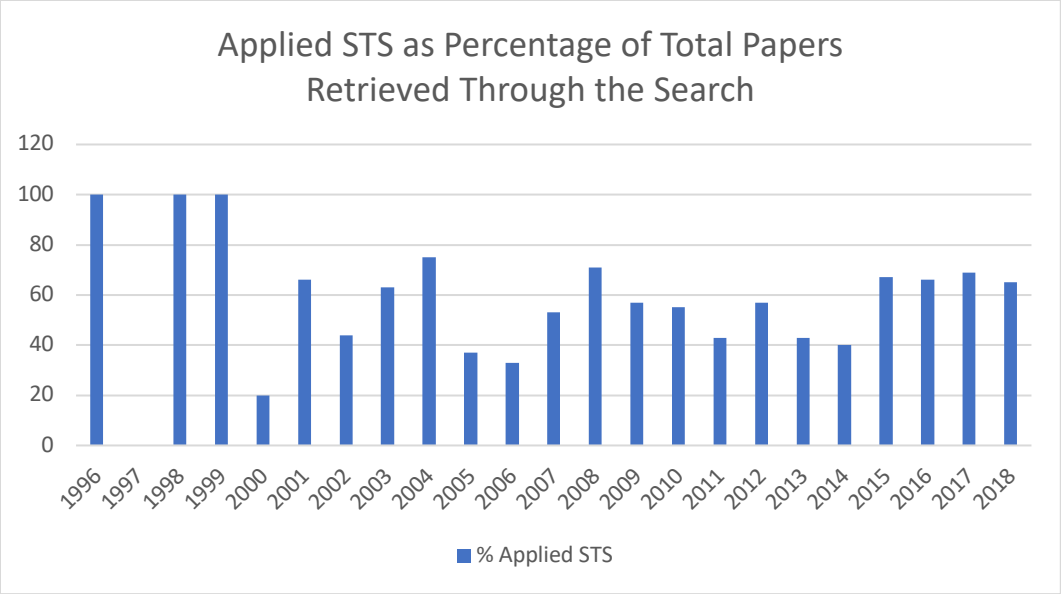

Figure 4: Percentage of applied STS papers of the papers mentioning "science technology and society" by year

To put these percentages in perspective, there was only one paper retrieved in 1996, a total of three papers retrieved from 1997 and 1998, and a total of two papers in 1999. The periods we focused on in our analysis include most but not all of the years in which the percentage of applied STS exceeded 60%. We selected 2017 and 2018 because there are 36 papers total during those two years, as opposed to 23 total in 2015 and 2016.

Qualitative Results by Time Period

1996-1999: Making the Case for a New, Integrative Approach

There are only nine papers total in the earliest of the periods captured in PEER. Despite their relatively small numbers, these papers express ambitions and concerns that become increasingly prominent and more fully developed in the periods of high activity that we say more about below. To various extents, all of the applied STS papers reflect a growing awareness that the new ABET criteria and the emergence of STS (understood as both "science, technology, and society" and "science and technology studies") create new opportunities for non-technical disciplines (typically categorized as humanities and social sciences) in engineering education. The authors of the applied papers all focus on the limitations of disciplinary approaches and often address unintended negative consequences of engineering education as traditionally delivered and experienced.

All of the authors of the applied STS papers are "practice-oriented," sometimes meaning engineering practice (as opposed to engineering science or engineering education) and sometimes referring to pressing, "real-world problems" that engineers could help address or that have in part been caused by technology. The authors argue that practical solutions to these problems require innovative combinations of knowledge and approaches that traditional disciplinary structures cannot provide and that there are many areas of knowledge that are very important for practicing engineering that are not usually emphasized in engineering coursework.

