



## Representations of 'The Public' in Learning Through Service (LTS) Versus 'Mainstream' Engineering Foundational Professional Documents

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# Representations of “the Public” in Learning Through Service (LTS) Versus “Mainstream” Engineering Foundational Professional Documents

## Abstract

“Benefitting society” is a core value in engineering, but the branch of the profession called Learning Through Service (LTS) promotes specifically the teaching of engineering *through service* – that is, through collaborative, respectful, and mutually beneficial relationships with “the public.” Guided by a theoretical framework of “social imaginaries,” this paper sets out to explore what the most prevalent LTS conceptualizations of “the public” are, and whether and how these conceptualizations differ from conceptualizations of “the public” in “mainstream” engineering. The premise of this research is that *how* LTS practitioners conceive of “the public” likely informs their conceptions of self, professional duty, professional right, and work with communities; and that knowing *what* imaginaries of “the public” LTS education fosters is important for throwing into relief ideologies that may underlie the critical, but often unseen and unstated, boundary between LTS and society.

Results are provided from a content analysis of 14 engineering documents, chosen for their representational value vis-à-vis the engineering profession’s identity, priorities, vision, and perceived relationship with society. The documents include National Academy of Engineering (NAE) reports, ABET accreditation criteria, disciplinary “Bodies of Knowledge,” engineering codes of ethics, and organizational/programmatic brochures. Qualitative data analysis was used to identify prevalent themes in representations of “the public” across all documents. Emerging codes were broadly categorized into six themes: a) characterizations of “the public,” b) professional duties related to “the public,” c) relationship between engineers and “the public,” d) societal problems in need of engineering solutions, e) engineers’ “social footprint” over time, and f) vision or mission statements. In LTS documents, the three most prevalent codes all fell under the third theme, “relationship between engineers and ‘the public.’” They were that engineers a) benefit “the public,” b) relate to “the public” in a collaborative way, and c) have a significant impact on the work of professionals outside engineering. The first of these three codes – that engineers benefit “the public” – was the most prevalent, by far, in both LTS and “mainstream” engineering documents. However, references to “the public” as unable to meet its basic needs, engineers as problem solvers, and engineers as benefitting the public were more common in the former group of documents than in the latter.

The paper closes with a discussion about the potential implications of our findings for both the LTS community and the diverse publics that the engineering profession aims to serve. One of the main questions it raises is whether LTS imaginaries of “the public” depart sufficiently from “mainstream” engineering imaginaries to foster collaborations that “the public” itself recognizes as respectful and beneficial. We view our findings as a step toward deeper understanding about how the LTS community’s construction of “the public” might enhance or weaken engineering practice and, ultimately, how it might support or undermine LTS engineers’ commitment to promote the social good.

## Introduction

*In the public discourse the words 'engineering' and 'science' are often used interchangeably but, as any scientist or engineer will confirm, they are often entirely different pursuits. Science discovers and understands truths about the greater world... Engineering, for its part, solves problems for people and society.*

-C.D. Mote, Jr.  
President, National Academy of Engineering<sup>1</sup>

*Historically, the undertaking of service projects – engaging marginalized individuals or communities in improving some facet of their lives – has been viewed by many as simply doing 'nice things for poor people'. [...] Showing 'solidarity with the poor' and making a human connection are necessary to sustain hope and thus affect change, and are powerful and essential elements in 'making the world a better place' <sup>2</sup> [p.6].*

-T. Colledge  
Editor-in-Chief, *Int'l Journal for Service-Learning in Engineering*

Engineers as “benefactors” to society is a core value of engineering and central to how the profession identifies itself both to its own members and to those on the outside<sup>3</sup>. As in the quotes above, the intended beneficiary of the profession’s technical solutions is “the public.” This category, however, is ambiguous. We submit that exploring the meanings it carries can provide insight into how engineers imagine their purpose; the social order; their own position, role, duties, and rights in this order; and ultimately their vision of what constitutes “effective” and “successful” applications of their technical expertise.

Drawing on the work of philosopher Charles Taylor, this paper employs a theoretical framework of “social imaginaries,” a concept defined as “the ways people imagine their social existence, how they fit together with others, how things go on between them and their fellows, the expectations that are normally met, and the deeper normative notions and images that underlie these expectations”<sup>4</sup> [p.106]. Unlike well-articulated worldviews, social imaginaries comprise an almost subconscious collective vision. As such, they surface in everyday forms of life (e.g., stories, images, social mores, routines) in ways that are experienced as “natural,” if not the only arrangement of social life possible.

The research herein is part of a larger project on engineers’ imaginaries of “the public,” which aims to shed light on the texture of the elusive boundary that the engineering profession raises between itself and society. Our ultimate goal is to begin to answer the following questions: What distinctions, values, and interests might this boundary promote? What impact might it have on engineers’ sense of self, applications of technical expertise, and, by extension, relationship with society? How does the engineering profession’s construction of “the public” enhance or weaken engineering practice and, ultimately, how might it support or undermine engineers’ commitment to promote the social good?

A prior content analysis of 14 foundational engineering documents – chosen for their representational value vis-à-vis the engineering profession’s identity, priorities, vision, and perceived relationship with society – identified the code that engineers *benefit* “the public” as the most prevalent overall based on the total number of coded segments across all 14 documents.

The second and third most prevalent codes were that engineers *solve problems* and that they must “benefit or improve engineering” by *building or sustaining their profession’s public image*<sup>3</sup>. Dominant characterizations of “the public,” were as members of “developing” countries and as “lacking information” about what engineering is and engineers do. Our analysis highlighted imaginaries of “the public” that privilege engineering knowledge, perspectives, and priorities over and above the knowledges, perspectives, and priorities of non-engineers – and especially over and above the knowledges, perspectives, and priorities of the publics engineers aim to serve. We concluded that:

...it seems possible, if not likely, that the engineering profession’s desire to help “the public” and maintain authority, when put into practice can draw and redraw a boundary between engineering and non-engineering worldviews that positions the former above the latter, naturalizing an epistemic hierarchy. This hierarchy places the engineering profession in charge of how it serves society, leaving it vulnerable to the circular premise that what engineers do promotes the social good just because they are engineers. It, therefore, seems that at the heart of engineers’ imaginaries of “the public” might lay a paradox. Namely, that the engineering profession’s identity vis-à-vis “the public” may systematically silence public voices, and thus at times undermine the profession’s aspiration to promote the social good in ways that diverse – and especially marginalized – publics experience, recognize, and celebrate as promotions of the social good. By extension, this identity might compromise the profession’s capacity to secure “the public’s” trust in engineers as professionals who can be relied on to, indeed, make the world “a better place”<sup>3</sup> [p. 26].

LTS is an approach to engineering education that emphasizes teaching engineering through collaborative, respectful, and mutually beneficial relationships with communities. It stems from a scholarly tradition that is rooted in the social sciences and that promotes principles of equity and justice. Distinguishing itself from exploitative or simply transactional relationships between professionals and “the public,” it extols the potential of service-centered learning to facilitate community empowerment and transformation in the form of social, institutional, and structural change. In engineering, LTS challenges the historical roots of the profession as a tool for colonialism and domination and strives for a new relationship with society that supports diverse, and especially marginalized, communities to realize their own goals<sup>5,6</sup>. It places students into settings where they typically interact directly with non-engineering partners such as non-profit organizations, schools, and impoverished or marginalized communities, domestically and internationally, in order to achieve the joint goal of student learning and community empowerment. Unlike “mainstream” engineering, LTS is based on sustained contact between engineers and “the public” in which local values, culture, and knowledges are, at least in theory, highly valued<sup>7,8,9</sup>.

LTS is an umbrella term, encompassing both curricular (such as Service-Learning) and co-curricular (such as Engineers Without Borders – EWB) educational approaches that marry student learning with community development through engineering projects<sup>10</sup>. As such, LTS presents a unique sub-culture, which defines itself through a strong and clearly articulated commitment to applications of technical expertise that occur *in relationship with* “the public.” This paper sets out to explore *how* LTS practitioners conceptualize “the public” in order to identify where these conceptualizations converge with or diverge from imaginaries of “mainstream” engineering; what social order they might promote; what values they might reflect; and what impact they might have on LTS engineers’ work and, by extension, relationship with society. In the end, we aim to gain a better understanding about whether the branch of the

engineering profession called LTS cultivates imaginaries that echo LTS's articulated values of equity, justice, empowerment, and transformation and bring engineers closer to the publics they aim to serve. Ultimately, we are interested in determining whether LTS aligns itself more closely with diverse publics' articulations of their *own* visions, definitions of their *own* needs, and visions of the role of technological applications in their *own* lives, and whether this alignment supports better or more consistently the engineering profession's aspiration to promote the social good.

