Redefining Engineering Literacy with Generative AI: Impacts and Implications for Diverse Languages and Expertise in Engineering Education

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Introduction

This theoretical perspective paper considers the affordances and risks of writing with Generative AI (GenAI) technologies in engineering. Conversations around GenAI have largely focused on faculty- and curricular-centered concerns with an emphasis on whether faculty up-skilling (D'Agostino, 2023) to learn the emergent technology would happen in time to win the higher ed arms race (Bogost, 2023), though Ariyo, Bai, and Xiao (2023) warn higher ed faculty to be wary of the "hype cycle" that often accompanies new educational technologies (p. 286). Still, much attention has been paid on faculty-centered issues like assignment prompts (Sayers, 2023), assessment (Carroll, 2023; Nikolic et al., 2023; Rudolph, et al. 2023), and pedagogy (Straume and Anson, 2022; Leander and Burriss, 2022). The following paper encourages a consideration of students outside the lenses of these faculty-centered concerns in order to examine how writing with GenAI chatbots might impact students' emergent identities as engineers.

Some recent work has focused on students and the impact of GenAI on their work. Berdanier and Alley (2023), for instance, argue that engineering students should still be taught to write, for writing is a process of thinking and learning, and that teaching/learning should include GenAI as another writing tool once "the basics are mastered" such as defining audiences and developing arguments (584). Qadir (2023) considers the potential impacts of GenAI on engineering education, including the continuing need for critical thinking and communication as well as the need for attention to equity issues around this new educational technology, including inappropriate student use of GenAI and the risks of unemployment once the technology emerges in the workplace. Others focus more directly on student use of these tools. For instance, Duinn et al. (2023) have found that students were interested in the technology, but also reported the outputs generated by the algorithm were not sophisticated enough to be useful for completing coursework. The question of sophistication is difficult to pin down due to the rapid development of the technology, for within the first year of public access, the power of widely available commercial platforms like ChatGPT have continued to develop in power and sophistication with the problems of hallucination and accuracy diminishing as many of the algorithms now have access to the internet, thus further edifying the outputs generated by the AI.

Despite these nascent discussions of student impacts, one issue missing from conversations around GenAI are the impacts they are likely going to have on how students develop expertise through academic literacy practices. The term literacy practices refers to the spectrum of oral and literate activities that students use to engage with learning activities in their curricula, and thus to develop and transfer knowledge from one setting to another, including speaking, listening, reading, and writing activities (Gee, 2015). The effects of GenAI on the development of engineering students' professional identities have not yet been determined. However, there are some clear affordances and likely negative impacts of the widespread use of this technology for students who use named languages other than English and/or non-standard dialects. GenAI can reduce the inequitable language labor required for individuals who must translate their research and writing into other named languages or discourses, an inequity prevalent in modern STEM

writing (Clavero 2011). On the other hand, GenAI can be a weapon that reinforces homogenization by generating prose in standard English by default, or what Baker-Bell (2020) calls White Mainstream English (WME), thereby reducing linguistic diversity. One focus of the following paper is to consider how this tension in students' use of GenAI may impact engineering education.

The main argument of this paper is that considering the impacts of diverse language practices in meaning making for the development of engineering expertise should be an important area of concern in the age of AI. Second, the paper argues that the homogenous power of the language models in GenAI chatbots threatens this language diversity. To develop this argument, the paper first examines the relationships between literacy and expertise (Gee, 2015; Winsor, 1996) and language diversity within technical communication in engineering education and generative AI (Gonzales, 2022; Bender et al., 2022). The paper then looks at an example of how linguistic diversity might impact meaning-making in engineering contexts by contrasting the nominalization of verbs in technical communication (Halliday 2004) with the grammar of animacy in Anishinaabe (Kimmerer 2013). This example shows style is more than just identity politics, but provides potentials for meaning that can substantively impact the development of alternative approaches to engineering work. The paper concludes with a consideration of how this focus can contribute to expanding the base of what kinds of cultural models are accepted within the discipline.