Applying STS to engineering practice takes the form of using ethical reasoning to inform the engineering design process or solving technical and non-technical problems simultaneously. The authors see these integrative approaches as a means of overcoming the incompatibility between traditional disciplinary structures and the problems engineers can contribute to solving. Many of the pedagogical interventions the authors describe are aimed at what might be called "reciprocal change and influence," in other words, having students and faculty from different disciplines (both technical and non-technical) come together to design or take a course with the expectation that all parties involved will learn and be changed for the better through the experience. Sometimes these integrative experiences bring engineering and other STEM students together. At other times, they combine students from all majors at an institution. In yet other cases, the integrative experience is more focused, as in bringing engineering, commerce, and government majors together to gain a comprehensive understanding of policies on the development, use, and regulation of technology. Some of the educational interventions are retrospective (as in looking back in time at things that have gone wrong), but others focus on what might be called "engineering in the making."

One of the common goals of the innovative, integrative educational enterprises the authors describe is to prepare students to identify the goals, values, and organizations that shape and motivate engineering work. A common tool to achieve integration is systems thinking, which sometimes means considering the Earth as a technological system, including all of the relationships among human beings, other organisms, and the physical world. Like the interdisciplinary integration referred to above, the aim of systems thinking is to transcend the limitations of the reductionist and value-neutral approaches that characterize conventional approaches to engineering. As Wiedenhoeft put it in his account of the rationale for the Colorado School of Mines' Nature and Human Values program, "University programs in Science, Technology, and Society (STS) demonstrate efforts to integrate seemingly disparate disciplines, but also show willingness to challenge traditional ways of assessing technical, economic, social, and ecological changes engineers bring about" [3, p. 4].

In addition to viewing STS as an integrative framework that is relevant to engineering, the authors also see STS as providing resources for helping engineers to recognize, appreciate, and engage constructively with differences in perspective. Downey and Lucena (1999) argue that "An unintended consequence of [disciplinary] learning is that engineering education also trains students to devalue perspectives born and living in other fields and locations" [4, p. 4]. This devaluation is particularly problematic given the globalization of engineering that most of the authors see as an important emerging phenomenon. As Wiedenhoeft puts it,"Today, learning how people, societies, and systems of all kinds work implies going beyond the obvious, developing not only understanding but appreciation for the validity of entirely different sets of values. . . .one of the great challenges. . .is to get engineers to accept willingly that there are, indeed, other, very valid paradigms to be seriously considered" [3, p. 3].

Authorship trends in this group of papers, depicted in Table 1 below, reveal that the majority of the papers are authored by interdisciplinary teams or individuals. One type of interdisciplinary individual would be exemplified by the authors who have undergraduate backgrounds in

engineering and graduate degrees in STS, a traditional humanities and social science discipline such as anthropology, or a functional domain such as public policy.

Table 1: Authors' backgrounds 1996-1999 (percentage)

Authors' expertise	Applied STS papers (n=6)	Other papers (n=3)
Cross-disciplinary	67%	33%
STS scholars only	33%	0
Engineers only	0	67%

The three papers in this time period that we deemed not relevant do share some concerns with the applied papers, including recognition of the changes demanded by globalization and a belief in the value of cross-cultural experiences and of integrating technical and non-technical content in educational experiences.

2005-2006: The Importance of Integrated, Sociotechnical Education for Both Engineers and Non-Engineers

Given the history of LEES and TELPhE—and the connection of both to STS—it is not surprising that the numbers of papers mentioning STS in the period 2005-2006 is high in both divisions. TELPhE and its predecessor (TEL) have overlapped considerably with LEES and its predecessor (Liberal Education Division, LED) in membership, topics, and concerns. The early leaders of the technological literacy effort within ASEE, David Ollis and John Krupczak, were professors of engineering who had been active in and served as chair of LED. When the Technological Literacy Constituency Committee was formed in 2006, most of the officers of the new group were also members of LED.

