THINKING WITH DELEUZE AND GUATTARI: LEARNING FROM EXPERIENCE OF HUMAN-MACHINE INTERACTION …AND… FUTURE OF WORK

by

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(Under the Direction of

Aliki Nicolaides)

ABSTRACT

Civilization-wide transformation in the future of work signals a new socio-technical challenge in adult education and human resource development. The technologically-driven, fast-paced, and innovation-focused workplace transformation is suffused with speculative-pragmatic accounts of the rise in automation throwing an exhausted workforce into the ever-increasing demand for efficiency, capability, and skills. The socio-technical complexity in the future of work challenges adult educators, human resource development scholars, and those who are committed to the scholarships *for* transformation: to experiment with different ways of learning that enables affirmative approach to the upcoming socio-technical transformation in the future of work. In aims to reconfigure education as a 'practice of constructing social horizons of hope' (Braidotti, 2019, p. 156), this transdisciplinary study experiments with a different way of knowing that facilitates inquiry into the experience of human-machine interaction in engineering education. This study seeks how a deliberately designed learning space promotes a mutual dialogue on human-machine interaction, through an embedded mixed-method inquiry with 30

undergraduate and graduate engineering students. Participants experienced the indirect guidance of a technological device, which in this study is called a nudge. Under the deception of artificial intelligence sending out nudges during the work process, participants with inquiry-based learning intervention exhibited a more attentive perception of the sensorial experience with the nudge device compared to the other groups (i.e., lecture-based group and a control group without any intervention). The findings allude that inquiry-based learning inviting non-human actors (i.e., technology) into the learning activity yields more nuanced perceptions of technology. Also, the young adult learners' different imaginations of engineering practices are surfaced throughout their learning from nudge experience. I included the autoethnographic accounts of my experience in the challenges of conducting transdisciplinary work as a novice qualitative researcher in the context of the future of work in collaboration with the mechanical engineering team. This dissertation is a momentary rupture of my continuing inquiry into the future of work with a cultivated taste for affirmative ethics (Braidotti, 2013; 2019) and generative knowing (Nicolaides, 2022).

INDEX WORDS: Adult learning theory, Pedagogy experiment, Transdisciplinarity, Nudge, Autoethnography, Industry 4.0.

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My laptop that I decorated with some stickers I brought from the record shop, and coffee places in different states. A white, insulated stainless steel tumbler filled with iced coffee, sometimes with a drizzle of almond milk and syrup, served with a reusable straw. A brown leather thought journal I received as my birthday gift from my sister, on which my name is engraved in gold letters. A Georgia-dawg-shaped stress ball. Pens and dull pencils. Lots and lots of highlighters, and post-it flags. Sticky notes attached on my screen that say my writing group's Zoom link, or encouraging words shared to me.

Books piled up physically on my shelf or virtually in my Kindle library. *A Thousand Plateau. Anti-Oedipus. What is Philosophy. Philosophy and the Mirror of nature. Thinking through Technology. The Order of Things. Precarious life. Art as Experience. Otherwise than being. Thinking with Deleuze. The Social Engagement of Social Science. The Automatic Society. What Things do. On the Mode of Existence of Technical Object. Professional Responsibility and Professionalism. Posthuman Knowledge. The Posthuman. Uberland. Dear Science. Thinking with Theory in Qualitative Research. Action Inquiry. Work Won't Love You Back. Nudge. Cultures@SiliconValley. Atlas of AI. Meeting the Universe Halfway*, to name a few. Tons of other articles stored in my Zotero library.

Photos on the wall that I took with my friends and my dog before I moved to the U.S. to pursue my doctoral study. Cards hanging on the wall that I received from my family, my Athens friends, and my homies. A printed picture of Cocoa beach which I visited with my sister during a road trip to Florida in December 2021. A squared whiteboard on which I wrote three values of 2022—consistency, well-being & deep connection—and my monthly goals for this year.

A cup of espresso I enjoyed during my weekly meeting with my advisor. The meetings with my advisor that I have had once a week since day one of my doctoral program, leading to occasional long-hour walks with deep check-in's. A handful of virtual and in-person conversations with my committee members and other professors on my last-minute request for some time to think with, (and their tolerance for my scattered thoughts expressed in my sometimes-broken language). Disorganized recollection of different conversations that I had with teachers and peers during my coursework. Tons of email threads starting with "this might be of your interest" and ending with warm regards. Numerous YouTube channels that curate and mix songs for my sleepless and writingful nights.

Unexpected invitations for collaboration from researchers from different regions, and disciplines. Thoughtful comments from my critical friends, colleagues, and anonymous reviewers of different journals and academic conferences. Some heartwarming words from my research participants that they want to read it once it got published. Some reflective words from my students who compared my teaching to a shower thought, a night-driving tune, or a good reminder of why they decided to major in engineering.

Sporadic Zoom calls, and facetime with my friends in different time zones. My writing group's daily reminder of affirmation and resilience. My mom's warm voice and wise words over the telephone. My dad's terrible effort of showing my family dog to me during the face time. Their trembling voice when I let them know that my inspiration of dissertation project was

their stories as engineers, who were in fact systemically defeated but remain mystically resilient and affirmative. Their willingness to share their vulnerable stories which became an entry point of my faith in affirmative ethics and generative knowing in the future of work.

Not a single word would possibly be written in this dissertation without the things I listed above.

Deep appreciation for all.

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CHAPTER 1

BEING ADDRESSED AT THE THRESHOLD OF TRANSFORMATION

In 2019, a few months later than I started my Ph.D., COVID hit the world hard. I was thrown into the world with a daily dose of news discussing Asian Hate, conspiracy theories, and irresponsible acts and words of leaders all while practicing a mandated work-from-home practice, on the brink of social isolation. Despite not having to worry about a stipend thanks to the continued graduate assistantship, my days back then were disquieting. Staying at home all day in a small studio, without any transportation method available at my hand at that time, I questioned my choice of doing a Ph.D. in the program entitled "Learning, Leadership, Organization Development." My doctoral program offers a purposeful interdisciplinary focus on transformation. Dedicating four years of my life to a terminal degree in the program *for* transformation in a country hundreds of miles away from my home means my conviction in the power of transformation. Still, I felt hesitant to believe so.

The belief in the affirmative power of transformation has not come easy. Behind my hesitancy was the lingering question of why I chose the program *for* transformation for my doctoral degree (Nicolaides & Lim, 2020). The disquieting days during Pandemic were a perfect condition for me to search for the answer to the question. I was living in a world of utmost instability. Reflective thoughts were my way of grasping the moments that are thrown upon me (Dewey, 1929). Every little question in my mind led to a different thought, action, and felted sense, tugging me into further questioning. I omnivorously read philosophies and theories

outside of my program. The resonation and reverberation of the concepts created a mysterious "thick fog" (Deleuze & Guattari, 1991/1994, p. 50) around the landscape of my thinking.

Interestingly, during that time, I was not the only one who was in the quest for seeking the meaning of work. The global crisis led to question a culture that sustained the logic of endless production (Latour, 2020). Workers explicitly questioned the emotional toll of espousing the value of productivity, performance, and efficiency in organizational workplaces (Jaffe, 2021). The so-called 'hustle culture' seemed to be challenged and even ridiculed by some. Workers, whom organization have demanded be ever resilient, agile, and engaged, now silently quit (Krueger, 2022). The passion paradigm, which previously motivated individuals to seek their professional passions and unconditional pursuit of 'what they love,' was challenged and shaken to its core (De Palma, 2020).

The growing sensation of overall despair and prevalent burnt-out intensified my suspicion of the power of transformation. Regardless of the labels of the fields—be its workforce development, human resource development, or adult education—the water I am swimming in, is built and firmly grounded on the belief that learning makes substantial changes in frames of reference, and the changes are beneficially transformative to individuals. I deem the kind of water I am swimming in, is the scholarships for transformation. Their fundamental premise is that the wholesome development of the individual and deliberate channeling of such a transformative power of individual development can result in the collective growth of society (Fejes & Nicoll, 2012; Gouthro, 2019; Käpplinger, 2015; Marsick & Nicolaides, 2015; St. Clair & Käpplinger, 2021; Yorks & Kasl, 2006). In aims to generate the force of potential, through the agential redemption of learners—or inspire learners to orient more towards affirmative ethics—the scholarships for transformation constituted the practices constructing the social horizon for

hope (Braidotti, 2019). The current collection of narratives, however, was telling me a different story. Workers feel numb, demotivated and less engaged in the rapid pace of techno-centric transformation (i.e., Crawford, 2021; Rosenblat, 2018; MIT Sloan Review, 2022) and signaled exhaustion and lethargy. Workers were too tired to stay motivated, let alone become affirmative. Braidotti (2019) observed:

> "This system is exhausting in that it pursues an internally contradictory aim: on one hand, it runs on the 'timeless time' (Castells, 2010) of a technologically interconnected society where the economy functions 24/7 and capital never stands still. On the other hand, it functions through a public discourse of health, fitness, and care of the self thus requires a conscious and self-regulating, health reserve of labour." (p. 15)

To me, this observation is even more highlighted in the future of work. The new language such as "digital transformation," "Industry 4.0" (Bartodziej, 2017), the "4th industrial revolution" (Schwab, 2014), to name a few, hover around the future of work. The civil-wide transformation in the world of work indicates how the exponential growth of computational technology enables digitalization, connectivity, and automation, and signaling a major shift in the world of work. The transformations are easily observable. 45,000 robots have been used in Amazon warehouses to move products (Menouar et al., 2017). More recently, Amazon is employing a drone to fully automate its delivery service (Riananda et al., 2021). Meanwhile, Amazon warehouses that employ Internet of Things technology, which enables interconnectivity between the cyber and physical domains, are notorious for their tight work schedules, horrendous workload, and dangerous working conditions (Palmer, 2021).

Sadly, this came to me as a dead-end future of the scholarships *for* transformation. The technologically-driven, fast-paced, innovation-focused workplace transformation seems not to be

transformative enough to drive cultural change, at least for those who are experiencing the innovation. The attrition rate of employees working for Nvidia, Tesla, and Space X is surprisingly higher than other for-profit companies in America (MIT Sloan Review, 2022). The example of the Amazon warehouses, or some emerging phenomenon of quiet quitting and great resignation signals how the future of work unfolds in reality. No one knows whether the technologically driven transformation happening in the Amazon warehouses will eventually become either remedy or toxin (Stiegler, 2016). The transformation may emancipate the workers from unnecessary duties (Danaher, 2019) or cause self-induced alienation (Crawford, 2021). Nevertheless, the image of the future of work suffused with an exhausted workforce on endless production paints a rather dystopian picture.

I became critical of the skills discourse that promotes upskilling and reskilling as one of the most responsive ways to deal with the future reality (i.e., McKinsey, 2021; World Economic Forum, 2020) and contributes to the reproduction of the dystopian image of the future of work. In the skills discourse, learning, as the main route to produce and circulate knowledge and skills, is positioned as a way of reproducing the productive workforce through the promotion of ideas to be agile for the future ahead and act upon reality. The scholarships for transformation—Adult education scholarship and human resource development scholarship—have advocated humanistic and liberal values (Fejes & Nicoll, 2012; Gouthro, 2019; Kapplinger, 2015; Marsick & Nicolaides, 2015; St. Clair & Kapplinger, 2021; Yorks & Kasl, 2006; Watkins et al., 2021). Nevertheless, as a part of skills discourse they are not free from the critique of education's inadvertent servitude for the knowledge economy by creating "possible worlds and their realization that is the object of capitalist appropriation" (Lazzarato, 2004, p. 200). The scholarships exist as a part of the research and development of a business enterprise or as a part

of a university or "a firm manufacturing knowledge production." (Braidotti, 2019) They somehow contributed to the reinforcement of a modern Sisyphean struggle, a restless yet futile journey to get something desirable but only to realize that is unreachable.

How was this possible? How have the scholarships *for* transformation strived for their servitude of the system as if it is their salvation? (Deleuze & Guattari, 1972/1983, p.29) People strive to obtain knowledge capital, despite their exhaustion and lethargy, constantly feeling the oppression of ever-increasing demands in the knowledge economy. People desire a system that is still repressive, going against their personal interests. Here, desire means a productive force that creates a continuous process of becoming (Deleuze & Guattari, 1972/1983). To Deleuze, "desiring" does not necessarily mean inherently preferable objects. In the knowledge economy system, the chains of desire continue to create another subject that desires to become more efficient, capable, and skillful. The endless desiring cycle reinforces the endless production of knowledge, which the adult education and human resource development scholarship have involuntarily served for.

How does desire work behind the claims, supposition, and theorization of learning in the future of work? To me, this question puts the scholarships *for* transformation in a "situation of being addressed… by which our obligations are articulated and pressed upon us" (Butler, 2004, p. 130). The future of work is the threshold moment for the scholarships *for* transformation either to be possibly bound to the outside of the field views or to create a new image, a new paradigm (Kuhn, 1967) or new planes of thought (Deleuze & Guattari, 1991/1994). It is "a threshold of transformation of forces" or "the virtual state of creative becoming." (Braidotti, 2019, p. 16) In order for the scholarships for transformation to perform, not claim, their commitment to transformation, it is imperative to explore if it is ever possible to create a world that is different.

This curiosity inspires me to test the power of transformation by conducting transdisciplinary work in the context of future of work. Transdisciplinarity provides conceptual tools that help navigate the complex, turbulent world by "attuning to the multiplicities of worlds" that inquirers also take part in creating (Marenko, 2021). It is a rebellious departure from thinking within the disciplinary boundaries and troubling the academic silos and conventions (Burnard et al., 2022). My critical perspective on the scholarships I would love to commit to, and their involuntary servitude for the knowledge economy system urged me to seek a liminal space of potential difference. Then I need to do my scholarly work differently.