Literacy Practices and Expertise

Writing in engineering education plays an important role in the socialization of students as engineers. Developing expertise in the classroom is closely related to the reading, writing, speaking, and listening practices that make up the "writing process" in the engineering classroom. Engineering thinking and judgement are thus cultivated in engineering curricula by doing design work through the various literacies of the engineering discipline[1]. As Berdanier and Alley (2023) argue, engineering students should still be taught to write in the age of GenAI, for "Writing is both a cognitive process and a deeply social process" (p. 583). Teaching engineering students to write supports the development of their capacity to critically develop relationships between their communication purpose, intended audience, and the arguments, evidence, and reasons that will persuade their readers. Also, it supports their ability to build, test, and critically reflect on knowledge. Thus, Berdanier and Alley argue, "we do not think that outsourcing this [writing] process is good for the development of expertise, especially for early career [engineering] students" (p. 583). Engineering educators should thus attend to the when/how writing is taught with/without GenAI. As Irish (1999) explains, "Careless use of writing may be destructive if only because it encourages understanding writing as afterthought rather than place-of-thought" (Irish, 83). This risk may be intensified by a technology that so easily obfuscates the labor involved in writing.

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[1] While I refer to the concept of engineering "disciplines," I am also aware of the contingent and dialogical nature of this intellectual space as one that is in flux through the dialogical relationships between its practitioners over time. See Prior and Hengst (2010) for a full discussion of disciplinarity as a dialogic and contingent activity that escapes neo-Platonic concepts of the ideal. Considering these tensions that constitute a discipline may well become salient as GenAI pushes the boundaries of convention in education and professional practice.

Literacy practices (e.g., reading, writing, speaking, and listening) mediate the formation of professional engineering identities. As influential linguist and educational scholar James Gee argues (2015), we all come into the world in a local home community in which we learn a primary Discourse comprised of the various ways of saying-being-doing-feeling shared among people who make up that home community. Language is inexorably tied to the cultural models that form our identities within social situations. We begin with a primary Discourse at home but then transition into public/social spheres wherein we acquire or learn other Discourses at school, temple, and work. These secondary Discourses allow us to get recognized as certain *whos* doing certain *whats*. That is, through these networked practices of saying-being-doing-feeling, we enact identity kits that allow us to get recognized as fulfilling certain social roles (e,g., engineer) by others and to recognize others fulfilling certain social roles (e.g., professor, scientist, police officer, bartender, etc.).

The relationship between literacy practices and the development of expertise has been well documented in writing studies scholarship (Bazerman, 1994; Beaufort, 2004; Berkenkotter & Huckin, 1995; Geisler, 1994; Norgaard, 1999; Winsor, 1996). For example, Geisler (1994) demonstrated how the literacy practices of novice students differ from but are related to the practices of expert writers in academic disciplines. Berkenkotter and Huckin (1995) show through their 10-year study of academic literacy practices how the development of genre knowledge contributes to the development of disciplinary identity or expertise. In her longitudinal study of academic literacies and the acquisition of expertise, Beaufort (1999) develops a model of five interlocking domains of knowledge required for the transition from novice to expert, from the classroom to the workplace. These interlocking domains include (1) discourse community knowledge, (2) subject-matter knowledge, (3) rhetorical knowledge, (4) genre knowledge, and (5) writing process knowledge. Beaufort's model demonstrates how subject matter knowledge in engineering is intimately connected to other kinds of writing procedural knowledge.

This aligns well with Winsor's (1996) longitudinal study of engineering students who move from their freshman year in college to professional practice. As Winsor explains,

> Engineering is knowledge work. That is, although the goal of engineering may be to produce useful objects, engineers do not construct such objects themselves. Rather they aim to generate knowledge that will allow such objects to be built … such knowledge generation is a rhetorical act (5).