In alignment with the new committee, there is a marked increase in numbers of papers mentioning "technological literacy" in 2005 and 2006. As interest in technological literacy grew within ASEE and, perhaps more significantly, in the National Academy of Engineering and the National Science Foundation, the projects and goals of the two groups diverged, though they were never in competition or estranged from each other. Their interests began to overlap more extensively again when the constituent committee became the Technological and Engineering Literacy/Philosophy of Engineering (TELPhE) Division of ASEE in 2011. One sign of the renewed overlap is "the philosophical turn" in which the TEL group went beyond identifying the knowledge technologically literate citizens needed to possess and began to articulate "the generalizable principles that distinguish engineering from related disciplines and that transcend particular technological milieus" [20, p. 1].

The 2005-2006 ASEE conferences had 39 papers mentioning STS, of which we deemed 15 to be practicing applied STS. Those 15 papers show striking commonalities in their arguments and assumptions about the role of STS in engineering education. Specifically, the general definition of STS that underlies all of these papers is that STS is the idea that technology and society are connected. The authors value this concept as an important way to help engineering students think about their work through big-picture perspectives, including cultural context and globalization. Authors emphasize the importance of this broader perspective in helping students learn to define

design problems in context, as well as learn to solve those problems through iteration and feedback between their design and its intended context. The authors value case studies as tools to demonstrate for students how technology and society interact and the complexity of defining and solving real-world problems. Accordingly, they argue for design projects as important opportunities for students to engage with these complex interactions in practice. Furthermore, authors call for the integration of STS into engineering courses and projects. By STS, they mean a variety of disciplines, i.e., concepts and worldviews drawn from the humanities and social sciences, communication, policy, ethics, and/or business. This approach is broader than the conception of STS as the study of sociotechnical interactions.

The extent to which these 15 papers agree on the meaning and value of STS for engineering education is striking, especially when compared with the 24 papers that we deemed *not* applied STS. These 24 papers vary widely in their arguments and their methodological and theoretical approaches. A third (n=8) of the 24 papers describe courses or programs intended for non-STEM undergraduate majors, as well as K12 and public outreach audiences. They are therefore not practicing our definition of applied STS, i.e., STS for engineers or engineering students. However, it is interesting that these 8 papers share some of the assumptions present in the applied STS papers, specifically the call for integrating technical and social knowledge. Although these authors are concerned with helping non-STEM majors and K12 and public outreach audiences achieve technological literacy, not engineering students, they echo the overall meaning and importance of integrated sociotechnical education that is present in the applied STS papers. The remaining 16 papers do not draw from STS theories or approaches. Most of these papers describe a specific course, project, program, or teaching tool, without making a generalized claim about STS or engineering education.

Authorship trends may reflect the common understanding of STS that is present in the applied STS papers and absent in many of the other papers (Table 2). Half of both groups' papers were written by teams of authors from different disciplines, such as engineering, STS, social sciences, and education. A third of the applied STS papers were written by STS scholars, while a third of the other papers were written by engineers. This discrepancy may explain why the applied STS papers share a worldview that the other papers do not. However, it does not mean that engineers lack an understanding or appreciation for applied STS; on the contrary, 20% of the applied STS papers were written by engineers, in addition to the many cross-disciplinary teams that include engineers.

Table 2: Authors' backgrounds 2005-2006 (percentage)

Authors' expertise	**Applied STS papers (n=15)**	**Other papers (n=24)**
Cross-disciplinary authors	47%	50%
STS scholars only	33%	4%
Engineers only	20%	33%
Education scholars only	0	13%

2010-2011: Demonstrating How Science, Technology, and Society Are Interwoven

Out of the 3,117 papers presented at the ASEE annual conferences in the years 2010 and 2011, only 24 papers mention the term "science, technology, and society." Out of these 24 papers, 11 practice applied STS. These papers explore engineering education by emphasizing how science, technology, and society are interwoven. In 2011, the Liberal Education Division added Engineering and Society to the division name. The revised description of the LEES Division reads,

> This division provides a vital forum for those concerned with integrating the humanities and social sciences into engineering education *via* methods, courses, and curricular designs that emphasize the connectedness between the technical and non-technical dimensions of engineering learning and work. The division is dedicated to helping engineers to develop an ability to communicate effectively, appreciate their professional and ethical responsibilities, and understand the interaction of engineering activities with politics, society, and culture. The division sponsors sessions and maintains a website and welcomes both engineers and non-engineers as members. [5]