My desiring difference led me to imagine a different future of work. I sensed the mystery in the future of work as a condition requiring us to be inquisitive and reflexive. In a world that is inevitably "a scene of risk" with the utmost uncertainty (Dewey, 1929, p. 41), inquiry means a deliberate dedication to continually reach toward the balance of certainty and uncertainty. The fine boundary between the known and the unknown, the certainty and the uncertainty, the comfort and the strange can be sought through the choice to become reflexive. "[T]he striving to make stability of meaning prevail over the instability of events is the main task of intelligent human effort" (Dewey, 1929, p.50). Borrowing Dewey's perspective and circling back to the power of education, the future of work may signal a transformative moment, which has a potential with its unknown quality.

The speculative accounts of the future of work mean it has its own potential of becoming. The experience of uncertainty that evokes challenges to individuals' ways of knowing and knowledge creating a different way of becoming (Nicolaides, 2022). The exponential growth of new technology that enables the realization and imagination of the future of work adds to the complexity. It offers an inquiry space with a potential experience of strangeness, which deserves

to be observed, felt, savored, reimagined, or undergone through iterative retelling. Indeed, new management practices with highly autonomous and predictive capacity report provide evidence of how the normative practice of work, including ways of knowing and doing work, are challenged, disrupting and dismantling human enterprise (Crawford, 2021; English-Luerke, 2017; Rosenblat, 2018; Tambe et al., 2019).

My intention to test out my desiring for difference has motivated my inquiry into the future of work. I experimented with the learning that is designed to facilitate inquiry or generative knowledge production (Nicolaides, 2015) into the future of work. My inquiry was braided through understanding, contextualization, and substantiation of the future of work, producing three pieces as follows.

Theoretical understanding of the role of adult learning in the future of work

This study offers a philosophical reflection on the position of adult learning in the emerging socio-technical landscape by intersecting different theoretical threads of inquiry to better understand and critically assess the responses generated in the terrain of adult education and learning. Through tracing the history of adult education and learning scholarship, I map the rhizomatic terrain of adult education and position a new learning theory that explains the complexities emerging in the future of work. Heavily influenced by the Deleuzian perspective of philosophy, I play with the concept of desire (Deleuze & Guattari, 1972/1983) in this study to better understand the effect of industrial logics of productivity, performativity, and efficiency on humans' cognition, behavior, and emotion.

The future of work discourse created by the industrial agents (i.e., Deloitte Global & The Global Business Coalition for Education, 2018; Dondi et al., 2021; Schwartz et al., 2018; World

Economic Forum, 2020) uncritically, subtly and unintentionally perpetuates the industrial logics of efficiency and productivity in discussing the future of work. This possibly contributes to the reproduction of a desire cycle that prioritizes the values of efficiency, efficaciousness and industriousness that may no longer work in the future of work. I understand such an effect of the dominant, business-oriented future of work discourse with the Deleuze and Guattarian insight on the extreme utopian-dystopian responses of humanity to the capitalism. I envision new learning that addresses the complexity of future of work and positions generative knowing theory as an example that facilitates adult learners' inquiry into the critical realities within the future of work context. Chapter 2 will discuss this portion of the study at length.

Empirical Evidence of New Ways of Knowing for the Future Engineers

I experimented with a newly designed learning intervention with undergraduate and graduate engineering students to explore the causal mechanisms of learners' different perceptions towards the socio-technical complexities fabricated in the experimental setting. This study employed an integrative mixed-method inquiry with an experimental design followed by a qualitative interview to better understand the socio-technical complexity emerging in the future of work.

Nudge is used to operationalize human-technology interaction in the context of experiment, as it indicates a technology-mediated poke that directs humans to make a decision and behave in a certain way (Thaler & Sunstein, 2009). In a situated context, humans get to understand the benefits, and costs of their choice, and thus slowly behave on the basis of the embedded feedback loop that the designer of the nudge intends to emerge. The experiment was designed through a collaborative effort with mechanical engineering researchers and aimed to

present the participants with an intense experience of technological intrusion in human behavior, cognition, and affect, otherwise put, being nudged.

Prior to the nudge experience, students were given a learning activity with a socio-technical orientation that was designed using the generative knowing theory to facilitate their inquiry into the future of work context. This learning activity involved philosophical discussion of the human being's ethical relationship with technology (i.e., Heidegger, Simondon, 1958/2017; Stiegler, 2015; Ihde, 1990; Verbeek, 2005) as a substance. The subsequent qualitative interview, guided by the critical incident technique (Flanagan, 1954; Ellinger & Watkins, 1998), explored how participants make meaning in their lived experience while being nudged within the experimental setting. The findings will be reported as a separate article in Chapter 3.

Auto-ethnographical Account of My Transdisciplinary Inquiry Experience into the Future of Work

I provided an autoethnographic account of my inquiry experience of thinking with theory and conducting a transdisciplinary inquiry into the future of work. This dissertation sums up my life experience as a novice qualitative inquirer, who attempts to think with Deleuze and Guattari while working with researchers with different research paradigms with ambitious intention to navigate the unknown context of the future of work in hopes to become more receptive to the multiplicity of worlds we (the inquirers) also take part in making (Burnard, 2022; Marenko, 2021). Enduring epistemological and disciplinary clashes pinned a hole in the thick fog during my inquiry process (Deleuze & Guattari, 1991/1994).

Using autoethnography (Chang, 2008; Adams et al., 2021), I elaborated on my inquiry experience. The daily conversations among scholars with different academic backgrounds and disciplinary training challenged me. They sparked my curiosity and doubt on my research, which becomes another thread of inquiry. This messy mind of indetermination, second thoughts, and epiphanies along the process of inquiry in relation to numerous others materializes what constitutes my scholarly subjectivity in conducting a qualitative inquiry and investigating the socio-technical complexity in the future of work. My experience of questions, chaotic thinking, and momentary breakthroughs was provoked by conversations with the human actors (i.e., collaborators, participants in experiments, and committee members) and non-human actors (i.e., data, experiment apparatus). I continuously interweaved the inquiries, without knowing what I was doing. This story is presented in Chapter 4.

Problem Statement

The socio-cultural transformation for a more generative, affirmative ethics (Braidotti, 2019) is necessary to make the technocentric transformation more inclusive in the future of work. From several observations of the current transformation, the industrial values of productivity, performativity, and efficiency continue to permeate the work culture and thus alienate the workforce from the transformative process. On one hand, workers are alienated from the process of work as automation of labor dehumanizes human labor (Rosenblat, 2018), numbs the workforce (English-Luerke, 2017), and exploits and marginalizes the invisible labor that helps the tech industry run smoothly (Crawford, 2021; Roberts, 2014). On the other hand, they are also alienated from the transformative and generative relationship between humans and technology (Braidotti, 2019; Simondon, 1958/2017; Idhe, 1990; Mitcham, 1985, 1994; Stigler,

2019) due to the prevalent solutionist belief that views technology as a mere tool and instrument (Wajmann, 2019), not something to become-with. Socio-engineering dualism in engineering education also reinforces engineers' from thinking about engineering issues together with social issues (Herkert, 2005; Martin et al., 2021; Polmear et al., 2021). Automated resume screening systems that are aided by natural language processes resulting in biased selection towards white male job candidates provide a representative case (Tambe et al., 2019). This phenomenon signals how the global-scale, technocentric transformation marginalizes the socio-cultural domain and diminishes the possibility of the forces becoming more mutually transformative.

As the current socio-cultural transformation in the future of work is assumed to present a qualitatively different experience in terms of human-technology interaction, exploring how people experience differences, and strangeness of advanced technology is important (Stiegler, 2019). Engineers are not only responsible for designing the socio-technical system based on their technical expertise; they also play a part in the socio-cultural transformation generated by the advanced technology. The alterity of advanced computational technology signals a different ethical relation with humans and, thus, different becoming of humans and technology in their intra-action[1] (Braidotti, 2019; Levinas, 1974/1981; Simondon, 1958/2017; Stigler, 2019). Engineers' ethical capacity becomes important in that they have the power and knowledge to instill their moral values and perspectives in the socio-technical system (Martin et al., 2021; Picon, 2004). It is important to understand the different experiences generated by human-technology intra-action within the socio-technical system through the lens of system designers.

[1] Intra-action means the mutual constitution of agencies (Barad, 2007, p. 33) engaged in the phenomenon. This view is coming from a quantum physics in which the act of seeing constructs a phenomenon. Phenomenon (the observed) cannot be separated from the subject who observe, and consequently does not have definitive boundaries or qualities. The act of observing produces what phenomenon is. In this regard, phenomenon inhibiting agencies is enacted and constituted by co-constituting relationship among agencies, and the co-constitutive relationship is called intra-action.

Equally important is understanding how engineers react and respond to the experience of difference in human-technology intra-action. This will hint at their ethical capacity to respond to the emerging complexity and how they perceive the different experience of the difference of human-technology intra-action.

Historically, the philosophical questioning of the use of technology allows a critical and interpretive understanding of technology to emerge, theorizing how technology is bound to social and moral values and thus can be only understood in the socio-technical interface (Stiegler, 2016; Trist, Emery, & Murray, 1997). The field of engineering has also begun to recognize the value of teaching engineering ethics with a socio-technical orientation as part of expanding professional responsibility of engineers in the technocratic society (Conlon & Zandvoort, 2011; Colby & Sullivan, 2008; Herkert, 2000, 2005; Li & Fu, 201; Martin et al., 2021; Picon, 2004). The current practice of engineering ethics education that highlights problem-based learning with prominent use of case studies reduces the multiplicity of reality (Fenwick & Parsons, 1998). I see the dominance of a problem-based approach to engineering ethics education as the main impetus separating the educative practice from the engineering practice (Fenwick, 2016) and reinforcing the solutionist culture among engineers. A problem-based orientation does not allow time for pausing to reflect and muse over the solution. It leads engineers to immediately jump into the process of problem-solving.

The current socio-technical transformation necessitates a novel ethics education that enables situated, participatory, and context-driven inquiry into engineering practice. A more inquisitive understanding and questioning of the technology is necessary. With the co-constitutive nature of human-machine interaction in the background, the emerging ethical challenges pose questions about the issue of power (i.e., Crawford, 2021; Roberts, 2014), agency

(i.e., Wajcman, 2019; Rosenblat, 2018), interdependence (i.e., Dahlman et al., 2021; Devendorf & Goodman, 2014; Seaver, 2017; Bucher, 2017), and the responsibility of the agents involved in the socio-technical scene (i.e., Boersen & Botin, 2013; Botin, 2015; Woide et al., 2021; Dodig-Crnkovic, & Persson, 2008; Thekkilakattil & Dodig-Crnkovic, 2015). The inquisitive re-examination of the embedded technochauvinism (Broussard, 2018), or the biased belief that technology is the one and absolute solution to every social problem, will help engineers to become more aware of socio-technical complexity. It presents one way of teaching that they are capable of creating and dedicating their knowledge and expertise to making the global-scale transformation become more mutually transformative.

Purpose and Research Questions

I think with theory in developing, designing, and implementing the inquiry-based learning activity for engineering ethics education in response to the observed and potentially enacted impact within the global-scale transformation in the world of work—the future of work. The new adult learning theory, generative knowing theory guides the design of the learning activity (Nicolaides, 2022; Nicolaides, 2015; Nicolaides & Lim, 2020; Yorks & Nicolaides, 2013). The undergirding philosophy of generative knowing theory is closely aligned with affirmative ethics (Braidotti, 2013, 2019). When faced with ambiguity, uncertainty, and the unknown, the deliberate mind to choose to endure and be in communion with the ambiguity influences learners to respond to the complexity of the unknown in a generative way that allows them to search for multiple meanings (Nicolaides, 2015). What is highlighted in generative knowing theory, is the power of motivation to choose to face ambiguity, not avoid it. I see this motivation can be understood with what Braidotti (2019) meant by affirmative ethics, which

propel “the positivity of an ontological desire that orients them toward the freedom to express all they are capable of becoming” (p.155).

This study aims to explore how adult learning theory may scaffold an inquiry into the experience of emerging socio-technical complexity, which evokes a strangeness of technology with highly autonomous and predictive capacity. I operationalized the human-technology interaction using the concept of nudge, which refers to a technology-mediated direction affecting human decision-making (Thaler & Sunstein, 2009). This study suggests, develops, and evaluates the educational activity that aims to promote a situated, participatory and context-driven inquiry into socio-technical complexity and help adult learners become imaginative and generative to the question of how humanity co-exists with technology.

The overarching question of my study is to see if it is ever possible to reconfigure learning as a practice to create different world. To test out my theory, I seek how desire works as Deleuze purported, desire works as a productive force of all. How does desire work behind the claims, supposition, and theorization of learning in my inquiry into the future of work? Deleuzian desire, as a pre-individualized, productive force of all, composites each piece of my inquiry into the future of work. In theoretical piece, I explored how adult learning and education scholarship contributes to the (re)production of desire in the future of work. In empirical piece, I experimented with a different way of knowing and seek how it produces if at all, any difference in the engineering culture. In autoethnographic piece, my question goes to my desire as an inquirer into the future of work to seek the multiplicity within my inquiry space. As a result, I have a list of research questions that guide each piece of inquiry:

Theoretical piece

- How has adult learning and education scholarship contributed to the cycle of desire for efficiency?
- In what ways, if at all, does reconfiguration of adult learning towards affirmative ethics reorient the flow of desire?