## Methods

The following section describes the documents used for this exploration, justification for the sources chosen, and a description of the methods used to code and build consensus on the coding. We acknowledge that our analysis is based on a small number of documents – three from LTS and 11 from “mainstream” engineering – which at first glance might seem inadequately representative of the whole of LTS or “mainstream” engineering. Even though it is possible that examination of additional documents would yield a more comprehensive list of prevalent themes in representations of “the public,” our selection, as we discuss below, was based precisely on the documents' representational value. In other words, the 14 documents we studied were all produced by institutions or individuals perceived as “authoritative voices” of the engineering profession or LTS.<sup>1</sup> Although we do not suggest that other documents representing LTS and “mainstream” engineering do not exist, we focused on these documents because they provide officially sanctioned or authoritative depictions of the “essence” of the engineering profession and LTS, as well as of the nature of the boundary that separates these fields from society. As such, we posit that they have a defining impact on LTS's and “mainstream” engineering's imaginaries of “the public.”

### *Data Set*

Fourteen documents formed the foundation of this analysis, broadly chosen to represent four categories: 1) LTS literature and organizational statements (LTS), 2) Professional society “bodies of knowledge” and vision statements (BOK/Vision), 3) Professional codes of ethics (COE) and 4) Profession-wide position statements (Prof-wide Position). Table 1 below details the names of these documents and justification for their selection. An earlier paper provides information on the number of pages reviewed per document, the number of distinct codes used per document, and density of coding (i.e., total number of coded segments and codes assigned to each segment)<sup>3</sup> [Table 1].

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<sup>1</sup> For example, “mainstream” document authors include the National Academy of Engineering (NAE), American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronics Engineers (IEEE), ABET accrediting body, and the National Society of Professional Engineers (NSPE). LTS document authors include Thomas H. Colledge, co-founder and managing editor of the *International Journal for Service-Learning in Engineering*; Angela R. Bielefeldt and Joshua M. Pearce, engineering professors at the forefront of LTS implementation into the classroom and research on the effects of LTS on engineering students; Purdue University's EPICS program, one of the first and most renowned LTS programs in engineering education; and Engineers Without Borders (EWB), one of the largest co-curricular and international LTS programs in the US, with both student and professional chapters.

Table 1. Justification for document selection

Document Category	Document	Justification
Learning Through Service (LTS)	<u>Colledge (Ed.) – Convergence: Philosophies and Pedagogies for Developing the Next Generation of Humanitarian Engineers and Social Entrepreneurs<sup>2</sup> – Introduction and Chapters 1 &amp; 2</u>	A collection of perspectives on LTS by early adopters and thought leaders of this pedagogical approach. A synthesis of articles that forms a distilled view of what LTS and its promise in engineering are. A book that was published by the International Journal for Service Learning in Engineering, the main journal about LTS in engineering.
	<u>Engineers Without Borders (EWB-USA) Strategic Plan 2015-2020<sup>11</sup></u>	A critical document for how a leading organization in the development and implementation of LTS sees its role in the interaction between engineers and traditionally marginalized communities. EWB-USA has had a significant impact on the spread of LTS in engineering, specifically through international service projects that are part of co-curricular activities. As such, it plays an important role in shaping many engineers’ conceptualizations of LTS.
	<u>Engineering Projects in Community Service (EPICS) Program Overview Website<sup>12</sup></u>	A definitional document describing LTS from the perspective of the EPICS program at Purdue University. EPICS was one of the first formalized initiatives that integrated LTS as a program into engineering education. Positioned at one of the largest engineering departments in the US, thousands of students have gone through EPICS, which is now adopted by over 30 universities and colleges as well as K-12 schools. Similar to EWB-USA, EPICS places students in direct contact with “the public” through community development projects and, therefore, represents both an early and a widespread perspective on LTS and “the public.”
Professional society “bodies of knowledge” and vision statements	<u>American Society of Civil Engineers (ASCE) Body of Knowledge V.2<sup>13</sup></u>	A discipline-specific representation of the key values, aspirations, and worldview of ASCE as well as a guide for civil engineering departments, which train future generations of civil engineers. Because of its specialization in civil infrastructure projects and public safety, civil engineering is often seen as the engineering discipline most closely tied to society.
	<u>ASCE – The Vision for Civil Engineering in 2025<sup>14</sup></u>	A discipline-specific document that sets forth a long-term vision for civil engineering as a discipline and considers the roles civil engineers will play in the future in relation to, among other things, society.
	<u>American Society of Mechanical Engineers (ASME) – 2028 Vision for Mechanical Engineering<sup>15</sup></u>	A discipline-specific document that sets forth a long-term vision for mechanical engineering as a discipline and considers the roles mechanical engineers will play in the future in relation to, among other things, society. Mechanical engineering is the largest of the engineering disciplines.
	<u>Institute of Electrical and Electronics Engineers (IEEE) Strategic Plan 2015-2020<sup>16</sup></u>	A discipline-specific document that details the future, and future role in society, of IEEE. After mechanical and civil engineering, IEEE is the third largest engineering discipline <sup>17</sup>
Codes of Ethics	<u>ASME Code of Ethics<sup>18</sup></u>	An official prescription of “proper” versus “improper” professional behavior for mechanical engineers, containing both aspirational and preventative ethical guidelines as well as implicit and explicit references to “the public.”

	<u>ASCE Code of Ethics</u> <sup>19</sup>	Similar to above. Civil engineers may see “the public” differently given the nature of their projects in civil infrastructure and public safety.
	<u>National Society of Professional Engineers (NSPE) Code of Ethics</u> <sup>20</sup>	Similar to above, but applicable to all engineers
Profession-wide Position Statements	<u>ABET Criteria for Accrediting Engineering Programs</u> <sup>21</sup>	A document detailing the officially sanctioned accreditation criteria by ABET, which are used as a guiding framework for assessing the quality of the education provided and qualifying most US engineering programs.
	<u>National Academy of Engineering (NAE) – Changing the Conversation: Messages for Improving Public Understanding of Engineering</u> <sup>22</sup>	A document speaking directly to the relationship between engineers and “the public.” The NAE is an introspective and guiding body in the engineering profession, representing the collective experience and aspirations of the profession’s leaders.
	<u>NAE – The Engineer of 2020: Visions of Engineering in the New Century</u> <sup>23</sup>	A centralized vision for how the engineering profession fits within the changing social context of the 21 <sup>st</sup> century.
	<u>NAE – Educating the Engineer of 2020: Adapting Engineering Education to the New Century</u> <sup>24</sup>	A guide for implementing an officially sanctioned vision for the engineering profession of the future, including the profession’s relationship with “the public,” through changes in engineering education.

### *Coding*

All 14 documents were independently coded by at least two reviewers using a shared code book. This code book was developed by three reviewers using emergent coding techniques <sup>25</sup>. The reviewers initially coded three documents. Their three preliminary sets of codes were then compared – similar codes were merged, while idiosyncratic ones that were deemed too detailed or too tied to one specific document were eliminated. The end result was the final code book, which comprised 99 codes broadly organized into six themes: a) characterizations of “the public,” b) professional duties related to “the public,” c) relationship between engineers and “the public,” d) societal problems in need of engineering solutions, e) engineers’ “social footprint” over time, and f) vision or mission statements. All 99 codes are shown in the appendix.

The finalized code book was used to analyze the remaining 11 documents, with the base unit of analysis being single paragraphs or entire bulleted lists. Once all 14 documents were coded, the inter-rater reliability for each document and each corresponding set of reviewers was determined using Cohen kappa values. Codes with kappa values greater than or equal to 0.6 were considered to indicate acceptable agreement <sup>26</sup>. Codes with kappa values less than 0.6 were reexamined by two of the reviewers who studied each segment that was assigned to those codes and collaboratively determined if the assignment was appropriate or not. In those cases where the reviewers deemed the assignment appropriate, they kept the code, whereas in those cases where they deemed the assignment inappropriate, they removed the code.

This three-tiered coding approach was used to instill confidence in the code application, given the varying degrees of experience between the three reviewers and the significant volume of coding involved (929 pages and over 4600 individual codes applied to document segments). For a more detailed explanation of the coding process, see <sup>3</sup>.

## Results

The results are organized by the six broad themes used to categorize the codes. The three LTS documents are compared to the 11 “mainstream” engineering documents, which are clustered together as a unit. Three metrics are used for the comparison:

- **Number of documents:** The number of documents in each unit (LTS versus “mainstream” engineering) that contained each code. This metric shows how prevalent a code was among the individual documents in each unit (e.g., whether it appeared in just one document or the majority of the documents in the unit). Codes assigned to only one document are highlighted with colored shading in Tables 2-6. In light of the fact that these codes may represent the particular bent of specific authors and not a trend in LTS or “mainstream” engineering documents, we report their prevalence with caution.
- **Raw count:** The raw count of segments in each unit that were assigned each code as a way to examine the prevalence of each code. This metric gives a global idea of how common a code was in each unit.
- **Coverage:** The average percent coverage of each unit by each code. This metric is used to normalize for the large variation in document size (ranging from 1 to 209 pages) and is calculated as the sum length of segments assigned a given code over the total length of the document. It allows ranking each code as a way to assess code dominance in each unit (codes that were only present in one document are highlighted to denote that the code may simply represent a focus of an individual document and are discussed cautiously with respect to generalization).