The applied STS papers presented at both the 2010 and 2011 ASEE Annual Conferences directly and consistently reflect the mental model suggested by the updated description of the LEES mission in ASEE. Some of the main themes include ethics, global context, the environment, societal context, and ABET. One of the papers that directly addresses the EC2000 standard that graduates "understand the impact of engineering solutions in a global, economic, environmental, and societal context" is Geselowitz and Vardalas' "Using History of Technology to Promote an Understanding of the Impact of Engineering Solutions among Engineering Students" [6]. This paper exemplifies the parallel development of the new accreditation criteria and a greater emphasis within LEES on the interweaving of science, technology, and society.

The authors of the 11 applied STS papers call for the integration of STS into engineering courses, projects, and research. Critical thinking skills about social, global, environmental, and political responsibility create desirable features of an engineer in the 21st century. However, this group of authors points out that these skills are not currently integrated effectively in engineering education. Creating well-rounded engineers requires greater inclusion of courses that are framed around ethics education and application. To accomplish this goal, these authors emphasize the interconnectedness of science, technology, and society. One paper [7] uses a module designed for an STS course and tests this curriculum in the field of environmental science and economics education to verify the transferability of the content, a tactic proven successful by this team of researchers. By using general applications of STS concepts, many authors demonstrate the importance, effectiveness, and successful implementation of STS into engineering education.

Authorship trends, as depicted in Table 3, demonstrate the prevalence of interdisciplinary scholarship. As indicated in the revised description of the LEES Division, it is important to create connections between technical and non-technical aspects of engineering education. Making such connections requires diversity of authorship. The majority of the scholarship comprising cross-disciplinary authors remains a consistent trend. Unlike the other periods of study, this particular time period experiences a decrease in STS only authorship, mostly because

these authors joined cross-disciplinary teams to emphasize the technical and non-technical connections in engineering education. It is evident that the revised description of the LEES Division influenced the scholarship for this time period.

Table 3: Authors' backgrounds 2010-2011 (percentage)

Authors' expertise	**Applied STS papers (n=11)**	**Other papers (n=13)**
Cross-disciplinary authors	55%	54%
STS scholars only	9%	0%
Engineers only	18%	23%
Education scholars only	18%	23%

2017-2018: Embedding Sociotechnical Thinking and Using More Sophisticated Assessment Methods

This time period has 36 papers total, with a high percentage (67%) of them falling into the applied STS category. This high percentage reflects a feature of the early period (1996-1999) that expanded and intensified over time: diversity of academic training and professional experience both within *individual authors* and *within groups of authors.* Many of the individual authors had both STEM and non-STEM training and experience, combining for example, (1) history, political science, and environmental health engineering; (2) public policy and electrical engineering; or (3) education (PhD) and an M.S. in mechanical engineering, 10 years of experience practicing engineering, and a research interest in the history of engineering education. Another type of diversity within individuals is a growing number of faculty with PhDs in engineering disciplines who identify engineering education as a co-equal research area with their technical research. Individuals with this kind of diversity also participate extensively in teams that design courses, degree programs, and assessment tools. The authorship teams themselves appear to be growing larger and more diverse as well. These trends reflect the fundamentally integrative nature of STS as well as a phenomenon mentioned by Downey and Lucena in the 1999 paper [4]: STS scholars taking an interest in engineering and engineering education.

The intellectual diversity of these teams and individuals also manifests itself in one of the other striking features of the scholarship in this most recent period: demonstrating the value of STS approaches for understanding and achieving diversity *within* engineering courses and curricula, as opposed to treating diversity as a peripheral issue of great importance but with little connection to or implications for the content and structure of individual engineering curricula. The quantitative results of our study reveal a significant preponderance of papers whose authors connected those papers to diversity. As Figure 5 below shows, 72% of the papers retrieved through the "science, technology, and society" search are linked with the ASEE Diversity Committee or the topic of diversity. Papers that take substantive approaches to diversity include "Putting Diversity in Perspective: A Critical Cultural Historical Context for Representation in Engineering" [8], "Revealing the Invisible: Conversations about –Isms and Power Relations in Engineering Courses [9], and "Dimensions of Diversity in Engineering: What We Can Learn from STS" [10].