Empirical piece

- How do participants perceive the role of the nudge device during their engagement in a mutually dependent engineering task? How do they perceive the nudge experience?
- Do different types of nudge and different ways of knowing affect the participants' assessment of the mutual interdependence of the task?
- What kinds of human-human relationship and human-technology relationship do participants produce in the experimental setting? In what ways, if at all, does learning intervention with socio-technical orientation contribute to the nuanced understanding of technology?

Autoethnographic piece

- How does desiring multiplicity function to produce my research process?
- How does the epistemological and disciplinary clashes I experienced as a novice qualitative researcher in conducting a transdisciplinary inquiry in the context of future of work challenge my inquiry process?

Disclaimer

When I think of thinking, I cannot escape from a Deleuze and Guattarian (1991/1994) perspective. They describe thinking as laying out a plane that may have infinite movements or diagrammatic features, creating an immanent plane. That is, thinking is "experimental and experiential," and "born under the constraint of experience as a material power, a force." (Semetsky, 2010, pp. 91-92). My experiential encounters with the world are forces that motivate me to think. In this process, I recognize how condemned I am, as a person who wants to think differently, "to attempt to lay out my own plane, without knowing which planes it will cut across" (p. 51). That is, through this process of questioning and experimenting with the world, making a hole through a "thick fog" (Deleuze & Guattari, 1991/1994, p. 50) that has rendered my inquiry process rather chaotic. Nevertheless, different ideas pierced through the thick fog, getting my thinking somewhere I had never expected to be.

As a result, I intend to ground my dissertation in a patchwork of concepts, which I assume to be pertinent to understanding the emerging phenomenon of the future of work, endorsing Deleuze and Guattarian perspectives on philosophy. I deliberately entitled my dissertation using the syntax of connective synthesis "and… and… then… and" to express my intention to think through future of work in the possibly polymorphous way. Deleuze and Guattari defined philosophy as "becoming, not history; it is the coexistence of planes, not the succession of systems" (p. 59). According to them, philosophy is metaphorically a *plane of immanence*, and concepts are the rhizomatic flourishment that builds upon the past concepts that have been produced by other precedent philosophers. That is, the seeds of concepts can be planted and be fully grown into new flourishment with the conscious effort of the thinker, which they called conceptual persona. All in all, philosophy has three elements that are:

> "the prephilosophical plane it must lay out (immanence), the persona or personae it must invent and bring to life (insistence) and the philosophical concepts it must create (consistency). Laying out, inventing, and creating constitute the philosophical trinity" (pp.76-77).

According to Deleuze and Guattari (1994), philosophy is all about new creative force, and what materializes the force is the image of conceptual personae. For instance, Braidotti's (2019) *posthuman* rejects the constitutive role that "the sexualized other (woman), the racialized other (the native), and the naturalized other (animals, the environment of earth)" (p.27) have played in service of defining the Man in the Western philosophy. Here, Braidotti is signaling her desire to produce a persona in marked contrast with the classical, Cartesian humanities and invent a new subject that orients towards the margins. The creation of concepts is what philosophy is, and without the proliferation of concepts, there is no philosophy.

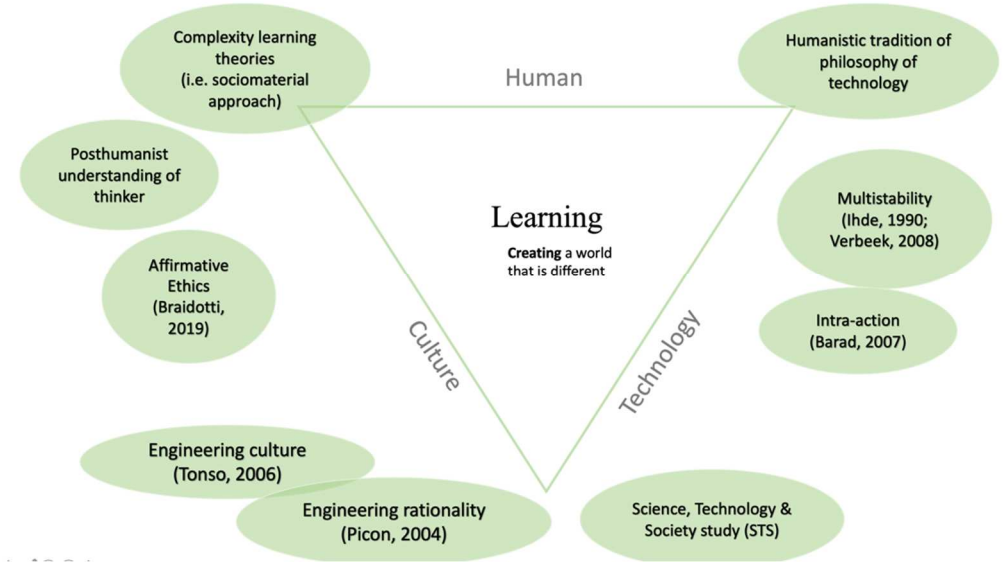
> You will know nothing through concepts unless you have first created them – that is, constructed them in an intuition specific to them: a field, a plane, and a ground … that shelters their seeds and the personae who cultivate them (Deleuze & Guattari, 1994, p.7).

Based on the Nietzschean verdict that Deleuze and Guattari mentioned in their book *What is Philosophy,* I have intentionally searched, discovered, plugged in, juxtaposed, placed, mapped, and drawn my plane of immanence with different combinations of concepts, or the "well-made concepts" (Deleuze & Guattari, 1991/1994, p. 77), that stimulate the creation of new insights that facilitate my inquiry into the future of work. They include, multistability (i.e., Ihde, 1990; Verbeek, 2005); affirmative ethics (i.e., Braidotti, 2013; 2019); anti-capitalist theories (i.e.,

Lazzarato, 2004); humanistic tradition of philosophy of technology[2] (Mitcham, 1994), engineering culture (Tonso, 2006), and engineering rationality (Picon, 2004) (See Figure 1.1.).

Figure 1.1.

My Plane of Immanence



Following are the brief sketches of how the concepts are related to my inquiry into the future of work.

Multistability

Post-phenomenologist (Ihde, 1990; Verbeek, 2005) postulates how the consciousness of technology always stays in relation to human's praxis and remains undetermined. How technology comes into being is stable in multiple ways (Verbeek, 2005, p. 118), meaning that the

[2] I am aware that Mitcham (1994) audaciously attempted to collectively and loosely label the heterogeneous body of literature with the different ontological backgrounds as a humanistic tradition of technology could be problematic. Nevertheless, I would like to utilize the gross categorization to better refer to the polylithic body of literature on human-technology-relationship.

perceptions of technology are always fleeting depending on the vantage point. Technology then does not frame or *determine* one material structure as purported by Heideggerian phenomenology; its role rather stays ambivalent and constructs multi-structure. This is why post-phenomenology takes departure from the phenomenological understanding of technology (Ihde, 2022). Technology engages with and takes advantage of reality by directing the humans' behavior onto and within the reality (Verbeek, 2005). According to Verbeek, technology has its own intentionality in two senses. First refers to the "intentions of the technology itself" and second to "the relations between human beings and world that are mediated by the technology" (Verbeek, 2005, p. 116). Technological intentionality co-constitutes the encounter between human and the world and humans are affected by being exposed to technological intentionality, be it voluntarily or involuntarily.

Intra-action

In quantum physics, the multistability of technology means that technology intra-acts as an agent with human beings and constitutes the phenomenon through its mutual relationship with human beings (Barad, 2007). Such a mutual constitution enacts what is possible in reality. That is,

> "Intra-actions iteratively reconfigure what is possible and what is impossible—possibilities do not sit still. One way to mark this is to say that intra-actions are constraining but not determining. … The world's effervescence, its exuberant creativeness, can never be contained or suspended. Agency never ends; it can never 'run out.' The notion of intra-actions reformulates the traditional notions of causality and agency in an ongoing reconfiguring of both the real and the possible. … Agency is not

> aligned with human intentionality or subjectivity. … Rather, it is inherent in the nature of intra-activity—even when apparatuses are primarily reinforcing, agency is not foreclosed." (pp. 177–178)

From the quantum physics perspective, physical substances in general, or matters, are in the process of becoming. Claiming the identity of matter—what Barad calls mattering—is only a product of a momentary rupture as the process of mattering is still ongoing, even when the matter's identity is decided. The matter contains infinite vitality, which is only possibly assumed and momentarily measured through the relationship it forms with other matters. Scientific apparatus is instrument in that it amplifies, reduces, or conveys the humans contact with the world. In this regard, scientific apparatus has its own technological intentionality, as it affords a certain way in which humans contact with the world, while playing a role in the material structure it contributes to create.

Science, Technology & Society Studies

The Science, Technology and Society (STS) scholarship, or what is now called critical algorithm studies, critically assesses the role of technology. They solicit more ethical reflection and enactment of technology in society in response to the extensive technocratic approaches to complex social problems (boyd & Crawford, 2012; Kitchin, 2017; Seaver, 2015). The STS inquiry corroborates how the advanced computational technology enacts its implicit surveilling power toward human society such as workers on factory floors (Crawford, 2021), on a platform business (Rosenblat, 2018), or in a corporation (Tambe et al., 2019; Wajcman, 2019). These inquiries signal a rising suspicion of engineers. The system designers' moral values and ethics are built-in the system they designed. Multiple pieces of evidence indicate that uncritical

perceptions towards technology or its intentionality in the management produces a subtly biased decision-making against a traditionally marginalized group of individuals (Broussard, 2018; o'Neil, 2018; Tambe et al., 2019). Also, perfunctory engagement of computational intelligence in managerial practice potentially numbs the workforce (English-Luerke, 2017; Waddell, 2016; Wajmann, 2019) and marginalizes the types of labor that sustain the whole system but are treated as invisible and nonsignificant (Crawford, 2021; Roberts, 2014). Such a stratification of knowledge labor in a digital age (Fuchs, 2010) can eventually lead to the favoritism to the high-skilled labor as well as individuals with capital (Acemoglu & Restrepo, 2019; Avis, 2018; Frey & Osburne, 2017). Workers with the easily-routinized or easily-standardized skills fear getting replaced by the computational intelligence in the survival capitalism (Brown, 2015; Crawford, 2021; Morgan, 2019; Rosenblat, 2018).

Affirmative Ethics

Braidotti defended affirmative ethics as a "collective practice of constructing social horizons of hope, in response to the flagrant injustices, the perpetuation of old hierarchies and new forms of domination." (Braidotti, 2019, p. 156) Affirmative ethics are distinguishable from an endless and romanticized strive for positivity. Affirmative ethics concern with resisting traditional knowledge parameters that perpetuate exclusion and embracing different ways of producing knowledge and subjects in a boundaryless way. This requires a constant liberation of desire towards infinite potential, or positive variation. In lineage of Deleuze and Guattarian desire, affirmative ethics are discussed as a way to arrange desire in a way which constantly resists the prevailing code of capitalist regime for a "linear composition of more performative and enhanced pan-humanity." (Braidotti, 2019, p. 44)

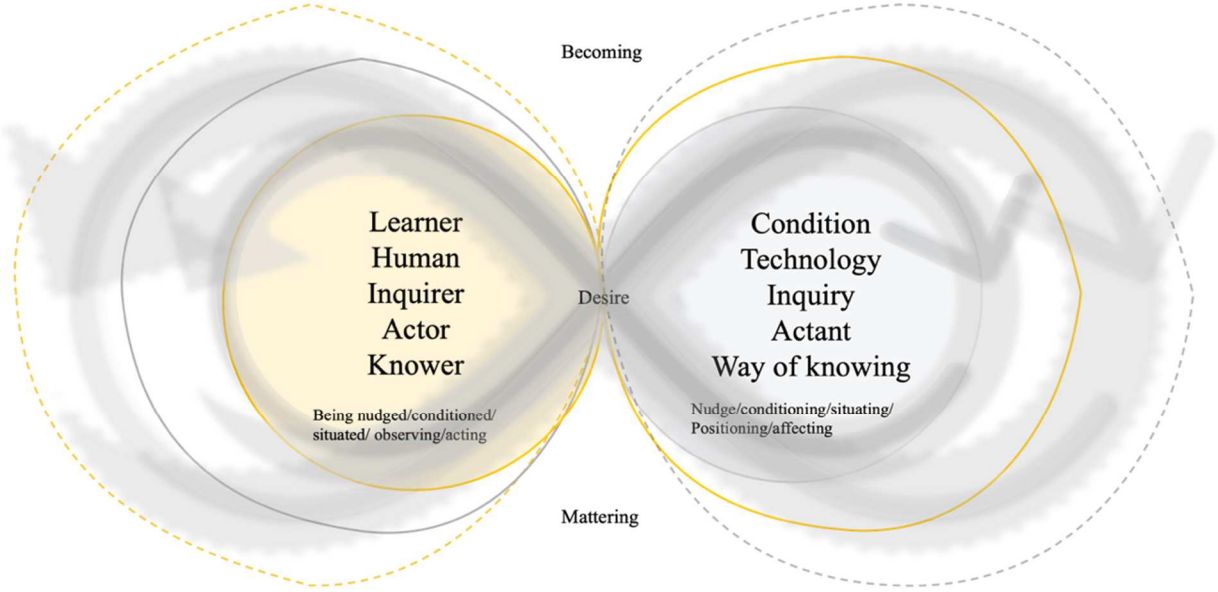
Humanistic Tradition of Technology

The philosophy of technology carries two connotations (Mitcham, 1994): one is the contemplation of the ethical *use of* technology, which pertains to the idea of engineering—that is, the instrumentalization of technology—and the other is the systematic reflection of the human being's ethical *relationship with* technology. The latter indicates the humanistic tradition, which treats technology as a subject matter, and foregrounds the meaning of technology in relation to human beings. Heideggerian account of human-technology that purports indispensable role of technology in human's way of being is situated within the latter. Heideggerian perspective offers a rich literature that facilitates an attentive, reflective yet critical description of human individuation through the human-technology-intra-action. The gravitational pull of the diverse discourses around the humanistic tradition of philosophy of technology is the "nontechnical aspects of human experience" (Mitcham, 1994, p.63), where technology plays a consequential role in shaping the experience and consequentially humans' ontology. Several philosophers' concepts reverberate and generate diverse discussions on how humans come to being in relation to technology, following or challenging Heideggerian philosophy (i.e., Braidotti, 2013, 2019; Deleuze & Guattari, 1987; Stigler, 2015, 2019; Ihde, 1990; 2022). I included the philosophical rendering on co-constitutive, emerging, and thus immanent nature of the human-technology relationship as a learning substance for my empirical piece.