### *a) Characterizations of “the public”*

Fifteen codes in total emerged as “characterizations of “the public.” Table 2 highlights the eight codes present in LTS documents and indicates their prevalence in “mainstream” engineering documents. These codes are ranked by their average percent coverage of the LTS unit and are listed in descending order. Table 2 also features the four codes that were assigned only to “mainstream” engineering documents. They too are ranked by their average percent coverage of the documents in this unit.

*Table 2. Comparison of codes pertaining to characterizations of “the public” between LTS and “mainstream” engineering documents<sup>2</sup>*

Code	LTS				“Mainstream”			
	Rank	# of Docs	Raw Count	Coverage	Rank	# of Docs	Raw Count	Coverage
Unable to meet basic needs/improve quality of life	1	2 of 3	10	2.94%	-	0 of 11	0	
Underserved	2	2 of 3	7	0.90%	8	2 of 11	2	0.25%
Lacking/desiring technologies	3	2 of 3	6	0.80%	6	3 of 11	9	0.46%
Developing	4	2 of 3	10	0.75%	1	2 of 11	13	1.23%
Poor	5	2 of 3	8	0.72%	9	5 of 11	9	0.24%
Engaged (non-engineers being active)	6	1 of 3	2	0.21%	10	3 of 11	5	0.23%

<sup>2</sup> Table 2 does not feature codes that were absent from LTS documents and not in the top 10 “mainstream” engineering document codes.



participants in the relationship)								
Expecting more from engineering	7	1 of 3	2	0.13%	11	3 of 11	5	0.20%
Customers	8	1 of 3	1	0.08%	7	2 of 11	7	0.44%
Technologically illiterate	-	0 of 3	0		2	3 of 11	17	0.62%
Entrepreneurs	-	0 of 3	0		3	1 of 11	2	0.60%
Lacking information (about engineering/engineers)	-	0 of 3	0		4	4 of 11	23	0.59%
Trusting of engineering profession (to improve the quality of their lives, or “entrusting” engineers with certain responsibilities or tasks such as “to create a sustainable world and enhance the quality of life”)	-	0 of 3	0		5	2 of 11	9	0.47%

Focusing on the five most prevalent characterizations of “the public” in LTS documents, we note the following:

- i. “The public” as “unable to meet its basic needs and/or improve its quality of life” was the most dominant code and entirely absent from “mainstream” engineering documents. Examples of excerpts with this code include, *“This growth is key to realizing our vision of a world in which every community has the capacity to sustainably meet their basic human needs”* (from LTS: <sup>11</sup>), and *“These program types often overlap in purpose, activities, and methods, but all seek to engage students in meaningful, transformative, real life adventures and educational experiences while simultaneously making a difference in the lives of others who lack the means to improve their own lives”* (from LTS: <sup>2</sup>).
- ii. “The public” as “underserved” appeared frequently in both units but was more prevalent in LTS documents (ranking 2<sup>nd</sup>) than in “mainstream” engineering documents (ranking 8<sup>th</sup>). Examples of excerpts with this code include *“Many underserved communities lack basic infrastructure, depriving them of the ability to improve their quality of life”* (from LTS: <sup>11</sup>), and *“Engineers also participate in community-based organizations—for example nongovernmental organizations that help support the development of underdeveloped and economically disadvantaged communities and nations”* (from “mainstream”: <sup>23</sup>).
- iii. “The public” as “lacking and/or desiring technologies” appeared frequently in both units but was more prevalent in LTS documents (ranking 3<sup>rd</sup>) than in “mainstream” engineering documents (ranking 6<sup>th</sup>). Examples of excerpts with this code include *“At the same time, there exists a persistent and growing need to address problems confronting a huge proportion of humanity - those at the Bottom of the Pyramid (BOP), billions of people often lack access to basic necessities, such as: adequate housing, energy, water quantity and quality, wastewater treatment, efficient agricultural products/processes, as well as meaningful employment opportunities”* (from LTS: <sup>2</sup>), and *“The American public is generally quite eager to adopt new technology...”* (from “mainstream”: <sup>23</sup>).
- iv. “The public” as “developing” was dominant in both units, but appeared less frequently in LTS documents (ranking 4<sup>th</sup>) than in “mainstream” engineering documents (ranking 1<sup>st</sup>).

Examples of excerpts with this code include “*Promote understanding of the practices that bring a successful engineering project to fruition in developing communities*” (from LTS: <sup>11</sup>), and “*By 2030, almost two billion additional people are expected to populate the earth, ninety-five percent of them in developing or underdeveloped countries*” (from “mainstream”: <sup>15</sup>).

- v. “The public” as “poor” appeared in both units but was more prevalent in LTS documents (ranking 5<sup>th</sup>) than in “mainstream” engineering documents (ranking 9<sup>th</sup>). Examples of excerpts with this code include “*Given that 80% of the world makes less than \$10 per day, one avenue which might attract such technical expertise to address the problems of the poor is to couch the problem in an entrepreneurial light – that is, to consider those 5.6 billion people as a potential market*” (from LTS: <sup>2</sup>), and “*ASCE works in collaboration with other domestic and international organizations to engage engineers in addressing the needs of the poor through capacity building and the development of sustainable and appropriate solutions to poverty*” (from “mainstream”: <sup>13</sup>).

The five most prevalent characterizations of “the public” in “mainstream” engineering documents were: a) developing, b) technologically illiterate (directly calling non-engineers ‘technologically illiterate’ or referring to non-engineers’ lack of knowledge/understanding of technology), c) entrepreneurs, d) lacking information, and e) trusting of the engineering profession. The codes “technologically illiterate,” “entrepreneurs,” “lacking information,” and “trusting of the engineering profession” were completely absent from LTS documents.

*b) Professional duties related to “the public”*

Thirty-three codes in total emerged as professional duties related to “the public.” The ten most prevalent codes in the LTS documents are shown in Table 3. They are ranked by their average percent coverage of the documents in this unit and are listed in descending order. Table 3 also features the ten most prevalent codes assigned to “mainstream” engineering documents. They too are ranked by their average percent coverage of the documents in this unit.

Table 3. Comparison of codes pertaining to professional duties related to “the public” between LTS and “mainstream” engineering documents

Code	LTS				“Mainstream”			
	Rank	# of Docs	Raw Count	Coverage	Rank	# of Docs	Raw Count	Coverage
Support self-reliance/ability to meet basic needs	1	1 of 3	7	8.17%	-	0 of 11	0	
Solve problems	2	3 of 3	41	7.98%	4	8 of 11	242	3.24%
Ensure sustainability	3	2 of 3	34	6.61%	6	10 of 11	167	2.85%
Establish partnerships	4	3 of 3	19	6.49%	17	5 of 11	20	1.97%
Practice virtuously	5	3 of 3	21	6.36%	1	10 of 11	271	10.45%
Build/sustain professional image	6	1 of 3	5	6.26%	2	11 of 11	237	5.73%
Build capacity/empower	7	2 of 3	20	6.11%	13	5 of 11	18	2.37%
Create a better world	8	2 of 3	10	5.30%	8	6 of 11	57	2.59%
Develop/support leaders in engineering	9	2 of 3	9	5.18%	15	7 of 11	110	2.10%
Promote diversity/multiculturalism	10	1 of 3	3	4.63%	27	5 of 11	27	0.65%
Consider societal impacts/context	16	1 of 3	8	2.73%	9	8 of 11	104	2.54%
Provide opportunities/products/services	19	2 of 3	7	1.80%	3	5 of 11	13	3.51%
Promote integrity	22	1 of 3	1	1.53%	7	3 of 11	6	2.85%

Enter public sphere/public policy	24	1 of 3	5	1.13%	10	8 of 11	126	2.51%
Hold paramount	26	2 of 3	5	0.97%	5	7 of 11	127	3.22%

Focusing on LTS’s five most prevalent professional duties related to “the public,” we note the following:

- i. “Supporting self-reliance and communities’ ability to meet their basic needs” was the most prominent code in LTS, but it appeared only in one document (<sup>11</sup>). This code was entirely absent from “mainstream” engineering documents. Although it aligns with the LTS ideal of cultivating empowering and transformational relationships with communities <sup>27</sup>, its presence in only one of the three LTS documents makes it difficult to assess its overall prominence as a core LTS value. An example excerpt with this code is “*EWB-USA’s vision is a world in which every community has the capacity to sustainably meet their basic human needs*” <sup>11</sup>.
- ii. “Solving problems” appeared prominently in both units of documents, although it was more dominant in LTS (ranking 2<sup>nd</sup>) than in “mainstream” engineering documents (ranking 4<sup>th</sup>). Prior analysis revealed that this code was the second-most prevalent code overall across all 14 documents. Examples of excerpts with this code include “*A great demand exists for engineering solutions which address problems of those least able to afford expertly designed systems*” (from LTS: <sup>2</sup>), and “*Horizontal or lateral thinking connects you with ideas and information not a part of but potentially related to civil engineering. As a result, you will be better prepared—as part of intradisciplinary and multidisciplinary teams—to help identify and solve the complex problems of the future*” (from “mainstream”: <sup>13</sup>).
- iii. “Ensuring sustainability” and the development of environmentally sustainable solutions appeared prominently in both units of documents as well, although it was more dominant in LTS (ranking 3<sup>rd</sup>) than in “mainstream” engineering documents (ranking 6<sup>th</sup>). Examples of excerpts with this code include “*This strategic plan highlights three complementary goals where EWB-USA will focus our efforts to support sustainable growth that is beneficial to all of our stakeholders*” (from LTS: <sup>11</sup>), and “*The vision sees civil engineers as being entrusted by society as leaders in creating a sustainable world and enhancing the global quality of life*” (from “mainstream”: <sup>13</sup>).
- iv. The duty of engineers to “establish partnerships” with “the public” was the fourth most prominent code in LTS and, while present in “mainstream” engineering documents, it was notably less prominent (ranking 17<sup>th</sup>). This code aligns with LTS’s strong emphasis on collaborative relationships with “the public.” Examples of excerpts with this code include “*Establish lasting partnerships with the critical stakeholders in the communities where we work: community leaders, community-based organizations, local government organizations and non-governmental organizations*” (from LTS: <sup>11</sup>), and “*Other critical choices the profession must make on this path to the vision include focused efforts to improve... partnerships among academic, industry and government to expand research and development and develop the next generation of engineer*” (from “mainstream”: <sup>15</sup>).

- v. LTS’s fifth most prevalent professional duty was to “practice virtuously” – that is, to apply one’s technical expertise with competence, honesty, impartiality, ethics, transparency, and loyalty. This code ranked 1<sup>st</sup> in “mainstream” engineering documents. Example excerpts include “*Complementary to the necessity for strong leadership ability on such projects is the need to also possess a working framework upon which high ethical standards and a strong sense of professionalism can be developed. These are supported by boldness and courage*” (from LTS: <sup>2</sup>), and “*Continued development of professional competence must come from lifelong learning, informed not only by the humanities—the mentorship from senior engineers, practical experience, and involvement in the local community grounded on a firm foundation in, and recognition of the importance of, the humanities*” (from “mainstream”: <sup>13</sup>).

The five most prevalent “duties” related to “the public” in “mainstream” engineering documents were: a) practice virtuously, b) build/sustain engineering’s professional image, c) provide products, service, and opportunities for learning, professional development, leadership, employment, and other types of advancement, d) solve problems, and e) hold paramount the public’s health, safety, and welfare.

*c) Relationship between engineers and “the public”*

Ten codes in total emerged describing the relationship between engineers and “the public.” Seven of these codes appeared in the LTS documents and are shown in Table 4. They are ranked by their average percent coverage of the documents in this unit and placed in descending order. Table 4 also features the codes that appeared in “mainstream” engineering documents. They too are ranked by their average percent coverage of the documents in this unit.

*Table 4. Comparison of codes pertaining to the relationship between engineers and “the public” between LTS and “mainstream” engineering documents*

Code	LTS				“Mainstream”			
	Rank	# of Docs	Raw Count	Coverage	Rank	# of Docs	Raw Count	Coverage
Engineers benefiting “the public”	1	3 of 3	52	20.30%	1	10 of 11	294	7.51%
Collaborative	2	3 of 3	42	13.61%	4	8 of 11	81	2.63%
Engineers impacting non-engineer professionals	3	1 of 3	5	11.79%	2	3 of 11	11	3.16%
Cross-disciplinary/interdisciplinary/interdependent	4	3 of 3	32	9.70%	5	8 of 11	122	2.31%
“The public” impacting engineers	5	3 of 3	21	8.44%	3	6 of 11	171	3.05%
Engineers engaging “the public”	6	1 of 3	8	2.16%	7	8 of 11	32	1.20%
Engineers impacting public policy	7	1 of 3	1	0.48%	6	6 of 11	36	1.38%

Focusing on LTS’s five most prevalent codes characterizing the relationship between engineers and “the public,” it is worth noting the following:

- i. That engineers “benefit the public” was the most prevalent code, ranking 1<sup>st</sup>, in both units (LTS and “mainstream” engineering documents). Previous analysis showed that this code was, *by far*, the most dominant across all 14 documents. Examples of excerpts with this code include “*Through the support of this field we hope to catalyze new approaches to*

*education that give rise to empathetic innovators equipped with the tools, experience and attitude to apply science and technology in an entrepreneurial way to make the world a better place*" (from LTS: <sup>2</sup>), and *"Because of their work with infrastructure and the environment, civil engineers can contribute to world stability"* (from "mainstream": <sup>14</sup>).

- ii. That engineers' relationship with "the public" is "collaborative" was the second-most prevalent code in LTS, appearing in all three documents, and the fourth-most prevalent in "mainstream" engineering documents, although with a notably lower average percent coverage in the latter unit (13.61% in LTS versus 2.63% in "mainstream" engineering). Examples of excerpts with this code include *"Build collaborative relationships with the larger development and engineering communities: universities, industry professionals, corporations, donors, non-governmental organizations and governmental organizations"* (from LTS: <sup>11</sup>), and *"Licensed civil engineers must be able to function as members of a team. This requires understanding team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, and time management and being able to foster and integrate diversity of perspectives, knowledge, and experiences"* (from "mainstream": <sup>13</sup>).
- iii. That engineers impact non-engineer professionals (e.g., professionals working in industry, "entrepreneurs," "stakeholders") was the third-most prevalent code in LTS, although it appeared only in one document. It was the second-most prevalent in "mainstream" engineering documents. Examples include *"EWB-USA fosters an environment of learning so our volunteers, community members and staff have the tools, training and passion to address the world's most pressing challenges. We strive for our work to inspire others to learn more, do more, and become more"* (from LTS: <sup>11</sup>), and *"We aspire to an engineering profession that will rapidly embrace the potentialities offered by creativity, invention, and crossdisciplinary fertilization to create and accommodate new fields of endeavor, including those that require openness to interdisciplinary efforts with nonengineering disciplines such as science, social science, and business"* (from "mainstream": <sup>23</sup>).
- iv. That engineers' relationship with "the public" is cross-disciplinary, interdisciplinary, and/or interdependent was the fourth-most dominant code in LTS, appearing in all three documents. It was the fifth-most dominant code in "mainstream" engineering documents, although with a notably lower average percent coverage in the latter unit (9.70% in LTS versus 2.31% in "mainstream" engineering). Examples of excerpts with this code include *"EPICS students gain long-term define-design-build-test-deploy-support experience, communication skills, experience on multidisciplinary teams, and leadership and project management skills"* (from LTS: <sup>12</sup>), and *"Dealing with the preceding problems and opportunities will require intra-disciplinary, cross-disciplinary, and multidisciplinary collaboration on projects and in research and development"* (from "mainstream": <sup>12</sup>).
- v. That the relationship between engineers and "the public" is such that "the public" impacts the engineering profession was the fifth-most prevalent code in LTS and the third-most prevalent in "mainstream" engineering documents, albeit with a notably lower average percent coverage in the latter unit (8.44% in LTS versus 3.05% in "mainstream")

engineering). Examples of excerpts with this code include “*Student ‘service learning’ efforts often include projects such as painting orphanages, repairing roofs, reading to children, and so on. It is recognized that such altruistic efforts certainly have value as students gain cultural awareness, civic responsibility, and develop critical leadership skills while simultaneously satisfying a real need experienced by the partnering community*” (from LTS: <sup>2</sup>), and “*Civil engineers are most involved in public policy regarding both the physically built environment and the preserved natural environment. Essential public policy fundamentals include the political process, laws/regulations, funding mechanisms, public education, government/business interaction, and the public service responsibility of professionals. These issues heavily influence many civil engineering decisions*” (from “mainstream”: <sup>13</sup>).

The same five codes above were also the top five codes characterizing the relationship between engineers and “the public” in “mainstream” engineering documents. Yet their order of prevalence was slightly different. In the “mainstream” unit, engineers: a) benefit “the public,” b) impact professionals outside engineering, c) are impacted by “the public,” d) form collaborative relationships with “the public,” and e) form cross-disciplinary, interdisciplinary, and/or interdependent relationships with “the public.” All of these codes, however, had a notably lower average percent coverage in “mainstream” than in LTS documents.

*d) Societal problems in need of engineering solutions*

The types of problems identified as key to how engineers impact or relate to society were assigned to 12 codes. Only six of these codes appeared in the LTS documents and were also the top six for the “mainstream” documents. They are shown in Table 5.