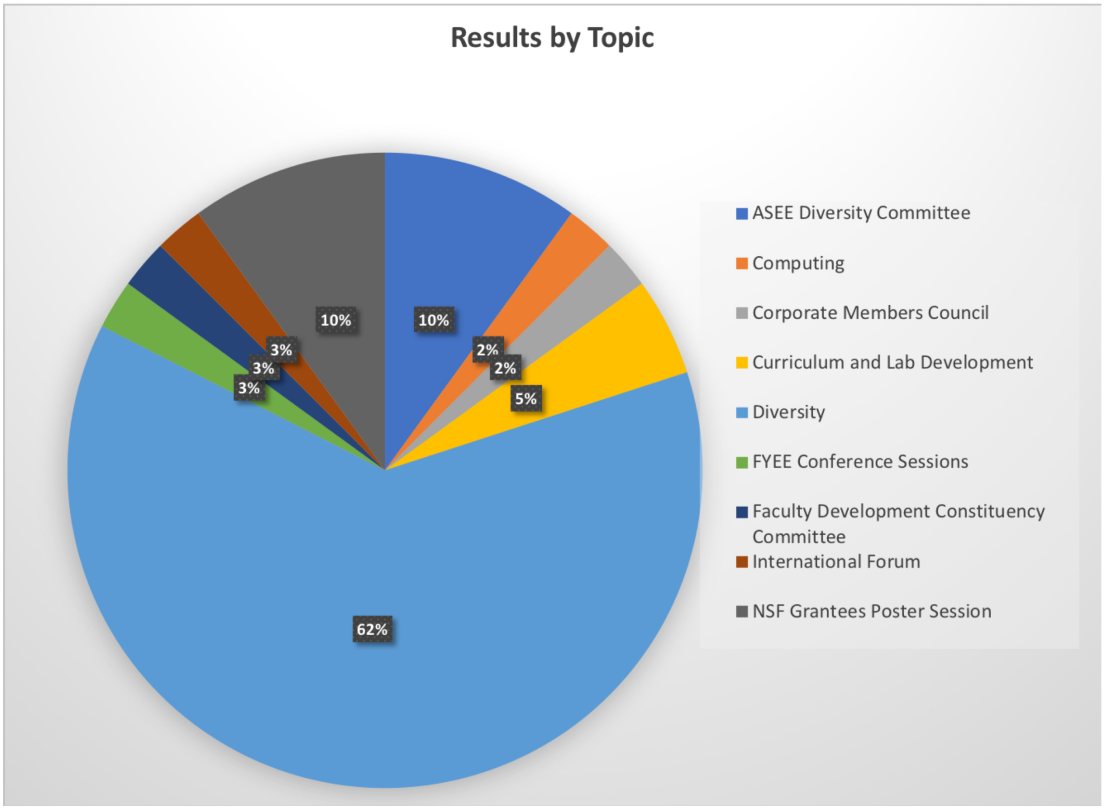

Figure 5: Topics tagged in the papers mentioning "science technology and society" by percentage

The three papers mentioned in the previous paragraph [8] – [10] illustrate other pervasive features of papers in 2017 and 2018: (1) locating their analysis in the context of a broad range of intellectual traditions and frameworks and (2) going beyond the obvious connections between STS and engineering to investigate in detail what is required for meaningful integration of STS perspectives, concerns, and topics into engineering education and practice. In "Which Factors Are Correlated with Engineering Students' Expectations of Ethical Issues?" [11], the authors find that telling students that there is "more to being a good engineer than technical knowhow" is not helpful in increasing ethical awareness among students, nor is emphasizing the importance of ethics in general. What *does* seem to work is highlighting the pragmatic value or usefulness of ethics in specific circumstances of engineering practice.