The desire behind my intention to create my own plane of immanence is to produce a new perspective in the future of work, with a taste for affirmation and generativity. This inquiry process is ever-expanding (see Figure 1.2).

Figure 1.2.

The diagram of my inquiry



The taste, as "the triple faculty of the still-undetermined concept, of the persona still in limbo, and of the still-transparent plane" (Deleuze & Guattari, 1994, p.77), modulates all the forces of laying out the plane of immanence, imagining the conceptual personae, and creating new concepts. Taste is the distinguishing feature of philosophy, and generative knowing theory (Nicolaides, 2015), which emphasizes the affirmative role of learning in the intensified complexity, concretizes my taste. My development of a taste for affirmation and generativity stems from my personal background as a person who inherited the belief in the meaning of education as a tool for survival in a competitive, social context from my parents. While they are engineers defeated by systems, they also felt the urge to take an alternative perspective on learning, contributing to my visceral feelings toward the upcoming socio-technical complexity (Lim, 2022).

Cultivating a taste for affirmation and generativity is what I suppose to be necessary to navigate through the socio-technical complexity. Generative knowers are capable of learning within complexity, approaching the situation with the intermingled causalities through "one's awareness of somatic, affective, and cognitively embedded being with a posture of reflexivity" (Yorks and Nicolaides, 2013, p. 9). What can be termed generativity, in this respect, relates to the capability of learners to respond to the complexity that they have never experienced yet with an intentional engagement of reflection. Connecting reflection and affirmation within the phenomenon of the future of work, may come across as a conceptual leap, which is what this study is designed to explore by putting the participants into a dialogue with a phenomenon of the future of work, in the context of artificially constructed human-machine interaction in an experimental setting.

This whole-part-whole conversation between the observer, the thinker, the inquirer (me), and the observed, thought and the inquiry is unfolded in three pieces of writing that show my momentary stay against complexity. The theoretical piece highlights my conceptual inquiry into the phenomenon of the future of work. The experiment piece produces empirical evidence that supports my thinking around the socio-technical complexity. My autoethnographic account shows how I am creating, inserting, and recognizing my subjectivity in the inquiry process. To some, this study may be seen as a theorizing effort that includes inductive observation and reflection. To others, this study may come across as a pedagogical study with deductive reasoning. I dare to claim that this study can be both, and that one common denominator of this study is to better philosophize the future of work.

CHAPTER 2

GENERATIVE KNOWING: RETERRITORIALIZING ADULT LEARNING THEORY FROM THE MARGINS

Adult education scholarship has carved a unique evolutionary path to becoming a pan-paradigmatic field, fortunately without any deviation from its own mission—"the well-being of the societies in which we live" (Gouthro, 2019, p. 73). It has strived to assert its scholarly identity as a separate field (Fejes & Nicoll, 2013; Kapplinger, 2015; St. Clair & Kapplinger, 2021). In the 1980s and 1990s, exploration of the scholarly identity of adult education led to an active debate of whether adult education scholarship could be defined as a discipline (Boeren, 1980; Plecas & Sork, 1986), only for scholars to determine that heterogeneity/multiplicity is the distinctive feature of adult education scholarship (Rubenson & Effert, 2019). In this regard, the rhizome has been employed as a rich metaphor and useful conceptual tool to describe how adult education scholarship has developed (Kang, 2007; Kapplinger, 2015; St. Clair & Kapplinger, 2021). Rhizome, a concept introduced by Deleuze and Guattari (1980/1987), is a system that seeks and produces connection(s) and multiplicities endlessly, without any gravitational forces that try to arrest and or unite the movement of potential (or what Deleuze & Guattari described as production). Unlike an arborescent structure that evolves with traceable roots, rhizomes branch out continuously without any origin. Tracing the origin, thus, is pointless in the case of rhizomatic structure. Instead, mapping and sketching the links and exploring what is behind the production of the connections are vital to understanding the structure and metaphor of rhizome

(i.e., Kuntz, 2018). Indeed, past attempts to map the unique evolutionary path of adult education scholarship have shed light on the different façade of adult education scholarship, highlighting multiplicity as its distinctive feature.

However, multiplicity in research of adult education has been reduced and limited to a point where the scholarship no longer extrapolates the intensifying complex reality that is endemic of liquid modernity rife with uncertainty (Gouthro, 2019). We see that this partially stems from the neoliberal logic of higher education that reduces the multiple meanings of learning in prioritizing the values of predictability, productivity, and profitability (Cunningham, 1992; Gouthro, 2019). The penetrating effects of marketization and commodification of learning are manifested in different forms, in different regional contexts (Fejes & Salling Olesen, 2016). In cases highlighting learners' employability, adult education has been "the hand-maiden of industry serving it obediently by training human capital via human resource development" (Cunningham, 1992, p. 181). Such reductive and obedient thinking that traps the multiplicities of adult learning into the channel that nurtures "a competent and efficacious person" (Fenwick & Tennant, 2004, p. 71) undoubtedly arrests the vitality of the production of multiplicity, or rhizome, of the scholarly discourse. Conditioning academia into another production of knowledge that serves the economy of capital and not of self and societal evolution (Braidotti, 2019; Gouthro, 2019) is no longer surprising.

Such a reductive conceptualization of adult education is prominent in the future of work discourse, where advanced computational intelligence gains a dominant role in the workplace decision-making process (Stiegler, 2016). In the future of work discourse, the role of adult learning is reduced to a channel for upskilling the workforce (Deloitte Global & The Global Business Coalition for Education, 2018; Dondi et al., 2021;Schwartz et al., 2018; World

Economic Forum, 2020) that will eventually make life easier, more productive, and more efficient. The surge of the expansive algorithm-human interface in the workplace and everyday life (Crawford, 2021; Rosenblat, 2018) demands rapid retraining and upskilling of adults through learning in response to the emergence of automated colleagues. The pragmatic undertone of this contextual demand enforces the stupefication of the public by urging more rapid-paced thinking processes, marginalizing human input in decision-making in the workplace, and inevitably deterring any theoretical thinking (Stiegler, 2016). Advanced computational intelligence, such as algorithms with a data-analytic and predictive capacity, enables a paced management of knowledge and work as a significant source of brain power, eventually separating knowledge from once-the-sole-subject-matter, or human workforce, even in areas such as talent management (Leicht-Deobald et al., 2019; Tambe et al., 2019). The human's position as the sole subject matter is now assisted and even replaced by the algorithm, which is more capable of rapid data processing. In this regard, once sought to nurture individuals' souls, adult education now turns its focus to nurturing individuals' capacity to become ever-capable, ever-efficient, and ever-skillful as a part of the entire labor system in a capitalist regime (Deleuze & Guattari, 1980/1987).

The paced and enforced rhythm of the system in which the field of adult education is situated, in the future of work context, ironically demands the restoration of the theoretical thinking that helps learners think through the complexity that prevails. It is still questionable whether adult education scholarship has been responsive to such a demand. The abandoned pursuit of theory building and testing in the context of adult education, narrated and recorded by Elfert, Kapplinger, & Smythe (2018), epitomizes the precarity of the practice of adult education under the influence of political and economic powers. This ironically suggests the importance of

maintaining the vitality of the theoretical discourses of adult education (Gouthro, 2019) against the neoliberal pushback against diversity. Learning as a pre-determined set of practices is inevitably conditioned by political and economic powers. The discussion around the meaning of learning through new theory-building matters in this regard as it liberates the scholarly discourses from the otherwise perpetuating logic of productivity, profitability, and practicality.

Deleuze and Guattarian philosophy offers an interesting insight into the complex nature of the relationship between adult education scholarship and capitalism by enabling us to explore what has motivated the production of the rhizome structure of adult education scholarship and its cascading effect. Plugging their concept of desire into the extant research of the field of adult education yields fruitful insight into how individuals are programmed to want what they resist and how adult learning has well-served the desire system despite its purposeful attention towards individual liberation and autonomy. Thus, in the following sections, we will first delve into the philosophical concepts of Deleuze and Guattari – mainly desire. Also, we will sketch the rhizome of adult education scholarship to understand better the position of adult education scholarship in the future of work discourse. Lastly, based on our discussion, we will suggest an emerging theory of adult learning, generative knowing, as a new approach to learning through complexity (Nicolaides, 2008, 2015; Nicolaides & Yorks, 2013; Nicolaides & Lim, 2020; Yorks & Nicolaides, 2013). This emerging theory is nomadic in that it refuses the reproduction of structures of efficiency and returns anew to the liberating, rhizomatic movement of the field of adult education. By doing so, we suggest that generative knowing as an emerging theory of adult learning through complexity in a way to resituate the role of adult learning in the future of work discourse, to promote affirmative ethics that grow the capacity for adult learners to navigate the complexity of different human-machine interaction.

Desire: An Invisible Force that Explains the Current Sisyphean Struggle

Deleuze and Guattari's (1972/1983) inquiry into desire starts from noticing the paradox of mass beings "made to desire their own repression" (Seem, 1972, p. xvii). This paradox cannot be understood with the psychoanalytical conceptualization of desire. In psychoanalysis, desire assumes lack and assumes that people want what they do not have. Such a conceptualization of desire idealistically assumes the object of desire should be inherently preferable, aligned with individuals' interest. However, it is equally valid that people invest in a system that is still repressive, goes against their interests, and constantly traps them into wanting more than they can have; people strive for their servitude to the system as if it is their salvation (Deleuze & Guattari, 1972/1983, p.29). Deleuze and Guattari highlighted such a paradox of desire and claimed that "lack (manque) is created, planned and organized in and through social production" (p. 28). That is, rebutting the psychoanalytical understanding of desire, they viewed humans' needs that steer action and thought do not come from a primitive instinct but have some link to the social structure.

The paradox of desire is recognized when we pay attention to the excessive promotion of a knowledge economy, the ironical yet consequential devaluation of human labor, and the speed of human knowledge production. Individuals' reaction to this paradox epitomizes Deleuze and Guattari's insight; people strive to obtain knowledge capital while constantly taking on the substantial emotional toll of work and feeling the oppression that ensues in ever-increasing demand in the knowledge economy. One thing to note is that human labor, i.e.; doctors, lawyers, and educators, all with specific skillsets, genuinely and voluntarily invest their energy in the system; they strive to get the ID cards from the company or become the go-to person (Boltanski & Chiapello, 2005) to attain seals of approval that signify their capability within the system and

help define them as "the efficacious person." The whole capitalist system subsists on the concept of desiring-production that romanticizes the value of becoming efficacious.

How the desiring-production of knowledge economy operates can be better understood with the concepts of machinic enslavement and social subjection (Deleuze & Guattari, 1980/1987), which constitutes the mechanism that reproduces power relations. Machinic enslavement refers to how individuals lose and uniformize their identities while working as a compartmentalized part of labor. Their position as a well-working cog in the wheel of the knowledge economy is signified by social subjection, through which individuals become a number losing their specificities. The control regime of power embedded in the capitalist system does not allow individuals to remain free from any identity or label. They are redefined and recategorized through social subjection. Through the mechanism, individuals are programmed to want what the repressive system wants. Desiring capability, efficiency and skillfulness implies how individuals become addicted and numb to enslavement.

According to Deleuze and Guattari(1980/1987), desire always precedes subjectivity, and subjectivity is just a residuum of the desire-production. Self-concept is not fixed and keeps changing according to the desire that the individual possesses. Desire, in this case, works as a productive force that generates a self-concept. Deleuze and Guattari suggest that there are three syntaxes of desire-production. First, a human's mind constantly connects to the objects that desire is grafted onto, so great effectiveness is rewarded with additional opportunities to be even more effective, thus continuously producing the desire for more in the form of "and then… and then … and then" (p. 8) more webs of desire are created. Second, the objects of desire, in this connective synthesis, are not the whole but the fragment, the part of the system that produces efficiently in the guise of promotion, access to more desire. That is, what humans desire is not

the object per se, but only the parts of them that attract their attention. In capitalist regimes, we desire the recognizable reputation of one's job, not the job itself. Although it may appear that the regime prescribes an identical desire structure, the desire system works distinctively for individuals. The pure relation that constitutes the web of desire produces a difference, which signals individuals' different desire systems. Every person's relationship with work is different; some people love their job, while others do not. Some are willing to define themselves with their professional identities, while others actively resist such identification. No single, dominating structure explains the intricate relationship between individual and work, showing how individuals' desire system that sustains the whole labor process in the capitalist system becomes autopoietic, and governed by the rule of "either …or ...". In the production of such difference, however, desire is recognized retrospectively. In this process, a subject emerges as a residuum of the desiring cycle. That is the feeling of pure intensity of difference that comes before the epistemological and sensual engagement that accompanies the revelation. At the a-ha moment of realizing the desire, humans gain perspective of what they want, leading to increased awareness of themselves. Once individuals understand what labor means, they become more aware of the self. Thus, desire produces subjectivity, not vice versa; individuals and systems are only mere products of the desiring production. Desire, in this way, can be understood to have a productive power that operates the desiring machine in the wheel of continual birth and rebirth of reproduction of that which wants to continue to be produced, i.e. reputation (Deleuze & Guattari, 1972/1983, p. 4).