Other scholars have further emphasized the importance of developing engineering knowledge, too. Norgaard (1999) argues that we must link subject-matter knowledge with rhetorical knowledge in order to support students' development of expertise as engineers. Litzinger, et al. (2011), argue that instructors must develop opportunities for deliberate reading and writing practices in the engineering curricula in order to foster effective learning experiences that sponsor students' acquisition of expertise. More recently, Lane and Karatsolis (2015) developed an approach to better connect subject-matter knowledge to rhetorical, genre, and writing-process knowledge for novice engineering students.

Thus, scholarship in writing studies and engineering education establish the principle that students develop their professional identity through the serial practice of the complex array of

reading, writing, speaking, and listening practices that constitute engineering curricula and learning activities. While some students are born to families made up of engineers and other professional in closely aligned fields (e.g., scientists), no one grows up using the language and literacy practices of engineering, exactly. These abilities are taught and learned and make up the basis for writing pedagogy in engineering education often called writing in the disciplines or writing across the curriculum. The underlying the academic literacy practices in engineering identities resides an array of linguistic practices – what Gee would call ways of saying-being-doing-feeling. Considering the cultural basis for these ways of making meaning is important in the age of AI as students collaborate with and negotiate language with large language models. However, before considering how language, identity, and engineering expertise relate to writing with GenAI chatbots, we must first consider linguistic diversity in technical communication and GenAI large language models.

Technical Communication and Linguistic Diversity

Technical communication courses that serve or are embedded in engineering undergraduate curricula, such as at my institution, are part of a wider movement referred to as writing in the disciplines, which has worked to address communication in engineering education for the last several decades (Irish, 1999; Paretti & McNair, 2009; Vest & Anderson, 1996; Wheeler & McDonald, 2000; Winsor, 2013). Much of this work has focused on how to best tie communication pedagogy with the kinds of communication practices evident in professional practice. For example, Collins (2010) argues for selecting samples that can help prime students' effective adoption of genre features in engineering writing that more closely relate to writing in the professions. More recently, Wilson-Lopez, et al. (2022) have examined the literacy practices used by professional engineers, such as how engineers assess accuracy, consistency, and other evaluative determinations when they read and write engineering texts.

However, while much attention has focused on higher-order concerns in WID approaches, the field remains rooted to a monolingual ideology (Gonzales, 2022, p.4) that perpetuates "attitudes of dismissal and rejection of, if not outright hostility toward, other languages" (Maylath, 2019, p. xviii). As the influential antiracist and composition scholar Inoue notes,

> very little scholarship directly addresses the ways in which the discourses expected of nurses, business majors, engineers, and others across all fields and professions are quite simply white supremacist (…) I'm getting really tired of hearing colleagues in Nursing or Business or Engineering tell me, or imply, that their students must use a white standard of English if they are going to be communicative and effective in their fields or professions. That's just bullshit. And it hurts students, Black, Latino/a, Asian, Native/Tribal, and White alike. We all lose. Our disciplines lose (Lerner 2018, p. 115).

Simply put, our students – whether because they are first-generation English speaking students or because they grow up in marginalized/minoritized communities – are using marked non-standard discourses, dialects, or languages on a regular basis, such as Black English, Spanglish, regional dialects like Southern English, or other named-languages like Chinese, Hindi, etc. Students use these languages and dialects to communicate with their families, communities, and team-members (see Baker-Bell, et al., 2020; Mckoy, et al., 2020).

Students' linguistic diversity notwithstanding, Standard English, or White Mainstream English, remains the language of science publication (Adúriz-Bravo 2013; Huttner-Koros 2015; Hyland and Feng 2017; Poe et al 2010). First-language English speaking scientists and engineers benefit from the linguistic resources they bring to the work, while non-native scientists must absorb the labor cost of researching in one named language and communicating about their research in another named language (Clavero, 2011). This discrepancy has led to a bottleneck in scientific publication that benefits English speaking writers and has resulted in fewer publications by non-English speaking writers (Primack et al., 2009; Vasconcelos et al., 2008), especially for writers who come from Asian nations (Man et al., 2004), even when the journal profile, length of the paper, and other factors are statistically controlled (Di Bitetti and Feareras, 2017).