Most of the applied STS papers in this period illustrate what might be called "embedded sociotechnical systems thinking" and report on the development of increasingly sophisticated tools to assess how students' perceptions and approaches are or are not changed over time as a result of their encounters with applied STS. Some notable papers in this regard are "Measuring Change Over Time in Sociotechnical Thinking: A Survey/Validation Model for Sociotechnical Habits of Mind" [12], "Refining Concept Maps as a Method to Assess Learning Outcomes Among Engineering Students" [13], and "The Whole as the Sum of More Than the Parts:

Developing Qualitative Assessment Tools to Track the Contribution of the Humanities and Social Sciences to an Engineering Curriculum" [14].

This group of papers also exhibits consistent concern with socially responsible innovation (SRI), and ethics and social impacts (ESI). Both SRI and ESI establish a connection between the kind of critical thinking that STS encourages and the creation of innovative products and processes that are ethically responsible and also commercially successful. In addition to integrating SRI, ESI, and related concepts into engineering courses and curricula, the initiatives reported in the papers focus on technology entrepreneurship as a domain in which STS can be a valuable resource. Papers exemplifying these concerns and emphasizing the intersection between STS and innovation include "Evaluating Innovations from a Critical Thinking Approach" [15], "Ethics and Responsible Innovation in Biotechnology Communites: A Pedagogy of Engaged Scholarship" [16], "Invitro Fertilization (IVF) as a Sociotechnical System: Using Actor-network Theory (ANT) for Teaching Undergraduate Engineers about the Ethics of Assisted Reproductive Technology (ART)" [17], "Precaution and Evidence: Legal Systems as Context Factors of Engineering Innovation and Entrepreneurship" [18], and "The T-Shaped Engineer as an Ideal in Technology Entrepreneurship: Its Origins, History, and Significance for Engineering Education" [19].

Closing Observations and Future Work

STS, then, appears to have been integrated into the discourse of ASEE as a set of strategies for locating engineering projects in the broader context of sociotechnical systems. The authorship trends we document here suggest that the engagement of STS scholars with engineering and engineering education has been a crucial part of developing applied STS and integrating it effectively into engineering curricula. Individuals who are themselves integrative and interdisciplinary, especially those who combine engineering backgrounds with STS or humanities and social sciences advanced training, seem to have played a leading role in the development of applied STS. The increasing size and diversity of the collaborative teams working in STS seems to have accelerated the growth and rigor of applied STS.

Although the impetus provided by EC2000 created an incentive for rethinking the role of general education in engineering education, it appears that much of what motivated the integration of STS in the discourse of engineering education was a combination of external developments (such as globalization and high profile technological disasters such as the *Challenger* explosion and Three-Mile Island) and a growing recognition within higher education, including engineering education, of the inadequacy of traditional disciplinary structures for providing useful approaches to real world problems. The ethical dimensions of engineering work are rarely visible at the level of individual projects or in the decontextualized environments of engineering classrooms and laboratories. As Martin and Schinzinger expressed it in their discussion of engineering as social experimentation, "Showing moral concern involves a commitment to obtain and properly assess all available information pertinent to meeting one's moral obligations. This means, as a first step, fully grasping the *context* of one's work, which makes it *count* as an activity having a moral import" [20, p. 90, emphasis in original]. Moreover, as Deborah Johnson's distinguished lecture at the 2018 Annual Conference of ASEE demonstrated, ethical responsibility on the part of practicing engineers requires an understanding of the contingent and usually convoluted sequence of events through which technological innovations translate (or not)

into into both desired outcomes and unintended negative consequences. STS provides tools and intellectual frameworks for tracing and anticipating those potential outcomes.