At the same time, it remains true that workers "take up opportunities to increase skillsets as a chance for them to enhance their treatment in the workplace" (Manche, 2021, p. 42). However, skill acquisition cannot liberate individuals from the desiring-production mechanism

inherent in the knowledge economy. Skills are made available for acquisition to guarantee a sense of individuals' autonomy so that the ever-exploitative means of production remain hidden. Often called the post-workerist paradigm, the new workplace welcomes creative, artistic production; workers are not so subjected to the fragmentation of their labor (i.e., Hardt & Negri, 2000). Nonetheless, this sanguine view is challenged by the very question that the post-workerist paradigm wants to solve. Can rethinking work as an aesthetic engagement lead to the emancipation of labor (Roberts, 2012)? Can transforming the notion of work in a capitalist system and supposing the informational, cultural, and self-determined values of work transcend potentially menial labor processes (Lazzarato, 1996)? The stratification of labor throughout the history of humanity separates the joy of cultural transformation. Some types of labor, including necessary labor (i.e., cleaning streets, maintaining sewage, and disposing garbage), cannot be reduced to an artistic process. Romanticizing the labor process does not bring about the emancipation of labor. It only renders the workers impotent in their deliberate and intentional resistance against the system for their autonomy. Romanticizing the meaning of labor, or the "do what you love" rhetoric, in the new economy somehow normalizes the exploitative nature of the capitalist regime only to trap workers into staying myopic (DePalma, 2020), constantly feeling the lack of their capability (Jaffe, 2021).

Algorithmic engagement in managerial practice succinctly romanticizes the meaning of labor by promoting a new managerial practice that allows much flexibility in workers' time management or facilitates their self-actualization (Rosenblat, 2018). What complicates matters is that the algorithm optimizes the process of labor by fully automating the process for utmost efficiency and profitability. The solutionist belief that technology can solve every problem also accelerates the normalization of algorithmic management that arguably dehumanizes the

workplace, numbing the workforce (English-Luerke, 2017; Waddell, 2016; Wajmann, 2019). Algorithmic management marginalizes the types of labor that sustain the whole system but are treated as invisible and nonsignificant (Crawford, 2021; Roberts, 2014). Stratification of labor in the digital age (Fuchs, 2010) can eventually lead to favoritism of high-skilled labor as well as individuals with capital (Acemoglu & Restrepo, 2019; Avis, 2018; Frey & Osburne, 2017), producing and enforcing another cycle of desire that traps individuals into longing for becoming-capable, becoming-efficient, and becoming-skillful. More competency is necessary to get valuable seals of approval from the system. Learning, in this regard, is an indispensable activity that enables an individual to acquire new skills that would let them supersede others in the stratified labor system and eventually trap them into the notion of an efficacious person.

The concept of desire as a productive force, thus, answers the question of why individuals in a capitalist society fall into this Sisyphean struggle voluntarily. What is lacking in desire is not the object of desire but the subject of desire. Humans often want more, even if they get what they want, and they feel the lack more than they should. People feel they need to be better, although they have done much work to acquire what they used to need and want. Somehow, although the object of desire is obtained, the sense of desire does not quickly go away, and the feeling of desire is grafted onto other objects of desire. Deleuze and Guattari noticed in this endless cycle of desire that desire moves onto different objects of desire, and the subject succumbs to the feeling of desire.

This explains how the becoming-capable, becoming-efficient, and becoming-skillful logic that prevails in the future of work context actually reproduces another cycle of desire that has little emancipatory power. When labor is embedded in the tight network of desiring-production cycle governed by capitalism, the potential for a retrospective a-ha moment that may

produce a reflexive subjectivity becomes docile in relationship to the system. Through what Deleuze and Guattari (1972/1983) referred to as an axiomatization, capital subsumes everything, including "knowledge, skill and taste," to its production process (Holland, 1999, p. 20). At the time of the industrial revolution, individuals came under the control of capital because their knowledge, skills, and tastes were measured, evaluated, and recorded as one source of productivity under the capitalist regime. Regardless of the wealth-production mechanism, individuals meaninglessly are not deemed as distinct and different humans as their beings are calculated by the capitalist regime that dominates labor production.

What learning produces here is another docile human being; Braidotti (2019) brazenly criticizes this way of instrumentalizing learning that teaches the learners to think outside of the box but not to challenge the status quo (p. 31). In a similar vein, Stiegler (2016) pinpointed that the short-circuited feedback loop created by the managerial practice of algorithms in the work context poses a challenge for the education system. "What kind of human being, and for what kind of work [oeuvre] – it is indeed a question of craft [ouvrer], or opening [ouvrir], and of working [oeuvrer] – should the education system form rather than deform?" (Stiegler, 2016, p.168, italics in original). Education needs a radical transformation that meets the complexity evinced by the expansion of algorithms in the workplace that challenges the taken-for-granted meaning of work but still reinforces the desire cycle embedded in the capitalist labor system that efficiency, productivity, and profitability are critical. The way in which the algorithm is imagined, replacing the workers with easily-routinized or easily-standardized skills, creates the fear of getting displaced by computational intelligence in survival capitalism (Brown, 2015; Crawford, 2021; Morgan, 2019; Rosenblat, 2018) as it is nearly impossible to defeat a machinic workforce that will be ever-capable, ever-efficient and ever-skillful.

This is an alarming insight for research in adult education. Although research has proclaimed itself as staying rhizomatic and somehow critical (Kang, 2007; Kapplinger, 2015), it is also true that adult education scholarship, as a part of the education system, is not so free from the criticism against the neoliberal reason that "is converting distinctly political character, meaning, and operation of democracy's constituent elements into economic ones" (Brown, 2015, p.17, italics in original). The neoliberal reason that espouses the value of predictability, productivity, and profitability has been observed in treating learning as a currency for earning (Cunningham, 1992; Gouthro, 2019), and its possible contribution to the composition of "a more performative and enhanced pan-humanity" (Braidotti, 2019, p.44). In this respect, the felted sense of crisis in the adult education field (Elfert et al., 2018; Ruebenson & Elfart, 2019) is worth recognition. Adult education research is deemed as having a "relevance deficit" (Ruebenson & Elfart, 2019, p. 24), especially in the policy community seeking new ways to respond to the emerging complexities in a long-term perspective. However, in the absence of "widening the debate, reformulating the problem, clarifying goals, and analyzing eventual conflicts between multiple goals (p.27)," adult education scholarship may have served the system by reproducing the idea of learning that helps people earn (Cunningham, 1992) not grow. What can adult education do as a response? New ideas of learning that aims for a more holistic growth of human being in a good first place to begin. Nonetheless, the neoliberal pushback against the diversity of ideas has reinforced the reproduction of ideas in adult education scholarship (Gouthro, 2019).

The question then evolves into what produces the desire for performance and profits in adult education scholarship. To probe this question, in the subsequent section, we will look into the development of adult education scholarship.

Adult Education Scholarship as a Rhizome for and against Sisyphean Struggle

It is undeniable that adult education and its theories have gone through multiple mutations and evolutions; it would be easy to understand adult education as a pan-paradigmatic field tending to the care of the individual and society through learning. Evolving the vitality of theoretical discourses of adult education in these liquid times is critical in guiding adult educators, students, practitioners, and scholars to learn their way through the complexity in meaningful ways that sustain the commitment to the mission of the field: "the well-being of the societies in which we live" (Gouthro, 2019, p. 73). Concurrently, the vitality of theoretical discourses in adult education has emerged through a myriad of attempts to solidify the identity of scholarly discourse as a separate field, and to define a unitary core of principles that reduce the complexity of learning potential (Fejes & Nicoll, 2013; Kapplinger, 2015; St. Clair & Kapplinger, 2021). How to delineate the boundary of adult education as a discipline ignited academic debate in the 1980s and 1990s, especially in North America, after the ambitious "intellectual project" (St. Clair & Kapplinger, 2021, p. 273) of Malcolm Knowles that strived to suggest a universal theory of the art and science of helping adults learn (Fejes & Nicoll, 2013). Only in 2000 did such a contested debate get challenged, when RELA (Research on the Education and Learning of Adults) explicitly invited "original, scholarly articles that discuss the education and learning of adults from different academic disciplines, perspectives, and traditions" (Fejes & Nicoll, 2013, p. 11). The implication was that adult education has been deemed as "a weak field" with little coherence and clarity while at the same time pronouncing its multiplicity as its distinctive feature (Rubenson & Effert, 2019).

Rhizome is a rich metaphor and a useful conceptual tool to describe the way in which the field of adult education has developed and evolved (Kang, 2007; Kapplinger, 2015; Kapplinger

& St. Clair, 2021). However, unlike an arborescent structure with traceable roots, rhizomes branch out continuously without any origin. Tracing the origin, thus, does not suit the rhizomatic structure. Rather, mapping and sketching the links, and exploring what is behind the production of the connections is a vital way to understand the structure and metaphor of rhizome (i.e., Kuntz, 2018).

Deepening and widening understanding of how adults learn is analogous to a rhizomatic movement; across generations of micro- and macro-level societal changes, the field of adult education adapted itself to encompass not only formalized education, but also informal and non-formal learning, treating any kind of learning in adulthood—including liberal and popular education as well as skills development—as adult learning (Merriam & Baumgartner, 2020). Through a continuous horizontal stretch of learning contexts, adult education has continually forged conditions for learning, with a disciplinary focus (Boeren, 2016) even though it is also conceived as undisciplinary discipline (Plecas & Sork, 1986). As the field has welcomed any diffusion and diversity of inquiries pertaining to the primary purpose of the discipline to learn, philosophy, sociology, and psychology (to name a few disciplines) continue to evolve and explain adult learning.

Besides the disciplinary multiplicity, what led the adult education scholarship to branch out is its pragmatic orientation and appreciation of the complexity of learning practice. According to Ruebenson and Elfart (2019), the field of adult education in North America emerged in response to the increasing need for practice. The expansion of the field of adult education as a practice led to the birth of an academic field that is expected to help practice gain a better understanding of what adults are doing. The field's emergence was followed by attempts to establish a unitary core of principles, represented by Malcolm Knowles' andragogy

(Kapplinger & St. Clair, 2021), which purportedly modernizes the art and science of educating adults for practice in the production of work. However, the attempts made to organize the field and claim the field as a separate discipline have been challenged, resulting in bifurcations such as adult education and human resource development, or adult education and vocational education as if these distinctions encompass a discipline.

Indeed, several critiques have challenged the legitimacy, lack of coherence, originality, and clarity of a field. For example, Plecas and Sork (1986) explicitly criticize the unconditional acceptance of new ideas without the theoretical mapping or discussion around the primary phenomena that the field of adult education is supposed to effectuate –the learner's thinking process or instructional process (p.59), and called this the 'illness' of the adult education. Arguably, the only cure to such an illness is theory building and the cumulation of knowledge (Merriam, 1987). However, because of the pragmatic undertones of the field of adult education in the North American context (St. Clair & Kapplinger, 2021), the attempts to establish a separate scholarly discipline faced several contested debates regarding the position of adult education (Boshier, 1980; Rubenson, 1982) that positioned adult education as a subset of lifelong learning (Milton et al., 2003; Field, 2005) that coincided with the demands for the constant updating of skills in the knowledge economy. Adult education, as a consequence, is replaced by learning, and this replacement explicitly emphasizes learning as a skill training and skill acquisition that drives adult learners to match their skills to the changing demands of a knowledge economy. The benefits of adult learning have been concomitantly discussed in the realm of workforce productivity and human competencies (i.e., OECD, 2003, 2005).

As such, the field of adult education has been built upon rhizomatic thinking, which engages continuous production of multiplicity (the horizontal thrust of adult learning theories).

Kapplinger and St.Clair (2021) describe that adult education research is rhizomatic as a response to attempts to modernize the practice of learning in adulthood. Kang (2007) advocates the rhizomatic movement of adult education that befits the postmodern image of the learner and learning condition, where everything goes. The postmodern ethos explicitly resists boxing the complexity of learning and its activities as another "adjective-plus-learning theories (p.206)". Still, the theoretical discourse of adult education has gone through stagnation, partially due to the neoliberal logic of higher education that arrests a liberating movement for learning under the values of predictability, productivity, and profitability (Cunningham, 1992; Gouthro, 2019). The penetrating effects of marketization and commodification of learning are manifested in different forms per different regional contexts (Fejes & Salling Olesen, 2016). The specific subfields of adult education that highlighted employability and work-related skills—workplace learning or adult vocational education—are naturally and inevitably shaped up by the neoliberal logic, and in this case, adult education has been "the hand-maiden of industry serving it obediently by training human capital via human resource development (Cunningham, 1992, p.181)." The binary thinking that traps the multiplicities of adult learning into the channel that nurtures "a competent and efficacious person (Fenwick & Tennant, 2004, p.71)," is undoubtedly present in the field, and in fact arrests the vitality of the production of multiplicity, or rhizome, by conditioning academia into another production of knowledge that serves the economy of capital and not of self and societal evolution (Braidotti, 2019; Gouthro, 2019).

At this point, adult education scholarship needs to contemplate the position of learning in the face of the future of work context where the rhythms of the capitalist regime are pronounced and where learning has been appropriated as a special antidote for individuals to well-adjust to the rapid societal transformation while creating another illusion of a panacea. Learning is

frequently conceptualized in policy reports as an instrument that evinces the desire of productivity. Learning is dominantly described as acquiring skills or other attitudes that are considered necessary for the future (McKinsey, 2021; World Economic Forum, 2020). McKinsey (2021) proposed the distinct elements of talent (DELTA) framework to identify the necessary skills and attitudes to be a future-ready citizen; World Economic Forum (2020) anticipated that within 5 years, the work time between human workforce and machinic workforce will become equivalent. These reports signal to adult learners the desire to be as productive as the machinic workforce, or at least be as adaptive for such rapid fluctuation.