While the emergence of GenAI may help facilitate the publication and/or accessibility of scholarship generated in other (non-English) named languages, it remains the case that Technical Communication needs to become more adept at navigating communication that happens outside white mainstream English (Gonzales, 2022). Consider for example the range of dialects enacted in informal conversations within engineering teams assigned for undergraduate curricula. Gonzales argues that changing languages is not just about changing words, for moving from one named language to another can have triggering effects as previous experiences of discrimination, racism, colonization, and other traumas can be re-embodied by the shift to white mainstream English (169). Language practices can be shields that protect and reify identities, but they can also be weapons that force assimilation, acculturation, and homogenization (Collins and Blot, 2006); likewise, technical communicators can be change agents or tools of oppression (Rude, 2009). Nevertheless, the field of TC still has much work to do to re-imagine what "professional" writing looks like outside of the white normative ideologies associated with the language used in science and technology formal communication. Unreflective approaches to GenAI and language diversity in technical and workplace communication writ large are not going to help this process.

When we project this conversation on linguistic diversity in technical communication into the emergent writing practices in GenAI, we can see how GenAI risks collapsing diversity even as it affords a level playing field for the production of texts in standard English. The power of GenAI as a writing tool is based on its large training data set; however, that apparent diversity belies the primacy of language practices from younger, white, more affluent users in the training data (Bender et al. 2022). GenAI programs like ChatGPT utilize machine learning, organizing language into tokens, representing units of meaning, often phrases, each assigned vectors to characterize relationships between tokens. Trained on vast text data, initially supervised by humans, then refined through a reward model, these systems predict the likelihood of tokens in a text stream. Despite their capabilities, they predominantly reflect white mainstream American English, with limited access to alternative dialects or languages. This bias, inherent in the training data and algorithms, perpetuates inequality by favoring dominant viewpoints (Weidinger et al., 16).

Thus, when we consider that GenAI technologies primarily generate language that aligns with WME language practices (and do so better than any other language or dialect), the consequences of GenAI in such assemblages suggests a further and invisible entrenchment of WME language practices in STEM communication and a setback for efforts towards linguistic justice. In order to

understand how this intensification and hyper-homogenization of language diversity through GenAI, we need to consider the dynamics of agency in the context of language and literacy.

Connecting Identity and Expertise to Style and GenAI in the Engineering Classroom

The final question I would like to address extends the idea of identity to style, and through that connection we return to GenAI in order to consider the affordances and potential limitations of this technology. GenAI represents a shift in how we write with(in)/through literacy technologies by repositioning the human in a collaborative relationship with the machine (Duin and Pederson 2021; Robinson 2022). While we have long used robots like Grammarly and spell check to help us write (Hart-Davidson 2018), writing with GenAI has shifted from working in human-machine assemblages to revising human-generated texts to collaboratively writing text that is partially autonomously generated by machine logics. Style emerges here as an issue of concern – both the style of the writer and the style of the algorithm.

The question of style or voice (and diversity of dialects) is an important concern for technical writing (Hodges and Ponce, 2022; Medina, 2014; Wilson and Crow, 2017), especially following the social turn in technical communication studies (Jones 2020; Walton, Moore, and Jones, 2019).-Style is larger than spelling and mechanics. Style encompasses a broad range of lower-order and higher-order writing concerns. As Jones explains: "Style is your choice of words, phrases, clauses, and sentences and how you connect these sentences. Style is the unity and coherence of your paragraphs and larger segments. Style is your tone — your attitude toward your subject, your audience, and yourself — in what you write" (Jones, 1998, p. 3).