Table 5. Comparison of codes pertaining to societal problems in need of engineering solutions between LTS and “mainstream” engineering documents

Code	LTS				“Mainstream”			
	Rank	# of Docs	Raw Count	Coverage	Rank	# of Docs	Raw Count	Coverage
Unspecified challenges/problems	1	3 of 3	5	3.06%	6	4 of 11	27	0.91%
Social infrastructure stresses (e.g., overall population rise, aging population growth, civil unrest)	2	1 of 3	8	2.16%	1	6 of 11	105	2.26%
Economic infrastructure stresses (e.g., economic disincentives that prevent engineer from serving the poor, adverse environmental impacts of economic growth, increase in poverty)	3	1 of 3	3	1.21%	5	3 of 11	31	1.58%
Natural resource stresses (e.g., fossil resources depletion, ocean mismanagement, sustainability requirements)	4	1 of 3	4	1.08%	3	8 of 11	93	1.68%
Quality of life	5	2 of 3	3	0.83%	2	7 of 11	52	1.91%
Physical infrastructure stresses	6	2 of 3	3	0.70%	4	5 of 11	56	1.63%

Non-descript or vague statements about the societal problems engineers address constituted the most prevalent reference to these problems in the LTS documents and ranked 6<sup>th</sup> by coverage in the “mainstream” engineering documents. Example excerpts include “*Over the years, there have*

*been many innovative and daring souls from around the world; faculty members, researchers, practitioners, and students, who have sought to nurture a spirit within the engineering and entrepreneurship communities; a spirit which encourages the assumption of leadership and use of academic skills to tackle some of the most pressing problems of marginalized peoples around the world – while implementing pedagogies and engaging in projects which produce a better educated student and citizen” (from LTS: <sup>2</sup>), and “We aspire to a public that will recognize the union of professionalism, technical knowledge, social and historical awareness, and traditions that serve to make engineers competent to address the world’s complex and changing challenges” (from “mainstream”: <sup>23</sup>).*

Social infrastructure, economic infrastructure, and natural resource stresses were the second-, third-, and fourth-most common codes respectively, though only present in one LTS document. Example excerpts include *“Engineers have a long track record of addressing the needs of people. From the design and construction of bridges which facilitate the transport of food stuffs to market, to developing life-saving pharmaceuticals, to development of electrical devices which lighten life’s burdens, and on and on,” “A great demand exists for engineering solutions which address problems of those least able to afford expertly designed systems. For many, this may be viewed as a moral issue, an imperative to act. But, unfortunately, economic constraints serve to prevent many from acting in this regard. There are no economic forces that drive participation by trained engineers to address the problems of most of the world,” and “The need for development is as great as it has ever been, but future development in such marginalized communities cannot simply follow past models of economic activity, which tended to waste resources and produce prodigious pollution. For the future, the entire world population needs ways to achieve economic, social, and environmental objectives simultaneously. There is thus a need for just sustainability, which is ‘the egalitarian conception of sustainable development’” (from LTS: <sup>2</sup>).*

Quality of life was the fifth-most prevalent code in LTS. An example excerpt is *“[...] in June 2006, the American Society of Civil Engineers (ASCE) convened the Summit on the Future of Civil Engineering – 2025. This gathering of civil engineering and other leaders, including international participants, articulated a global vision for the future of civil engineering. The vision sees civil engineers as being entrusted by society as leaders in creating a sustainable world and enhancing the global quality of life” (from “mainstream”: <sup>13</sup>).*

Social infrastructure stresses was the most commonly cited problem in “mainstream” engineering documents, and natural resource stresses was present across the most number of “mainstream” engineering documents (8 of 11). Example excerpts include *“Civil engineers are rightfully proud of their legacy. During the past century, clean water supplies have extended general life expectancies. Transportation systems serve as an economic and social engine. New bridges, blending strength and beauty, speed transport and bring communities closer together” (<sup>14</sup>), and “We are inspired by a vision that calls us to: Develop sustainably through new technologies and techniques, and respond to the global environmental pressures brought about by economic growth” (from “mainstream”: <sup>15</sup>).*

e) Engineers’ “social footprint” over time

Statements that captured the temporal presence of engineers or engineers’ work in society were coded as engineers’ “social footprint” over time and are shown in Table 6. Overwhelmingly, both LTS and “mainstream” engineering documents referred to engineers’ “social footprint” as increasing over time – both in the past and in the future. Examples include “*demands by industry, and by society as a whole, for the knowledge, skills and abilities of engineers continues to expand and deepen*” (from LTS: <sup>2</sup>), and “*In particular, the civil engineering community must increasingly seek opportunities to use its abilities to improve the quality of life in more areas of the world with our services*” (from “mainstream”: <sup>14</sup>).

Table 6. Comparison of codes pertaining to engineers’ “social footprint” over time between LTS and “mainstream” engineering documents

Code	LTS				“Mainstream”			
	Rank	# of Docs	Raw Count	Coverage	Rank	# of Docs	Raw Count	Coverage
Increasing	1	2 of 3	16	8.89%	1	5 of 11	54	1.46%
Constant	-	0 of 3	0	-	2	1 of 11	1	0.08%
Decreasing	-	0 of 3	0	-	-	0 of 11	0	-

f) Vision/mission statements

Table 7 shows the codes that appeared most prevalently in LTS and “mainstream” engineering documents’ vision/mission statements. Vision/mission statements in the LTS unit appeared in only one document and included most commonly the following two codes: that engineers “benefit ‘the public’” and that they “create a better world.” Vision/mission statements in the “mainstream” engineering unit appeared in seven documents and included most commonly the following four codes: that engineers “benefit ‘the public,’” benefit/improve their profession through “developing/supporting leaders in engineering,” “create a better world,” and “ensure sustainability.”

Table 7. Comparison of codes co-occurring with segments coded as Vision/Mission between LTS and “mainstream” engineering documents

Thematic Category	Code	LTS		“Mainstream”	
		# of Docs	Raw Count	# of Docs	Raw Count
Vision/Mission		1 of 3	10	7 of 11	53
Relationship between engineers and the public	Engineers impacting “the public”\Benefiting “the public”	1 of 3	4	6 of 11	20
Professional duties related to the public	Create a better world	1 of 3	4	5 of 11	16
Professional duties related to the public\	Benefit/improve engineering\Develop - support leaders in engineering	1 of 3	2	4 of 11	20
Professional duties related to the public	Ensure sustainability	1 of 3	2	4 of 11	16
Professional duties related to the public	Solve problems	1 of 3	2	4 of 11	14
Relationship between engineers and the public	Collaborative	1 of 3	2	3 of 11	8

g) Most prevalent codes across all six themes

Table 8 shows the top five most prevalent codes (by coverage) across all six themes for the LTS and “mainstream” engineering documents. In the LTS unit, all five of these codes fall under the theme “relationship between engineers and ‘the public.’” They are that engineers a) benefit “the



public,” b) collaborate with “the public,” c) impact non-engineering professionals, d) relate to “the public” in cross-disciplinary, interdisciplinary, and/or interdependent ways, and e) are impacted by “the public.” In the “mainstream” engineering unit, four of the top five codes fall under the theme “engineers’ professional duties related to ‘the public.’” They are that engineers a) practice virtuously, b) build or sustain their profession’s image, c) provide opportunities, products, and services, and d) solve problems. The fifth most prevalent code overall (which ranked 2<sup>nd</sup> among these five codes) is that engineers benefit “the public.”

Table 8. Top five codes by coverage for LTS and “mainstream” engineering documents

Rank	LTS			“Mainstream”		
	Theme	Code	Coverage	Theme	Code	Coverage
1	Rel.	Engineers benefit the public	20.30%	Duties	Practice virtuously	10.45%
2	Rel.	Collaborative	13.61%	Rel.	Engineers benefit the public	7.51%
3	Rel.	Impacting non-engineering professionals	11.79%	Duties	Benefit/improve engineering\Build-sustain professional image	5.73%
4	Rel.	Cross-disciplinary/interdisciplinary/interdependent	9.70%	Duties	Provide opportunities/ products/ services	3.51%
5	Rel.	“The public” impacting engineers	8.44%	Duties	Solve problems	3.24%

Duties = Professional duties with respect to “the public”  
 Rel. = Relationship between engineers and the public

## Analysis

Our initial exploration of how LTS tends to conceptualize “the public” revealed that:

- a. LTS’s most prevalent characterization of “the public” is that it is “unable to meet its basic needs” and/or “improve its quality of life.” Also prevalent are characterizations of “the public” that highlight additional deficiencies (i.e., “underserved,” “lacking/desiring technologies,” “developing,” and “poor”). The 6<sup>th</sup>-, 7<sup>th</sup>-, and 8<sup>th</sup>-most prevalent characterizations, all of which are markedly less dominant than the top five and appear in only one document<sup>2</sup>, present “the public” as “engaged” (e.g., articulating their own needs and goals), “expecting more from engineering” (e.g., requiring engineers to possess not only technical knowledge but also cultural awareness), and “customers” (e.g., creating future markets in which engineers ought to be able to work). The most prevalent characterizations of “the public” in “mainstream” engineering documents also highlight deficiencies (e.g., “developing,” “technologically illiterate,” and “lacking information” about engineering and engineers) although in one document they depict “the public” as “entrepreneurial”<sup>15</sup> and in two documents as “trusting of the engineering profession” to improve its quality of life<sup>13, 14</sup>.