However, the notion of adaptability in this context is only in service of efficient productivity, not the full development of self and society. More radically put, adult learning is positioned as a tool to enable the masses to serve the sustaining oppression voluntarily. Cunningham's (1992) critique of adult education becoming 'learning for earning' is still resonating in the field of adult education. Furthermore, the increased use of knowledge and computers as a means of production situates individuals in a constant feeling of energy deprivation, and soul-lessness (Crawford, 2021; Rosenblat, 2018). Knowledge workers are embedded in the abstract form of labor, which makes it hard for them to separate their self-identity from their work identity (Berardi, 2009).

The desire to be functional and competent manifests in the demands for training digital literacy and developing computational thinking. Indeed, a plethora of critical algorithm studies criticize that the current hype towards training for digital literacy and computational thinking is embedded in solutionism (Bridle, 2018; Crawford, 2021; O'neil, 2016; Rosenblat, 2018). The backdrop of such solutionism is "the belief that any given problem can be solved by the application of computation (Bridle, 2018, p.8)." That the training efforts for the adult workforce

are oriented towards enhancing digital literacy and the capacity of individuals to think like computers shows such solutionism only provides localized meanings – the logic of competence or functionalism – but not a global code – living and working with the advanced technology. Unfortunately, this lack of global meaning-scheme is what Deleuze and Guattari (1972/1983) explained as a central logic of how capitalist society (re)produces desire-machine. Somehow, the ambiguous positioning of adult education scholarship positively served the neoliberal system to enforce another cycle of desire.

The rhizomatic development of adult education scholarship shows the potential of the scholarship to produce knowledge that "differ qualitative from the epistemic accelerations of cognitive capitalism." (Braidotti, 2019, p.155) However, the neoliberal logics that indict the value of profitability, have partially conditioned the adult education scholarship (Gouthro, 2019) and practice (Elfert, M., Käpplinger, B., & Smythe, S., 2018). The outpouring of reports that insist on the importance of digital literacy signals that the neoliberal logic would gain momentum to condition and block the rhizome that adult education scholarship has produced.

At this point, it is necessary to mention how Deleuze and Guattari (1972/1983) acknowledge the possibility of revolutionary power that desire encompasses. Their conceptualization of a capitalistic regime subtly dictating human desires may imply a sense of doom, making it hard to argue the optimistic undertone of their conception of desire (Tuck, 2009). Nonetheless, desire is a neutral force to Deleuze and Guattari, and multiplicity is the key feature of desiring-production. That is, "desiring-production is pure multiplicity, that is to say, an affirmation that is irreducible to any sort of unity" (Deleuze & Guattari, 1972/1983, p.42). The continual process of producing desire hints the possibility of reorienting desire in an affirmative, generative manner if the locus of focus is put on the difference in repetition. Despite the chronic

entrapment in desire-reproduction, positive variation is possible once people continue the process in a way in which they joyfully engage in the "interplay of the desiring-machines and the repression of desire" (p.382). Such a positive variation is aligned with what Butler mentioned about the potential freedom by performing agency in deviation from the indicated gender identity (Holland, 1999; Mazzei & Jackson, 2022).

More currently, Braidotti (2019) plugs in and highlights the underlying positive undertone of Deleuze and Guattarian philosophy in the global-scale transformation driven by technological development. What she referred to as affirmative ethics is "a collective practice of constructing social horizons of hope (p.156)," in what she termed as "posthuman condition" that can be easily saturated with nihilism and fatigue "with its distinctive combination of speedy transformation and persistent inequalities" (p.2). Her argument is loud and clear: "despair is not a project; affirmation is" (p.3). Her affirmation-as-a-project resonates with what Deleuze and Guattari championed – the permanent revolution through a continual intersection and collection of individual and social resistance against the majoritarian logics of the capitalism that espouse the value of performance and profitability.

Asserting the force of affirmative ethics in the current period of saturated nihilism, thus, translates into thinking from the margin, and resisting the old hierarchies perpetuated (Braidotti, 2013; 2019). According to Braidotti (2019), the onset of such an assertion is repositioning the human subject, of which the image that has been reproduced by humanistic Major Science, into a "posthuman subjects who want to know otherwise and produce knowledge differently" (p. 155). Although rhizome produced in past adult education scholarship proves such resistance, still, there has been little discussion about how such a rhizome produced in adult education scholarship works against the accelerated capitalization of knowledge. What kind of new

learning is necessary to resist the reproduction of desire for performance and profits and enable adult learners to think otherwise? Our curiosity into this inquiry has motivated the noetic engagement with the research in adult education, which is suggested in the following section.

Generative Knowing: An affirmative and intentional break of the Sisyphean struggle

What marks advanced computational technology is its expansive application into different domains of life, which originally were only to be subordinate to human capacity. Now human cognition, embodied movement, and bodily function are integrated into the human-technological interface, thanks to the development of wearable/smart technologies (Crawford, 2021). As a result, the assumptions that humans' being remains in the position of the ultimate decision-maker, and the subject who governs all the feedback loops, are shaken to the core. In this context, Braidotti (2019) suggests different positions of the human subject, escaping from an individual concept of 'Man', "but a new collective subject, a 'we-are-(all)-in-this-together-but-we-are-not-one-and-the-same' kind of subject (p.53)." Her claim of defying a human-centered ontology by understanding being as becoming shakes not just the long-standing assumptions of Western philosophy but also the field of adult learning that builds upon humanist, cognitive-dominated, and even individualist notions of the learner. Indeed, the learner in the humanist paradigm is deemed as ones who can achieve a self-actualized, autonomous self (i.e., Rogers, 1961); learner from the cognitivist paradigm is capable of learning cognitive abilities to enhance their skills (i.e., Lewin, 1980) ; learner from the constructivist paradigm, emphasize meaning-making from the practice of critical reflection (i.e., Lave & Wanger, 1991; Piaget, 1934) (Merriam & Baumgartner, 2020). Departing from such dominant discourses, other ways of viewing the learner have emerged on the basis of the ecological perspectives that encompass and

resurface non-human actors as significant agents of learning (Fenwick, Edwards, & Sawchuk, 2015; Lange, 2018; Tour et al., 2021; Smythe, 2018).

By putting the relational network of learners at the center of the learning discourse, learners may acknowledge and recognize the positions they are conditioned in, and the systems they are embedded in; this experience of connectivity starts transformative and sustainable learning (Lange, 2018). Tour et al. (2021), in a similar vein defined adult digital literacy as an "outcome of the purposeful interaction between human agencies and technological agencies (p.7)." Acknowledging the agential power of technological apparatuses used in the practice and multiple ontologies within the digital literacy education framework let more expansive perspective emerge. Smythe's (2018) ethnographic study of the older adults learning how to use the digital government technology also offers an empirical snapshot of the entangled ontology. One of the participants' small mistakes of pressing the wrong keyboard button and failing to copy and paste the email address incites frustration of the researcher. This instance, and the kinesthetic involvement of participants in writing the email implies that "automated technologies are not neutral backdrops to human activity. They actively produce material constraints and possibilities (p.209)" Fenwick & Edwards's (2015) understanding of learning as co-emergent fits well with these empirical evidences as the reflection happening in the moment of interaction with technological apparatuses signals that the environment surrounding oneself is reconfigured through the reflective practice, as well as the learners who are deeply engaged with the environment experience their own changes (Yorks et al., 2021).

Learners within the ecological perspective are deemed as the ones who are receptive and responsive to the affective, cognitive and even somatic involvement of the newly surfaced non-human actor. Building upon a relational learner, the generative knower, suggests a different

nature of learner, as becoming receptive to multiplicities. By engaging in generative knowing, one can delight in the joy of being in "between-times," negotiating different modes of realization in the virtual (Bogue, 2019). Through generative knowing, the self can encounter multiple possibilities in the virtual, not confining oneself to the traps of impotence in the face of uncertainty.

Generative knowing describes ways of being and becoming while undergoing experiences with all the forces that complexity catalyzes, including uncertainty and ambiguity (Nicolaides, 2008, 2015; Nicolaides & Yorks, 2013; Nicolaides & Lim, 2020; Yorks & Nicolaides, 2013). Generativity builds upon and departs from the constructivist paradigm that Wittrock's generative theory established, integrating developmental psychology, human abilities and human learning, and the "relationships between stored knowledge and the generation of learning" (Wittrock, 1974/2010, p. 40). What generative knowing suggests beyond Wittrock's cognitive generative learning theory is that learning is a co-emergent process that unfolds (in the actual) but also enfolds (in the virtual). Here, the actual means the materialized reality, perceived and understood in the series of time where the virtual is embedded; the virtual is not yet materialized. It is the potential, imaginative, and thus immanent plane of thoughts (Deleuze & Guattari, 1980/1987). Generative knowing suggests that individuals' mind escape from the actual – the realized and manifested reality – by passing through a mixture of time and space making meaning entangled with the virtual, plugging into a potential field with immanent possibilities, through encounters with the unknown, creating the space for generativity; creatively activating potentials (Nicolaides, 2015).

To experience generative knowing is to participate in a felt ontological inquiry of human being and becoming standing at the threshold of the unknown, "a door in every moment" to yet-

to-be-known potentials. Research (Nicolaides, 2008) shows that in the face of ambiguity, adults with more complex ways of knowing are able to address the gap between their epistemology and ontology, by approaching potentiality through "one's awareness of somatic, affective and cognitively embedded being with a posture of reflexivity that frees becoming" (Yorks and Nicolaides, 2013, p. 9). Thus, generative knowing liberates learning as a force of creation, something new emerging out of the unknown, and learners freely traverse the actual and the virtual, the real and the possible, through generative ways of being and becoming.

The onset of generative knowing, evokes desire to both willingly encounter, and welcome ambiguity. What generative knowing implies, is that the desire to think and act against complexity can be reprogrammed and reoriented (Nicolaides, 2013). This is aligned with what Bateson (1991) says about learning to avoid economization of mind; this also connects with Torbert's (2004) triple-loop awareness which reorients one's mind towards complexifying one's assumptions and beliefs. Specifically, through the phenomenological study (Nicolaides, 2008) which engaged nine adults with more complex ways of knowing, being and doing in a year-long co-inquiry, three principles of generativity emerged in exploring their lived experiences of encountering ambiguity. First is the principle; encounter at the threshold of ambiguity (previously described as an encounter and rupture earlier in the research, 2008, 2015). Individuals' desire to endure an encounter at the threshold of ambiguity while resisting the instinct to escape or survive lets them sit in the moment of complexity for a longer span of time. As time goes by, a learner begins to loosen, surrender their habitual way of reacting and responding to the crises of complexity allowing for a different move further into the presenting complexity, a process of inquiry described as in-scending. During this movement deeper into the complexity, moving underneath the experience of ambiguity, individuals undergo the dilemmatic

flow of energy; the persistent encounter of ambiguity and the consequential transcendence happening within oneself. Ambiguity naturally introduces a disquieting relationship between the learner and the present condition, one's capacity to endure the encounter and "be in the stillness (p. 10)" of the threshold is necessary. As the learner allows for the drag beneath the experience by in-scending, the learners begin to receive rather than react, adapt, or respond allowing for the unbinding of deeply grained beliefs, assumptions, and habits of meaning making that awaken something new. Awaring (Author, 2022) is how generative knowing receives the signals of potential becoming. By allowing for a close, intimate, vulnerable relationship with the felt sense of ambiguity, by enduring an encounter of the unknowing through an experience of ambiguity , a sense-breaking doorway beyond traditional knowing emerges. Stepping into a luminous plane of infinite possibilities, one begins to commune with ambiguity. More precisely, through the process (in-sending movements and flows), one begins to question their desire to orients towards problem-solving and turn towards the enfolding possibilities that stillness within the experience of ambiguity liberates. Learning, in this way, makes ready for human being to experience the awakening of and blurring of boundaries, becoming porous and open to creatively activating multiplicities of potentials.

Generative knowing vitalizes learning by creating a new concept of learner, learner as being and becoming. The future of work context is an amalgam of desires to understand the ambiguity resided within the future. However, if the future of work is to be continuously novel in ways that invite and make ways for new thinking and differences, it is necessary to examine if the suggested image of future of work in the discourse opens up the possibility of "infinite Now (Deleuze & Guattari, 1994, p.112)." Also, as the scholars and educators in the field of adult education, it is necessary to understand how learning, if any, has served as a vehicle to facilitate

such an agential assembly. In this regard, research in the field of adult education needs to imbue the affirmative ethics that are generative, and that can convey the notion of new futures that goes beyond conventional either-or views towards the future of work, as a utopian vision where technology liberates humanity from compulsory work and fetishizing the upcoming change (i.e., Danaher, 2019) – or a dystopian vision in which technology will displace human labor (i.e., Brynjolfsson and McAfee, 2014; Acemoglu & Restrepo, 2019; Frey & Osburne, 2017).

Conclusion: Implications for Adult Education

Affirmative ethics means the constant reorientation of desire towards a hopeful horizon of a future – in the context of the future of work; meaning is not only functional, digitally competent, and digitally-literate as assumed in practice but expands capable of learning through complexity, becoming generative (Nicolaides, 2015) . Currently the future of work literature privileges different skills, proficient digital literacy, timely organized work management skills and unremittingly disturbed conditions with swarming technological interventions (i.e., Wergin, 2021; Newport, 2016).