Thus, style is closely tied to the development and performance of identity (Cicero, 2010; Connors, 2000; Micciche, 2014). For example, Butler's (2008) notion of "inventional style" blurs the lines between invention and style, which is to say that coming up with an idea, finding the words for an idea, is already a statement of style and identity. Butler, Ray, and Vanguri (2000) argue that style marks socially recognizable identities or roles for readers. Thus, using an "engineering" or "technical" style enables readers to recognize you as an "engineer." Style serves in this conversation as an extension of the discussion about language and identity above.

One of the key stylistic features of technical writing has been characterized by M.A.K. Halliday (2004) as grammatical metaphor. Halliday examines the complexity of discourse by showing how we pack sentences to create new meaning potentials, a demonstration of the semogenic power of language to create meaning. Halliday writes,

> Written technical discourse, in particular, is characterised by rather simple clause and sentence structures: each sentence typically one clause, that clause consisting of just one or two nominal groups (one of them perhaps 'governed' by a preposition), propped up by a verbal group, usually a relational process and most typically the verb *be*. The nominal groups, on the other hand, may be enormously long and complex – since all the lexical material is compressed into these one or two groups (33).

Halliday measures this complexity in two ways: (1) lexical density is measured by the number of lexical items per clause, and (2) grammatical intricacy is measured by the "length and depth of the tactic structures whereby clauses come together to make up a clause complex" (33).

Grammatical metaphor packs meaning into nominalization forms that allow for more generalized/abstract meanings to be expressed. Scientific/technical discourse operates at the intersection of process/thing where new meaning potentials open new possibilities for explaining and conceptualizing the world. At some point, these intersections become systemic when the connection is no longer apparent and can no longer be unpacked.

> We have seen that, in grammatical metaphor, everything shifts in the direction of the concrete: 'packing' the text adds stability and permanence, superimposing on the commonsense construal of experience syndromes of features which collectively serve to establish general principles. In order to stabilize, the grammar creates a semiotic universe made of 'things'; hence the interesting paradox: that the most abstract theorizing is achieved by modelling everything into the concrete. To make 'planets move' into a theoretical term, you turn *move* into a thing, called *motion*, and get the *planets* to function as a class of this thing, namely *planetary motion*. This would not work if *motion* immediately divested itself of the semantic feature of 'process'; but it does not – it begins as a semantic junction of 'thing' and 'process', and then evolves into a more abstract 'thing' in which is distilled a large amount of knowledge that has been accumulated from studying how things move (47-8).

Halliday's analysis of what he calls grammatical metaphor demonstrates the importance of nominalizations for creating new potentials for meaning that exceed the possibilities of using verb phrases that are more congruent with our embodied experience in the world. Stabilizing processes within noun phrases also opens these concepts to the wide range of resources available for qualifying nouns (adverbs, adjectives, prepositional phrases, etc).

In contrast to the nominalization that underwrites technical communication is the emphasis on verbs to make meaning of the world in *Anishinaabe.* Robin Kimmerer (2013) describes the interrelationships between her experiences as an academic scientist and as an indigenous Potawatomi woman. Kimmerer grew up speaking English, as her family lost ties to their indigenous language as a result of forced migrations in the late 1800s. Kimmerer started learning Anishinaabe later in life after she had enjoyed success in her academic career. As she began learning Anishinaabe, she was at first struck with the language's emphasis on verbs – everything was a verb, even "to be a Saturday," she notes. At first, Kimmerer notes that she found this linguistic structure to be confusing, but realized the importance of the framework when she contemplated the term *wiikwegamaa* 'to be a bay.' Kimmerer describes this moment of realization, writing that "When bay is a noun it is defined by humans, trapped between its shores and contained by the word. But the verb wiikwegamaa – to be a bay – releases the water from bondage and lets it live" (55). When we consider the bay through the verb structure, our attention shifts to the dynamic interrelationships between the water and its surroundings, such as how the water in the bay is connected to other bodies of water, animals and plants in the bay and on the shore.