The LTS and “mainstream” units’ overlapping focus on deficiencies is marked by an important – albeit perhaps subtle – difference. Namely that the deficiencies highlighted in LTS documents foreground what seem to be perceived as unjust inequalities between engineers and “the public,” implicitly distinguishing engineers as “haves” of solutions, resources, and technologies and, thus, as rightful “interveners” and “benefactors” of the “have-not” “public.” In contrast, the deficiencies in “mainstream” engineering documents

communicate a public ignorance about engineering and/or engineers that seems to reinforce, rather than attempt to bridge, what we have documented elsewhere as a commonly perceived among engineers epistemic hierarchy that privileges “engineering knowledge, perspectives, and priorities over and above other knowledges, perspectives, and priorities – and especially the knowledges, perspectives, and priorities of publics engineers aim to serve”<sup>3</sup> [p. 29].

- b. “Supporting self-reliance” and/or communities’ “ability to meet their basic needs” is the most commonly articulated professional duty in the LTS unit, although it appears in only one document<sup>11</sup>. The remaining four most prevalent duties continue on the same general theme of improving the human condition (i.e., “solving problems,” “ensuring sustainability”) but by “establishing partnerships” with the communities that engineers aim to serve and by “practicing virtuously.” In “mainstream” engineering documents dominant codes involve ethical practice in an ideal form (i.e., “practicing virtuously,” “holding paramount” the health, safety, and welfare of “the public”), while serving society (“providing opportunities/products/services,” “solving problems”) and “benefitting or improving engineering” by “building/sustaining the profession’s image.”

A comparison between dominant conceptualizations of duties in LTS versus “mainstream” engineering documents suggests that although the expectation to “solve problems” with competence, honesty, impartiality, ethics, transparency, and loyalty is prevalent in both units, LTS tends to conceptualize engineers’ duties in terms of *relational* problem-solving and perhaps even the attempt to help close socio-technical inequality gaps (e.g., “supporting self-reliance” and/or communities’ “ability to meet their basic needs”). In this regard, LTS’s vision may be more “public-centered,” providing an opening for shifts in power that enable disenfranchised communities to define *what* technological goods and services they want; play an active role in the development, implementation, and maintenance of the solutions *they* desire; and ultimately gaining greater control over *their* lives and futures. “Mainstream” engineering documents, on the other hand, paint engineers’ duty as delivering technological goods and services that *engineers* view as benefitting society, and doing so in a manner that *engineers* determine as honorable. In this regard, “mainstream” engineering’s vision seems more “engineer-centered” and, by extension, paternalistic. Indeed, the code “supporting self-reliance” and/or communities’ “ability to meet their basic needs” was not detected in any of the “mainstream” engineering documents.

The difference in the two units’ focus must not be overstated however. Engineers’ duty to “benefit or improve engineering” by “building/sustaining the profession’s image” was dominant in both units of documents, ranking 2<sup>nd</sup>-most prevalent in “mainstream” engineering documents and 6<sup>th</sup>-most prevalent in LTS, but having greater percent coverage in the latter (6.26%) than in the former (5.73%). Usually focusing on recruiting new engineers, increasing the diversity of the profession, better preparing students for the technological challenges of the future, and gaining prestige in the eyes of “the public,” this code suggests a strong inwardly-focused dimension of how LTS and “mainstream” engineering alike conceptualize the profession’s relationship with “the public.”

- c. LTS imaginaries of engineers' relationship with "the public" place engineers unambiguously in the position of "benefactor" (i.e., "engineers benefit 'the public'"). Less dominant, but still prevalent, conceptualizations of this relationship are that engineers operate in *collaboration* and *interdependence* with "the public" (i.e., "collaborative," "cross-disciplinary/interdisciplinary/interdependent"), employing knowledges from non-engineering fields (i.e., "cross-disciplinary/ interdisciplinary/ interdependent), and impacting, as well as being impacted by, diverse partners (i.e., engineers "impacting non-engineer professionals," "the public" impacting engineers). Notably, "mainstream" engineering documents depict engineers' relationship with "the public" similarly. Although in a slightly different order and with lesser prominence overall, the five most prevalent codes are the same as in the LTS unit. They reveal imaginaries of a relationship in which engineers benefit "the public," impact non-engineer professionals, are impacted by "the public," and practice in the context of collaborative as well as cross-disciplinary, interdisciplinary, and interdependent partnerships.

A side-by-side examination of the LTS and "mainstream" engineering document codes reveals an *a priori* and overwhelmingly strong conviction in both imaginaries, but especially in LTS's, that engineers' relationship with "the public" is, above all else, beneficial to "the public." Additionally, the ideals of collaborative and cross-disciplinary/inter-disciplinary/ interdependent relationships with "the public" are far more prevalent in the LTS than in the "mainstream" engineering unit (13.61% and 9.70% coverage in LTS versus 2.63% and 2.31% in "mainstream").

- d. The universe of societal problems in need of engineering solutions was less clearly defined in LTS than in "mainstream" engineering documents. Specifically, the most dominant code in LTS was "unspecified challenges/problems." This code was followed by three societal problems that appeared in only one document<sup>2</sup> – namely, social infrastructure stresses related to health and unemployment, economic infrastructure stresses, and natural resource stresses – as well as quality of life stresses, which appeared in two documents<sup>2, 11</sup>. In the "mainstream" unit, on the other hand, social infrastructure stresses related to health, unemployment, education, the labor force, and political instability were ranked first and were followed by quality of life, natural resource, physical infrastructure, and economic infrastructure stresses.
- e. Both LTS and "mainstream" engineering documents refer to engineers' "social footprint" in society as increasing over time. This code was discernably more prevalent in the LTS unit than in the "mainstream" engineering unit (8.89% versus 1.46% coverage respectively). Further research would be required to determine if this difference stands upon examination of a greater number of LTS documents and if so, why.
- f. Vision/mission statements in the LTS unit articulate most commonly a commitment to "benefit 'the public'" and "create a better world." Vision/mission statements in the "mainstream" engineering unit articulate most commonly a commitment to "benefit 'the public'" and "benefit/improve engineering" through the "development/support of leaders" in the profession. It is worth highlighting that "benefitting 'the public'" is a

dominant message in the vision/mission statements of both units. “Creating a better world” and “benefitting/improving engineering” through the “development/support of leaders” in the profession are also dominant messages in both units, although the former ranks slightly lower in “mainstream” engineering documents than in LTS and the latter ranks slightly lower in LTS than in “mainstream” engineering documents.

- g. Examination of the five most prevalent codes across all six of the above themes illustrates that the LTS documents are dominated by codes about engineers’ *relationship* with “the public” (i.e., engineers “benefit ‘the public,’” work “collaboratively” with “the public,” “impact non-engineer professionals,” have “cross-disciplinary/ interdisciplinary/ interdependent” relationships with “the public,” and are “impacted by ‘the public’”). This focus aligns with LTS’s stated commitment to helping communities via collaborative problem solving that employs multiple types of knowledges and elevates all participants involved. “Mainstream” engineering documents, on the other hand, are dominated by codes about engineers’ *duty* to “the public” (i.e., “practicing virtuously,” “benefitting/improving engineering” by “building/sustaining the profession’s image,” “providing opportunities/products/services,” and “solving problems”). The locus of these codes is engineers and the engineering profession. In contrast to LTS’s top five codes, they depict a relationship with “the public” that reinforces engineers’ professional power; privileges their knowledge, perspectives, and priorities; and maintains a distance between the engineering profession and “the public” by conceptualizing their interactions as primarily transactional. The fifth and 2<sup>nd</sup>-most prevalent code in this unit – that “engineers benefit ‘the public’” – is the only of the top five codes pertaining to “engineers’ *relationship* with the communities they aim to serve.

## Discussion

This paper set out to explore *how* LTS practitioners conceptualize “the public” in order to identify convergences and diverges from “mainstream” engineering, and *what* social order these conceptualizations might promote, values they might reflect, and impact they might have on LTS engineers’ work and, by extension, on their relationship with the communities they aim to serve. Also central to our analysis is the attempt to identify convergences and diverges between LTS’s imaginaries of “the public” and its explicitly articulated commitment to collaborative, respectful, and mutually beneficial relationships with “the public” that are informed by principles of equity and justice and that facilitate community empowerment and social transformation.