In order for individuals to be fully immersed in the texture of the present, they must devote their attentive care "to the conditions which give each present experience a worthwhile meaning (Dewey, 1938, p.49)" and freely imagine an "infinite Now (Deleuze & Guattari, 1994, p.112)," and resist yet other discrete skillsets that increase their productivity. Challenging the taken-for-granted assumptions and getting away from the economization of mind (Bateson, 1991), or thinking that goes beyond the habitual "either-or view" (Dewey, 1938), may reorient desire in an affirmative way that concretizes the future with utmost uncertainty. As such, new theorization of learning through complexity, what we suggest as generative knowing (Nicolaides,

2015) would offer a conceptual tool to explore how affirmative ethics can be scaffolded in the context of the future of work.

The turn to the future of work is necessary as it epitomizes and materializes the paced capitalist logic of (re)producing desiring machines, and often adult learners fail to recognize such subtle and nuanced order of logic. Generative knowing is a helpful approach to learning in this respect as it necessitates an intentional search for new ways of being and becoming. The virtual plane of the future of work is like a "door in each moment" an invitation to step into possibility of receiving a real integrative view that accepts a new anthropo-techno-ecology (Nicolaides, 2015, p. 15). This new thinking, is intentional in creating affirmative ethics in a future of work, opening up potential ground for learning to expand beyond the acquisitive, cognitive and individualist processes that continue to be reproduced as ways of knowing, being, and doing.

This article does not attempt to review all the possibilities that may arise from the future of work nor does it suggests the right way that adult learning and education may pursued. What we are pursuing is new thinking that may vitalize the discussion around the future, and how to create conditions for adult learners to feel that the future ahead of them "consists of possibilities that are felt as a possession of what is now or here (Dewey, 1938, p. 18)." We suggest that by re-foregrounding the pronounced purpose of adult education (educative experience for self and society), recentering the attention towards its role as a generative force reorienting individuals' desire towards vitality, not productivity, is one way to ensure a response to ethical challenges proposed in the future of work context. Revitalizing learning as a process that generates new possibilities, generative knowing responds with new philosophical inquiries that solicit the restoration of human beings and belonging and their will-to-power (Braidotti, 2013, 2019; Crawford, 2021; Stiegler, 2016). In this way, we may make learning through the future of work

not a tool to program individuals' desire to be functional but as an esthetic experience of becoming.

CHAPTER 3

A MIXED METHOD STUDY: LEARNING THROUGH THE TECHNOLOGICAL NUDGE

The paradigmatic shift in the manufacturing practice, also known as Industry 4.0, drives the macro-level industrial change with the pronounced moral matter of technology. With the exponential advancement of communication (ICT) and big data technology (Bartodziej, 2017), the central tenet of Industry 4.0 is a seamlessly interconnected organization of the cyber (i.e., computational software), physical (i.e., manufacturing hardware), and social (i.e., plant operation workers) elements at manufacturing sites (Yilma et al., 2021). The ever-intensified interconnectivity among cyber, physical, and social elements of the manufacturing scene signals qualitatively different roles of technology and its effect on the co-determination of human-technology interaction. The new arrangement of human actions and experience does not pivot only on the cognitive capacity of humans but also is afforded by technological artifacts. Qualitatively different human-machine interaction constitutes the significant change brought forth in industry 4.0, with the Science and Technology Studies(STS) scholarship critically assessing the growing power of technology and raising concerns regarding the issue of power (i.e., Crawford, 2021; Roberts, 2014), agency (i.e., Wajcman, 2019; Rosenblat, 2018), interdependence (i.e., Dahlman et al., 2021; Devendorf & Goodman, 2014; Seaver, 2017; Bucher, 2017), and the responsibility of the agents involved in the new socio-technical scene (i.e., Boersen & Botin, 2013; Botin, 2015; Woide et al., 2021; Douer & Meyer, 2020; Dodig-Crnkovic, 2008; Thekkilakattil & Dodig-Crnkovic, 2015).

The emerging socio-material structure with qualitatively different human-technology interaction in Industry 4.0. requires multiple and nuanced conceptions of technology. Diversifying the senses of technological artifacts enhances awareness of "the built-in morality" of things and, thus, escaping from the technocracy (Verbeek, 2005, p.216). Critical inquiries into the increased power of algorithms and artificial intelligence solicit the engineering field to become more inclusive, diverse, and reflective while highlighting the exhaustive impact of technology on collective society and individual cognition (i.e., Broussard, 2018; Crawford, 2021; Rosenblat, 2018). These critical inquiries mean the rising public suspicion of the underlying intention and desire of professionals behind the practices (Fenwick & Parsons, 1998). They question the techno-centric and technocratic transformation embedded in Industry 4.0. which is built and constructed by engineers' knowledge and expertise and their potential to instill the desire and values in the socio-material structure that they create, offer, or imagine (Martin et al.. 2021; Picon, 2004; Wajcman, 2019).

This moment is a transformative point for engineering education. Recent floods of critical inquiries into computational advancement signal the increasing prominence of the public purview of engineering's responsibility, which the field of engineering ethics education has worked on. The field of engineering ethics education has offered a fruitful ground to discuss the ways to cultivate the social responsibility of engineers (Colon & Zandvoort, 2011; Herkert, 2000, 2005; Li & Fu, 2012; Martin et al., 2021). Topics such as humanitarian engineering (Mitcham, & Munoz, 2010), social-justice engineering (Cech, 2013; Riley, 2008), and the applications of such topics to educational practice (Birzer & Hamilton, 2019; VanderSteen et al., 2010; Rottman & Reeve, 2020) are worth noticing. Nevertheless, ethics in the context of engineering education has been overlooked and pushed to the margins of developing the future engineering workforce

(Martin et al., 2021; Polmear et al., 2019; Steele et al., 2016; Zhu & Woodson, 2020). This is due to the culture of the engineering field without socio-technical perspectives (Martin et al., 2021), or the lack of evidence-based studies on the pedagogy of engineering ethics education (Polmear et al., 2019; Steele et al., 2016; Zhu & Woodson, 2020). Furthermore, there is a paucity of educative practice which integrates the insights from Science and Technology Studies (STS) in engineering ethics education (Colon & Zandvoort, 2011). What pulls for attention in engineering ethics education is how to enact the socio-technical orientations in engineering education practice. How can the socio-technical orientation be enacted and enhance engineers' critical awareness of technology? What kind of educative experience does facilitate socio-technical thinking for future engineers? How is an educative experience with the socio-technical orientation designed and implemented in practice? How does, if any, teaching socio-technical thinking enhances the reflective capacity of undergraduate and graduate engineering students? These threads of question inspire this study.

This study designed, implemented, and assessed the learning intervention that aims to enhance the socio-technical thinking of undergraduate and graduate engineering students. Employing the adult learning theories (Fenwick, 2016; Nicolaides, 2015) with the socio-material orientation, the learning activity is designed to enable a participatory inquiry into the changing dynamics between humans and technology in Industry 4.0. The changes in the human-technology interrelation signal a different socio-material structure that possibly reshapes the position of adult learners (Fenwick, 2016) or, more extensively, the process of human individuation and human existence (Ihde, 1990; Verbeek, 2005, 2008). By developing a scaffolding activity based on inquiry that aims to facilitate learning through socio-technical

complexity purposefully, this study responds to the solicitation for pedagogical studies on education in engineering, embodying socio-technical interest (Martin et al., 2021).

This study employed an integrated mixed-method inquiry, with the experiment and qualitative approach being the primary method and the quantitative survey embedded as a secondary method. In the first part of the study, I implemented the learning activity prior to the artificially organized experience of human-machine interaction in the experiment setting, called a nudge. The learning intervention was implemented in two ways: inquiry-based (Torbert, 2004; Nicolaides, 2015) and lecture-based. The focus-group interview and survey were used to explore and deeper understand the patterns of association of participant's behavior and perception in the nudge experience. In the second part of the study, individual interviews were employed to explore how, if at all, the learning intervention broadens their perception of engineering responsibility and culture. Future work and implications are discussed.

Literature Review

Engineering Education with a Socio-Technical Orientation

Both the field of Science and Technology Studies (STS) and engineering education demand more engineering education with a socio-technical orientation. In Science and Technology Studies (STS), the societal aspect of engineering is recognized as important as the technical aspect of engineering. Therefore, the role of technology is critically assessed, particularly in the face of the growing power of computational intelligence. STS scholarship, also known as critical algorithm studies, raises concerns about the extensive use of computational technological solutions and possible technocratic approaches to complex social problems, soliciting more ethical reflection and enactment of technology in society (Boyd &

Crawford, 2012; Kitchin, 2017; Seaver, 2015). The inquiry corroborates how the advanced computational technology enacts its implicit surveilling power toward human society, such as workers on factory floors (Crawford, 2021), on a platform business (Rosenblat, 2018), or in a corporation (Tambe et al., 2019; Wajcman, 2019), signaling a rising suspicion of engineers or the system designers' ethical capacity as the system built and designed by engineers inevitably reflects their moral values and desires. For instance, Wajcman's (2019) qualitative study with time management software designers and developers shows how engineers' treatment and perception of time as "an individualistic resource, a commodity, a sequence of events that can be mastered by means of computational expertise (p.1285)" is narrated and embedded in the design of the calendar app.

Within the engineering education community, the solicitation for integrating both macro-ethics (i.e., how to reflect the social implication of technology as a whole) and micro-ethics (i.e., how to act ethically) (Herkert, 2005) and promoting the development of "socio-technical professional identity" (Martin et al., 2021, p. 59) is highlighted based on a thorough introspection on engineering rationality (Picon, 2004). Historically, engineering knowledge and practice are born at the intersection of political, economic, and social changes. Since the Renaissance, engineering knowledge, rooted in mathematics, mechanics, physics, and chemistry, has become widely applied in practice within the scientific and industrial transformations on the macro-level. The conception of engineers is transformed from "engineering artist of the Renaissance" to "the employee of one of today's large corporations" (Picon, 2004, p. 428). The Cold War in the 1980s and the force of globalization in the 1990s also shaped the engineering discourse, moving its focus from quantity – building and providing the "engineering pipeline" – to quality (Jesiek et al., 2009). However, engineers come to ahistoricize and decontextualize their knowledge with a

"desire to ground their practice on an indisputable science and on ahistorical rationality, effectiveness and efficiency"—or what is referred to as "engineering rationality" (Picon, 2004, p.431).

Engineering rationality, which enables the technocratic approach to a social problem, is problematic on several accounts. First, the technocratic approach unintentionally marginalizes a specific population of society, reproducing the structure of inequity, which is in stark opposition to what engineering aims for, bettering society through expanding knowledge and practice (Riley, 2008). Second, given the impact and power of engineering knowledge and practice, particularly in the future of work, with the increased appearance of algorithms and artificial intelligence in practice, technology affects more than it intends to on an ecological level (Mitcham, 1994). Third, the technocratic approach disrupts human beings. Technology provides a condition for intersubjective experience to humans and constitutes a major part of their sense of being (Ihde, 2008). Privileging engineering rationality does not do justice to the inter-relational ontology between humans and technology, possibly creating massive confusion in human's understanding of humanness.

Martin et al (2021), based on their review of empirical and theoretical studies in engineering ethics education, suggest reforming engineering education in a socio-technical-oriented way is transformative, challenging the core assumption of the field—or the engineering rationality—to generate "engineering education for ethics." (p.59). On a cultural level, deconstructing the bifurcated engineering education paradigm that distinguishes the social dimension of engineering as 'soft' and the technical dimension of engineering as 'hard' science and privilege, 'hard' science over 'soft' science is necessary to promote the professional identity development of engineer with a socio-technical lens. The disciplinary culture is translated into

implementing educational practices in engineering (Cech, 2014; Godfrey, 2014), possibly promoting the idea to students in a hidden curriculum. Transforming engineering education with the socio-technical lens enables the development of an engineer capable of considering both micro and macro ethics (Martin, Conlon & Bowe, 2021; Picon, 2004; Herkert, 2000; Mitcham, 1987).

The background of increased solicitation for engineering education with a socio-technical orientation in engineering education is mainly pertinent to the deliberate attempt to transform the engineering assumption—engineering rationality—that the engineering field holds (Martin et al., 2021; Herkert, 2005). Transforming engineering education in a socio-technical-oriented way is particularly important in the critical reality emerging in Industry 4.0., with the qualitatively different human-machine interaction generating multiple layers of meanings that include both individual-level recognition (i.e., how I respond to the machine's guidance?) and collective-level awareness (i.e., how are the humans supposed to react to the changing conditions while maximizing our collective effort?). The increased impact of technology on the whole society necessitates engineers to become more sensitive to the social issues that their design of the system might incur, or the macro-ethical issues (Herkert, 2000). Taking a comprehensive and integrated approach using the socio-technical lens responds to needs from outside and within the educational practice of engineering to develop a more responsible engineer.

Despite the salient consensus on promoting a socio-technical perspective in engineering education (Herkert, 2000; 2005), there is a paucity of studies that enact the comprehensive and integrated approach to the practice of engineering with a socio-technical lens in the educative practice (Colon & Zandvoort, 2011; Martin et al., 2021). The most frequently used practice of teaching ethics to engineers—i.e., case-based approach— is used with a wide range of

pedagogical intentions and substances (Li & Fu, 2012), engaging either deductive (i.e., applying moral theory to the practical problem) or inductive (i.e., openly drawing ethical lessons from the problem) reasoning (Rottman & Reeve, 2020). Albeit the continuous effort to enhance the case-based approach in engineering ethics education, several critiques pinpoint the inherent limits of the case-based approach. First, an artificial process of framing problems in designing the case study may detach the learners from real practice (Fenwick & Parsons, 1998). There is a lack of discussion around the power issues of who gets to decide which cases to be considered good and presented (Martin et al., 2021; Colon & Zandvoort, 2011), putting the development of a good case (Herkert, 2000) at the heart of designing the ethics education for engineers. Finding or developing a case that bridges both micro-ethics (i.e., personal enactment of professional responsibility) and macro-ethics (i.e., philosophical reflection on technology) increases the burden for engineering ethics educators. An integrative ethical framework is necessary to enable this approach, which unfortunately has been overlooked due to the lack of integration of the principles of STS scholarship in educative practice. (Colon & Zandvoort, 2011).