The cultural orientation towards a grammar of animacy in Anishinaabe privileges such ecological thinking that is not as readily apparent in the noun-centered frameworks of English. The contrast between Halliday's discussion of nominalization via grammatical metaphor in technical communication on the one hand, and Kimmerer's description of the impact of thinking through verbs on the other hand, reveals the power of language and specifically the structures of language available to us in the generation of meaning. The language that individuals use to engage with

the world (including through engineering work) has the power to dynamically shape the potentials of meaning available to the speaker/writer. Language differences are more than identity politics and style, but instead afford important potentials for meaning.

Concepts and the languages we use to express them are intertwined in a recursive dynamic in which one may affect the other. We all use varied cultural epistemologies to make sense of and take action within the various socio-cultural ecologies we find ourselves in throughout our social lives, and "a growing body of research shows that explanatory preferences can vary within individuals, depending on the reasoning context, and across cultural communities, with perceived relevance of causes closely linked to cultural epistemologies" ojalehto and Medin, 2015, p. 265). Science and engineering are cultural practices (Medin and Bang 2014). When we don't teach them as cultural practices, we risk explicitly and/or implicitly teaching students that their received epistemologies are not relevant to science and engineering, thus further reifying them as primarily white, male, middle class pursuits.

In the context of engineering, being able to use diverse conceptual resources can impact design of technologies and policies. The example of the Flint water crises, for instance, shows how conceptualizations of water as a utility (Sackey, 2020) enabled design choices that had substantial negative impacts on people who used (drank, internalized, embodied) the water. Emphasizing the role of diverse language practices within the nexus of style, invention, and identity in the formation of expertise leads to other ways to consider how these language shifts can impact engineering education.

Conclusion: GenAI and Engineering Thinking

Without question, students are using GenAI in formal and informal ways throughout the engineering curriculum. While students must still be taught how to write and develop ideas through literacy practices as they develop engineering expertise, their collaborative work with GenAI will impact these students in ways that are obvious and also difficult to detect. Important to this paper is the ways in which serial repetition of practices, namely the collaborative reading/writing with GenAI bots, will alter the language practices of users. While GenAI undoubtedly poses important benefits for students who primarily use named languages other than English, it also threatens to collapse the diversity of languages and the cultural models students have available to make meaning through their engineering work.

Thus, while standard English or WME remains an important part of engineering communication, the ways in which students draw on non-standard English to develop Engineering knowledge and their impacts on student experience and design work need more attention. If the focus of engineering education and expertise resides within the acquisition and development of knowledge, as Winsor's work shows, then engineering educators should attend to the richness of language diversity that students bring to the classroom as important conceptual resources. As GenAI literacies are developed in engineering education curricula, instructors may want to explicitly address the linguistic tensions embedded within the technology. I am not arguing here for abandoning WME as a focus of technical communication, but the potential for hyper homogenization by GenAI language models may pose a risk for the diversity of thought and expression in engineering at the expense of those on the margins – namely, those on the

periphery of the white upper-middle class cultural practices that make up dominant American language, society, and power.

To that end, Holly, jr. and Comedy (2022) argue for "racial equity within invention" by expanding who has the authority within communities of invention and design (332). They further note, "At this point in our history, society's viewpoint of who is smart, who can contribute, and who should get opportunities remains dangerously skewed and shortsighted" (334). The dominant assertion that the language and cultural practices required for student success must be rooted in standard English is like the pot calling the kettle white, to echo Inoue's words cited above. Moreover, allowing students access to a wider range of language resources will, in turn, afford a wider potential for meaning making. As Holly Jr. and Comedy assert, increasing diversity in the invention community will improve the quality and quantity of invention (332). This paper contributes to this perspective by emphasizing the importance of addressing diversity at the level of language. It may be still to early in the GenAI era, but the early evidence suggests these models threaten linguistic justice in engineering education and any approaches to GenAI literacy should therefore explicitly address these power dynamics while making space for diverse languages, identities, and ways of making meaning in engineering.

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