Our analysis suggests that at the center of LTS’s imaginaries lies an aspiration and conviction that engineers benefit “the public” through relationships of collaboration and interdependence that involve cross-disciplinary and interdisciplinary work. This position not only aligns with LTS’s commitment to equitable and just engineering, but it also signals a strong service ideal that brings together two disparate parties: a) engineers, who are depicted as possessing the ability to implement technological solutions desired by “the public” and informed by “the public’s” knowledges, perspectives, and priorities, and b) “the public,” who is depicted as lacking the technologies necessary for thriving or, worse, the ability to meet its basic needs, and as unable to innovate technological solutions on its own. A closer look at the six broad themes of codes that emerged from our analysis provides further insight.

Coupled with LTS's commitment to collaboration, are imaginaries that depict "the public" as *Other* in three fundamental ways: a) its suboptimal living conditions ("unable to meet their basic needs" and/or "improve their quality of life," "underserved," "lacking/desiring technologies," "developing," and "poor"), b) its inability to improve these conditions by itself ("unable to meet their basic needs" and/or "improve their quality of life"), and c) its desire for engineers' technological interventions ("lacking/desiring technologies"). That three of LTS's relatively prevalent characterizations also present "the public" as possessing potential assets and influence – namely, agency ("engaged") and the ability to impact the engineering profession ("expecting more from engineering," "customers") – suggests that the deficits dominating LTS's imaginaries are perhaps perceived not so much as "inherent" in "the public" due to "the public's" presumed epistemic or other type of inferiority, but more as the result of structural inequities that, with proper engineering assistance, can be at least partly redressed.

Indeed, LTS's imaginaries of engineers' duty to "the public" seem to point to a belief that "the public's" inability to meet its basic needs and/or improve its quality of life is, at least partly, a correctable condition. As such, these imaginaries call for interventions that "solve problems" and "ensure sustainability," while ultimately closing socio-technical inequality gaps – if not redressing imbalances of power – by rendering communities more self-reliant and, in the end perhaps, making engineering interventions less necessary as well. It is theoretically possible, although it would require further research to confirm, that at least partly due to such a vision, the LTS documents we reviewed tended to refrain from naming the challenges/problems most in need of engineering solutions. From an LTS perspective, such challenges/problems might be too diverse to describe; too locally specific to characterize in the abstract; and inappropriate, if not impossible, to define *in the absence* of the specific publics affected by them. Regardless, LTS imaginaries of "the public" conceptualize engineers as having the ability, if not duty, to facilitate community empowerment and social transformation.

The codes that emerged dominantly in both the LTS and "mainstream" engineering units are that "the public" is "developing" ("characterizations of 'the public,'" 4<sup>th</sup> and 1<sup>st</sup> rank respectively, 0.75% and 1.23% coverage respectively); that engineers have a duty to "solve problems" ("professional duties related to 'the public,'" 2<sup>nd</sup> and 4<sup>th</sup> rank respectively, 7.98% and 3.24% coverage respectively) and "practice virtuously" ("professional duties related to 'the public,'" 5<sup>th</sup> and 1<sup>st</sup> rank respectively, 6.36% and 10.45% coverage respectively); that engineers "benefit 'the public'" ("relationship between engineers and 'the public,'" 1<sup>st</sup> and 1<sup>st</sup> rank respectively, 20.30% and 7.51% coverage respectively), form "collaborative" relationships with "the public" ("relationship between engineers and 'the public,'" 2<sup>nd</sup> and 4<sup>th</sup> rank respectively, 13.61% and 2.63% coverage respectively), "impact non-engineer professionals" ("relationship between engineers and 'the public,'" 3<sup>rd</sup> and 2<sup>nd</sup> rank respectively, 11.79% and 3.16% coverage respectively), form "cross-disciplinary/interdisciplinary/interdependent" partnerships ("relationship between engineers and 'the public,'" 4<sup>th</sup> and 5<sup>th</sup> rank respectively, 9.70% and 2.31% coverage respectively), and are "impacted by 'the public'" ("relationship between engineers and 'the public,'" 5<sup>th</sup> and 3<sup>rd</sup> rank respectively, 8.44% and 3.05% coverage respectively); and that societal problems in need of engineering solutions include "social infrastructure stresses" ("societal problems in need of engineering solutions," 2<sup>nd</sup> and 1<sup>st</sup> rank respectively, 2.16% and 2.26% coverage respectively), "economic infrastructure stresses"

(“societal problems in need of engineering solutions,” 3<sup>rd</sup> and 5<sup>th</sup> rank respectively, 1.21% and 1.58% coverage respectively), “natural resource stresses” (“societal problems in need of engineering solutions,” 4<sup>th</sup> and 3<sup>rd</sup> rank respectively, 1.08% and 1.68% coverage respectively), and “quality of life” challenges (“societal problems in need of engineering solutions,” 5<sup>th</sup> and 2<sup>nd</sup> rank respectively, 0.83% and 1.91% coverage respectively).

Within these convergences, five codes were discernibly more prominent in LTS than in “mainstream” engineering documents.<sup>3</sup> Namely, that engineers “benefit ‘the public,’” build “collaborative” relationships with “the public,” form “cross-disciplinary/ interdisciplinary/ interdependent” partnerships and are “impacted by ‘the public.’” One dominant code that appeared only in LTS is that “the public” is “unable to meet its basic needs or improve its quality of life.” By contrast, dominant codes that were markedly more prominent in “mainstream” engineering documents are that engineers have a duty to “provide opportunities/ products/ services” to “the public” and to “hold paramount” the health, safety, and welfare of “the public.” Four additional codes that were prominent in “mainstream” engineering documents and did not appear in LTS are that “the public” is “technologically illiterate,” “entrepreneurial,” “lacking information” about engineers and engineering, and “trusting of the engineering profession” to improve the quality of its life.

In the end, LTS’s imaginaries seem to depart from “mainstream” engineering imaginaries’ conceptualization of engineers as *a priori* “possessors” of the technical knowledge required to develop and implement solutions; rightful arbiters of what technical innovation is “good” for “the public’s” health, safety, and welfare; and benefactors to the technologically uninformed “public” (entrepreneurs and non-entrepreneurs alike) via transactional deliveries of technologically-related opportunities, products, and services. More succinctly, LTS’s imaginaries of “the public” seem to depart from “mainstream” engineering’s apparent embrace of an epistemic hierarchy that renders engineers’ knowledge, perspectives, and priorities superior to the knowledges, perspectives, and priorities of “the public,” places the engineering profession in charge of how it serves society, and reflects a professional ideology of righteous paternalism. LTS’s alternative vision seems to promote a view of the world wherein conditions of disenfranchisement are acknowledged and understood as, at least in part, reversible through cross-disciplinary and interdisciplinary solutions. Engineers’ role in this worldview is to enter relationships of interdependence with diverse groups of professionals and marginalized communities, add their technical expertise to a mix of other knowledges, and collaboratively develop solutions that accomplish two main goals: a) leave underserved publics better able to meet their basic needs and/or improve their quality of life, and b) leave engineers with a broader skill set than the one they develop in school and greater public recognition about their contributions to society.

A closer look at LTS’s imaginaries of “the public,” however, reveals nuances that raise questions about the true extent of these imaginaries’ departure from “mainstream” engineering. Despite LTS’s emphasis on practicing engineering *in relation to* disenfranchised publics, LTS’s imaginaries depict the “public” as largely and significantly “deficient.” As such, they render “the public” as *Other*, distancing engineers from the communities they aim to serve through a deficit construct. We have indicated elsewhere that this construct “highlights resources, knowledge, and

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<sup>3</sup> This list of codes includes only codes that appear in more than one LTS document.

skills ‘the public’ is assumed to lack while staying silent on assets ‘the public’ may possess that could complement, expand, or at times even challenge” the knowledge, solutions, and worldview of engineers<sup>3</sup> [p. 27]. If LTS’s deficit construct is rooted in a belief that “the public’s” suboptimal living conditions, inability to improve these conditions without outside technical help, and lack/want of technologies stem from structurally imposed inequities, this belief did not emerge as dominant in the LTS documents we examined. The first question then that arises is the following: to what extent do LTS imaginaries of “the public” confine disenfranchised communities into spaces of deficit that limit their ability to achieve their full potential as equitable partners and agents of change? Concomitantly, do these imaginaries leave room for community contributions that can strengthen, surpass, or even reject the expertise of engineers when this expertise is deemed unresponsive to community concerns?