As we indicated at the outset, the work reported here is the result of an exploratory study. The 4 periods we focused on are only a fraction of the 22 years total that PEER allows us to search electronically, and our examination of the papers within each period was necessarily confined to the most obvious features of the papers and their authorship. While we have established some correlation between the trends in publication and events outside of ASEE, those connections should be explored in much more depth. We could conduct a more rigorous assessment of the limits of PEER's searching capabilities and of our choice of the phrase "science, technology, and society." Since the acronym STS refers to "science and technology studies" as well as "science, technology, and society," it is possible that our choice of "science, technology, and society"excluded papers coming from a science and technology studies perspective. To test that possibility, we also conducted a search using the terminology "science and technology studies." The results of that search are reported in Appendix A. The numbers and trends in those results are similar to but not identical with the results for "science, technology, and society." These similarities and differences should be the focus of future work but do not appear to undermine the conclusions we reach here. In the course of our analysis, we also noticed that some papers published in 2018 that fell into the applied STS category were not included in the search results. It is possible that a search for the word "sociotechnical" would produce more comprehensive results. We could also draw more on the experience of ASEE members who were instrumental in some of the changes we described here in constructing an account of how STS as been applied in engineering education.

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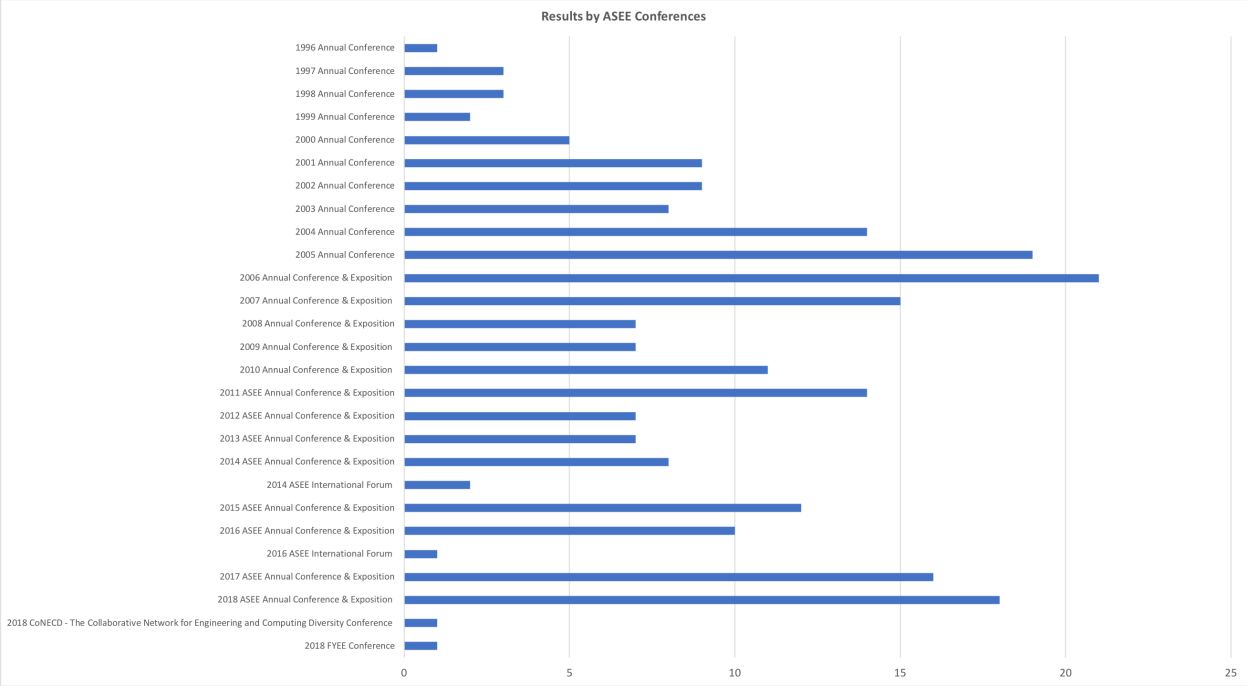
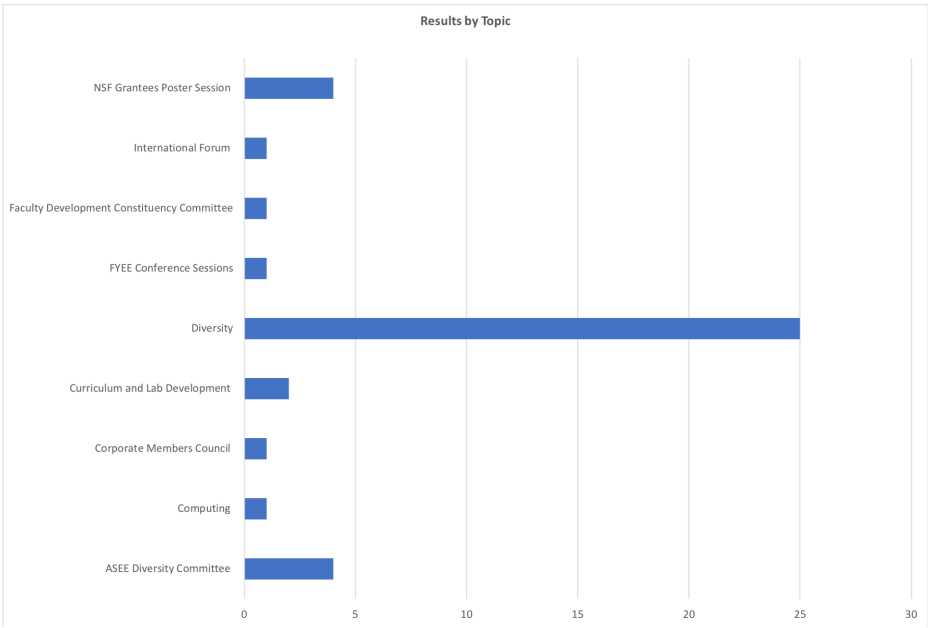
Appendix A. Search Results Not Focused on in Analysis





Search Results for "science and technology studies"

- 2018 (27)
- 2017 (24)
- 2016 (28)
- 2015 (25)
- 2014 (15)

- 2013 (9)
- 2012 (6)
- 2011 (16)
- 2010 (9)
- 2009 (4)
- 2008 (3)
- 2007 (3)
- 2006 (6)
- 2005 (2)
- 2004 (3)
- 2003 (1)
- 2002 (2)
- 2001 (2)
- 2000 (1)
- 1999 (1)

Results by Division

- Civil Engineering (1)
- Community Engagement Division(8)
- Computing & Information Technology (1)
- Continuing Professional Development (1)
- Design in Engineering Education(6)
- Division Experimentation & Lab-Oriented Studies (2)
- Educational Research and Methods (13)
- Electrical and Computer (2)
- Engineering Design Graphics (2)
- Engineering Economy (1)
- Engineering Ethics (21)
- Engineering Leadership Development (1)
- Engineering Leadership Development Division (1)
- Engineering Physics & Physics (1)
- Engineering Physics and Physics(1)
- Engineering and Public Policy (2)
- Entrepreneurship & Engineering Innovation (2)
- First-Year Programs (2)
- Graduate Studies (2)
- International (9)
- K-12 & Pre-College Engineering(2)
- Liberal Education (5)
- Liberal Education/Engineering & Society (53)
- Manufacturing (1)
- Mechanical Engineering (1)
- Mechanics (1)
- Minorities in Engineering (1)
- Multidisciplinary Engineering (3)
- New Engineering Educators (1)
- Pre-College Engineering Education Division (2)
- Student (1)
- Systems Engineering (1)
- Technological Literacy Constituent Committee (3)
- Technological and Engineering Literacy/Philosophy of Engineering (7)

- Women in Engineering (11)

Results by Topic

- ASEE Diversity Committee (1)
- ASEE Global Programs (1)
- Diversity (45)
- FYEE Conference Sessions (1)
- International Forum (1)
- NSF Grantees Poster Session(12)
- Pre K-12 Education (1)
- Student and Curriculum Development (1)
- Undergraduate Education (1)