Exploration of the five codes that are discernibly more prominent in LTS than “mainstream” engineering documents raises additional questions. Specifically, when LTS imaginaries depict engineers as “benefitting ‘the public’” – the most dominant code by far in LTS documents – to what extent do these depictions reflect experiences, assessments, and testimonies of marginalized publics who have experience with LTS? In other words, do LTS imaginaries grant engineers the authority to speak about the societal benefits of LTS *on behalf of* such publics? If so, how does such liberty align with LTS’s articulated values of equity, justice, empowerment, and transformation and bring engineers closer to the publics they aim to serve? Furthermore, might the claim that LTS, *by design*, “benefits ‘the public’” leave LTS engineers vulnerable to what we identified in an earlier paper as a “circular premise that what engineers do promotes the social good just because they are engineers,” regardless of how “the public” feels about it?<sup>3</sup>

Similar questions arise for LTS’s imaginaries of “collaborative” and “cross-disciplinary/interdisciplinary/interdependent” relationships with “the public” as well as “the public’s” impact on engineers. The excerpts in the LTS documents about the collaborative nature of LTS range from saying nothing about *who* LTS engineers’ collaborators are, to pointing to unspecified partners, making mention of other professionals only, and when they do include marginalized publics, being largely vague about those publics’ specific contributions to the collaboration or the specific value of their contributions to the solutions that ensue. Furthermore, none of the excerpts with this code depict marginalized publics as having assets that can complement, expand, or challenge the knowledge, solutions, and worldview of engineers. The same is the case for excerpts about the “cross-disciplinary/interdisciplinary/interdependent” nature of LTS engineers’ relationship with “the public.” Once again, the primary focus of these discussions is other professionals. Disenfranchised publics are either not mentioned or when they are their contributions tend to be vague or unspecified. Finally, excerpts discussing “the public’s” impact on LTS engineers highlight primarily the expansion of the latter’s skillsets beyond the purely technical. But they fail to acknowledge that underserved publics may have technical knowledge to offer too, or experiences, values, and goals with significant relevance to the development of technically sound, locally appropriate, equitable, and just engineering solutions. It thus seems important to ask if LTS’s imaginaries of “the public” have, in and of themselves, a marginalizing impact. It also seems important to ask if these imaginaries cultivate in engineers the worldview that would help them develop the vision and skills to form partnerships with “the public” that can bolster marginalized communities’ agency and voice, and can result in “community empowerment” and “social transformation” that marginalized communities themselves recognize

as meaningful and beneficial.

## Conclusion

This paper's findings suggest that LTS imaginaries of "the public" embed a similar paradox to the one we described in our initial analysis of all 14 foundational engineering documents, as a unit<sup>3</sup>. Namely, that although they depart significantly from "mainstream" engineering imaginaries' overt paternalism, they continue to promote a deficit-based conceptualization of the disenfranchised communities that LTS aims to serve. In short, they a) privilege engineers' technical expertise over and above the technical and non-technical knowledges of "the public," b) position engineers in the role of generous "givers" of technological goods (an empowered, masculinized position) and "the public" in that of desirous "receiver" of these goods (a disempowered, feminized position), exacerbating existing imbalances of power between the two, and c) obscure assets that marginalized publics often bring to the table – like the well-documented ability to acquire, surpass, correct, and even reject engineering knowledge<sup>3</sup> – which equitable and just collaborations would be expected to highlight and respect.

Equally importantly, LTS imaginaries of "the public" stay silent on engineers' vulnerability to engage in ways that disenfranchised communities experience as sub-optimal or even harmful, overlook historical evidence of LTS engineering failures, and are devoid of calls for routine introspection and adjustment as well as continuous and careful listening to the voices and recommendations of the diverse publics with which LTS engineers engage. In the end, what is difficult to ignore is that LTS imaginaries of "the public" lack any messaging, let alone prevalent messaging, promoting the ability of, if not necessity for, underserved publics to be in the lead of LTS work. If this is not a core element in LTS imaginaries of "the public," it seems important to ask how exactly these imaginaries conceptualize "community empowerment" and "social transformation," and how exactly these conceptualizations align with the visions of the publics that LTS aims to help. In closing, we wonder what room LTS imaginaries leave for marginalized communities to speak for themselves about *what* "community empowerment" and "social transformation" look like to them, *what* about them they would like LTS engineers to see and understand, and *how* LTS collaborations could best support them to meet their immediate needs and realize their broader aspirations.

## Limitations

The greatest limitation of this work is that the results are based upon a small number of sources: three LTS documents and 11 "mainstream" engineering documents. For this reason, the focus or perspective of one document may have exaggerated the prevalence of codes that may be significantly less prevalent in other documents. Additionally, some of the documents we analyzed are related. For example, two NAE documents both center on the theme of "the Engineer of 2020," presenting similar ideas through similar language<sup>23, 24</sup>. The same is the case for the three codes of ethics<sup>18, 19, 20</sup>. Finally, though we took measures to reexamine codes with low inter-rater reliability, we were not able to check the additional segments for which our code assignments did not fully align due to the vast quantity of codes and summative lengths of the 14 documents. This means that the prevalence of some codes may be underestimated or overestimated in our results.



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## Appendix

1. **Characterizations of “the public”**
  - a. Consumers [1]
  - b. Customers [2]
  - c. Developing [3]
  - d. Engaged [4]
  - e. Entrepreneurs [5]
  - f. Expecting more from engineering [6]
  - g. Lacking information (about engineering/engineers) [7]
  - h. Lacking/desiring technologies [8]
  - i. Poor [9]
  - j. Technologically illiterate [10]
  - k. Trusting of engineering profession [11]
  - l. Unable to meet basic needs/improve quality of life [12]
  - m. Underserved [13]
  - n. Unprepared to participate in discussions about technology [14]
  - o. Urban [15]
  
2. **Engineers’ “social footprint” over time**
  - a. Consistent [16]
  - b. Decreasing [17]
  - c. Increasing [18]
  
3. **Engineers’ professional duties related to “the public”**
  - a. Affect change [19]
  - b. Build capacity/empower [20]
  - c. Communicate/interact [21]
  - d. Consider societal impacts/context [22]
  - e. Create a better world [23]
  - f. Ensure sustainability [24]
  - g. Enter public sphere/public policy [25]
  - h. Establish partnerships [26]
  - i. Exchange/share knowledge [27]
  - j. **Hold paramount**
    - Public health [28]
    - Public safety [29]
    - Public welfare [30]
  - k. Increase public understanding [31]
  - l. Innovate [32]
  - m. Learn from successes/failures [33]
  - n. Make technologies available to “the public” [34]
  - o. Meet diverse needs [35]
  - p. **Practice virtuously**
    - Be equitable/fair/transparent [36]
    - Be loyal [37]
    - Practice ethically/responsibly [38]
    - Practice with excellence/competence [39]
    - Practice with honesty/trustworthiness [40]
    - Practice with impartiality/lack of bias [41]

- q. Promote diversity/multiculturalism [42]
- r. Promote integrity [43]
- s. Promote learning [44]
- t. Promote respect [45]
- u. Provide opportunities/products/services [46]
- v. Remain economically competitive [47]
- w. Serve/promote public service [48]
- x. Shape the future [49]
- y. Solve problems [50]
- z. Support cost-effectiveness [51]
- aa. Support customization [52]
- bb. Support growth-prosperity [53]
- cc. Support human welfare [54]
- dd. Support local leadership [55]
- ee. Support self-reliance/ability to meet basic needs [56]
- ff. **Benefit/improve engineering**
  - Build/sustain professional image [57]
  - Develop/support leaders in engineering [58]
  - **Education-related**
    - Better prepare engineering students [59]
    - Encourage education in engineering [60]
    - Offer engineering students broader training [61]
  - Recruit [62]
- gg. Volunteer [63]

#### 4. **Relationship between engineers and “the public”**

- a. Collaborative [64]
- b. Cross-disciplinary/interdisciplinary/interdependent [65]
- c. Engineers impacting “the public” [66]
  - Benefitting “the public” [67]
  - Engaging “the public” [68]
  - Harming “the public” [69]
  - Impacting non-engineer professionals [70]
  - Impacting public policy [71]
- d. Justification for the relationship [72]
- e. “The public” impacting engineers [73]
- f. The relationship is not... [74]

#### 5. **Societal problems/issues in need of engineering solutions**

- a. Cost-benefit constraints [75]
- b. Demographic changes [76]
  - Aging society [77]
  - Increase in minority populations [78]
  - Worker-pensioner ration changes [79]
  - Youth bulge [80]
  - Economic infrastructure stresses [81]
- c. Intellectual property [82]
- d. Lack of self-reliance [83]
- e. Moral/religious repercussions [84]
- f. Multilingual influences/cultural diversity [85]

- g. Natural resource stresses [86]
- h. Physical infrastructure stresses [87]
- i. Population changes (overall)**
  - Decrease [88]
  - Increase [89]
- j. Project management [90]
- k. Quality of life [91]
- l. Scarce technological resources [92]
- m. Social infrastructure stresses**
  - Education [93]
  - Health [94]
  - Labor force tensions [95]
  - Political instability/national security/terrorism [96]
  - Unemployment [97]
- n. Unspecified challenges [98]

**Vision/mission statements [99]**