The prevalent individualist, problem-based approach of the current engineering ethics education separates the learning process from the actual engineering practice, and STS principle is discussed to enable the development of engineering ethics education with a socio-technical perspective (Colon & Zandvoort, 2011; Herkert, 2000; 2005; Martin et al., 2021). Then the question of how becomes essential—how is it possible to enact the STS principles and enhance engineers' critical awareness of technology? In what ways is engineering education transformed with a socio-technical orientation? In what ways does the practice of education become more inclusive, participatory, and situated so that engineering students no longer feel disengaged from the societal aspect of engineering? In what ways do educative practices help learners

"reconceptualize what it means to be an engineer" and "develop a socio-technical professional identity?" (Martin et al., 2021, p. 59). The threads of inquiry echo what complexity learning theories (i.e., Fenwick's socio-material approach) are trying to answer, which will be reviewed in the subsequent section.

Locating the Production of Knowledge in Relation to Others

Complexity learning theories, albeit the polylithic composition of its own, generally assume that knowledge is not an object to be "acquired, grasped, held, possessed, exchanged, and wielded" (Davis, & Samara, 2000, p.53), but something produced and emerged. Such an "enactivist perspective of cognition (Varela et al., 1993)," questions the meaning of knowledge and expertise in relation to others. That is, from complexity learning theories, knowledge needs to be discussed with a question of where it is, not what it is. Translating this approach into engineering ethics education, then, transforming engineering education in a socio-technical-orientated way should start with questioning where the socio-technical perspective lies, not what the socio-technical perspective is.

The current prevalence of an individualist, problem-based approach in the current engineering ethics education, however, separates the learning process from the actual engineering practice as pointed out in several studies (i.e., Polmear et al., 2019; Steele et al., 2016; Zhu & Woodson, 2020). This can be a problem in the purview of complexity learning theories as it blocks locating the production of knowledge in relation to others. Conlon and Zandvoort (2011) problematize the prevalence of separation of individual engineers from the social, organizational, and institutional context in engineering ethics education. Such an individualistic approach to engineering ethics education not only puts too much emphasis on the

individual capacity to think and act ethically but also belittles the scrutiny of the condition under which such an ethical capacity can be enacted (Swiersta & Jelsma, 2006).

The socio-material perspective on professional development (Fenwick, 2016) is worth noticing in this respect as it situates knowledge production in relation to the environment, rules, tools, and social relations of the practice. Fenwick and Parsons (1998) warned about the reductive nature of the problem-based approach to professional learning. The problem-framing activity of the problem-based approach to professional learning reduces the complexity residing in reality and creates silos between learning and practice, which is discussed as the limitation of the current ethics engineering education practice (Polmear et al., 2019). Furthermore, the problem-based approach to ethics training prioritizes reductionists' logic towards the complexity of the practice, "ensuring the continued epistemic privilege accorded to performativity and control" (Fenwick & Parsons, 1998, p.54). Doing so perpetuates the assumption that ethics education is a naval-gazing exercise, as shown by a dominant management-oriented perspective embedded in the current designs of ethics education benefiting only those in positions of power (Picon, 2004).

Professional learning for engineers in this respect should go beyond the individual acquisition of knowledge and provide a reflective space and learning activity that integrates situated, participatory, and relational inquiry into their professional enactment. Then what relations should be discussed for promoting the socio-technical professional identity, particularly in the context of Industry 4.0?

Engineering practice, as one subset of professional practices, is an embodied activity of engineers which enacts their knowledge and their human-more-than-human relationship. The solicitation for a relational inquiry in the engineering profession is ever salient in Industry 4.0,

which is a new concept to explain a paradigmatic shift in manufacturing practice that innovates the manufacturing practice via the growing predictive capacity of algorithms (i.e., smart factories) (Bartodziej, 2017). From a technological perspective, this contributes to the increased usage of the internet of things, a technology that integrates physical, social, and cyber elements of production and aims for a seamless human-machine partnership (Yilma et al., 2021). From a humanistic perspective, however, Industry 4.0, signals a different ontology: not only humans but also machines have the capacity to make decisions and exert an agential influence on the system. Such a fusion of human agency and machine agency in the technologically advanced manufacturing practice explicitly entangled the deployment of artificial intelligence and colonizing the decision-making process (Mohamed et al., 2020).

The new socio-material structure within the transformation of the manufacturing practice signals new ethical challenges that require a different and robust reframing of the concept of responsibility. As humans and machines are entangled in the whole process of decision-making, it is hard to discern who or what is to blame in case of systemic malfunction (Thekkilakattil & Dodig-Crnkovic, 2015). With the presence of both human and machine agencies, thus, the complexity of ethical issues inevitably increases. With the machine agency foregrounded in Industry 4.0, reconceptualizing the machine-human interaction is necessary to facilitate the inquiry into the changing dynamics between human and machine agents.

This reconceptualization enables the interpretation of the relationship between the two as mutuality. A phenomenological tradition of the philosophy of technology is useful as it deems technology as an active mediator that has its own intentionality (Ihde, 1990; Verbeek, 2008) and shapes the social context where human beings make relation to the world, by promoting or evoking a certain way of behaving (Verbeek, 2005). Different technological mediums indicate

different possibilities of meaning-making with the world revealed through the diverse affordances which entail the multiplicity of the dialogic process.

Technology, in this regard, does not work only as a neutral mediator of human perception but as an active mediator that widens the accessibility to the world that is otherwise unrecognizable (Verbeek, 2005). Indeed, several studies on human-machine interaction view technology as a social actor with the potential capacity to reach an "I-Thou" relationship (Westerman et al., 2020) that requires careful yet endless attentiveness to the strangeness and unfamiliarity of the otherness. The newness of this experience in an open space in proximity to the alterity signifies the possibility of another way to construct oneself (Levinas, 1981). The mutual interrelation between humans and machines then surfaces the ethical question by enabling the "proto-experience of the other (Purcell, 1996, p.134)" and activating "the context in which the text of knowledge unfolds (p.135)." The effective scaffolding of learning in the new socio-technical landscape then needs to increase engineers' awareness and capacity to take responsibility for the alterity humans experience in proximity to machines.

Encountering the alterity of the machine means opening up a portal into the unknown, inviting curiosity. Generative knowing theory (Nicolaides, 2008; 2015; 2022) treats learning as a way of being and becoming while undergoing the mysterious part of the experience, the experience of having an experience (Nicolaides, 2022). Following a Deweyan understanding of undergoing experiences, generative knowing theory explains that adult learners can attune to the territory beneath experience where knowing is still taking shape and has not yet been actualized in action. Through vigilant engagement with a generative inquiry, the human-machine interaction becomes a rich source of experience, inviting adult learners' curiosity and the emergence of generative knowing (Nicolaides, 2002; Nicolaides & Lim, 2020).

The inquiry-based scaffolding activity with a socio-technical orientation benefits engineering education on several accounts. First, it enacts the relational epistemology (Fenwick, 2016; Nicolaides, 2015) and responds to what the engineering ethics education literature has solicited (Martin et al., 2021; Herkert, 2000, 2005; Li & Fu, 2012; Colon & Zandvoort, 2011; Colby & Sullivan, 2008). The scaffolding activity with socio-technical orientation fills in the perceived lack of integrative ethics framework by facilitating a participatory, authentic, and inclusive inquiry process among learners. Second, Inquiry-based pedagogy engages multiple ways of knowing that involve divergent thinking (i.e., reflection, story-telling, imagination) and convergent thinking (i.e., documentation, knowledge integration, story-making), which enables a liberal imagination of the potential future scenarios in the future of work. Third, the scaffolding activity possibly promotes the professional responsibility of engineers in response to Industry 4.0, or what Stiegler (2016) envisioned as an "automatic society."

In an automatic society, the increased deployment of advanced computational technology is expected to affect humanity and possibly create a technocratic society. The critical inquiry into the amplified surveilling effect of algorithms and artificial intelligence on the workers (Crawford, 2021; Rosenblat, 2018; Tambe et al., 2019; Wajcman, 2019) or the general population (Broussard, 2018; O'Neil, 2915) buttresses such a suspicion. The amplified suspicion of the public would concern more with the professional motives, desires, and intentions of the designer of the technical system, who are mostly engineers. Consequently, the widened scope of professional responsibility of engineers also includes addressing the increased public doubt toward engineers' intentionality.

However, without a deep understanding of the social context of their practice (Fenwick & Parsons, 1998), the answers to those questions are partially appealing to a certain population

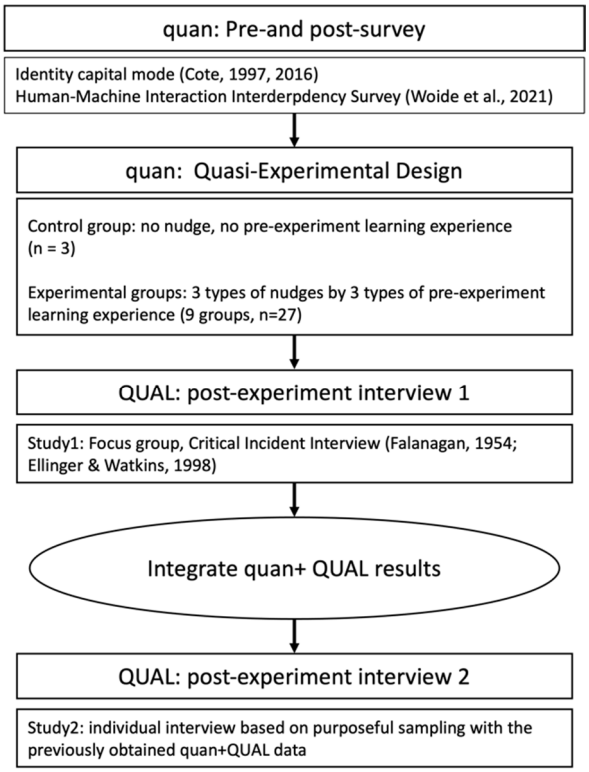
group, and thus potentially regarded as technocratic. In this respect, the professional responsibility of engineers now spans from efficient and effective decision-making to philosophical, reflective reflection on the technology, which is also natural considering the historical evolution of engineering practice (Picon, 2004). The socio-technical lens responds to the needs of both educational practices of engineering and the whole society to develop a more responsible engineer.

Study 1 Methodology

I used mixed-method inquiry to experiment with different ways of knowing in engineering education (Greene, 2007). Mixed-method aims to maximize the synergy of qualitative and quantitative inquiry by combining the mental models employed in both paradigms and engages "multiple ways of making sense of the social world and multiple standpoints on what is important and to be valued and cherished" (Greene, 2007, p. 20). The main impetus for designing this study with a mixed-method framework lies in its orientation of a different understanding of the socio-technical complexity in the future of work. I designed this study in consideration of interactive mixed-method design, giving more weight to a qualitative component (see Figure 3.1.).

Figure 3.1.

Procedural diagram: an integrative mixed-method study



Study procedure

The data I collected in this study are mapped in the following table (See Table 3.1.). I explored the causal mechanism in a nudge situation, which I define humans' behavior is indirectly guided by the technological device in performing a certain task. To be specific, I assumed the causal mechanism created in the nudge situation to be different as per the learning intervention given to the participants prior to the nudge situation. The learning intervention was designed in aims to enhance participants' awareness of different aesthetics of technological artifacts, with a socio-technical orientation. The learning intervention was facilitated using two different methods: inquiry-based, and lecture-based, assuming that different ways of knowing contributes to creating the different patterns of participants' behavioral change and perception to the nudge. The following research questions guide the inquiry:

1) How do participants perceive the role of the nudge device during their engagement in a mutually dependent engineering task? How do they perceive the nudge experience? Do different types of nudge and different ways of knowing affect the participant's assessment of the mutual interdependence of the task?
2) What kinds of human-human relationships and human-technology relationships do participants produce in the experimental setting?
3) In what ways, if at all, does learning intervention with socio-technical orientation contribute to the nuanced understanding of technology?

Table 3.1.

Measures for Each Construct Assessed

Construct Assessed	Focus-group Interview	Surveys for Participants	Observation during the Experiment	Individual Interview
Perceived socio-technical complexity during the nudge experience	X		X	X
Perceived level of their progress in terms of adult development		X		X
Perceived level of interdependence during the nudge experience	X	X	X	

Learning Intervention Design: Learning Intervention with socio-technical orientation

I designed both inquiry-based and lecture-based intervention with socio-technical orientation in aims to enhance the reflective capacity of engineers responds to the needs of the engineering education field (Martin et al., 2021; Colon & Zandvoort, 2011; Picon, 2004; Herkert, 2000; Mitcham, 1987). Generative knowing theory (Nicolaides, 2015; 2022) guides the design of intervention as it highlights a participatory and generative inquiry process into the complexity. I used the patchwork of philosophical concepts that discuss the ethical relationship between humans and technology (Mitcham, 1994) as the substance of the lecture-based intervention.

Both interventions aim for learners to become more aware of different aesthetics of technological artifacts, or what is called a post-phenomenological perspective (Verbeek, 2005; Ihde, 1990), which goes beyond the classical understanding of technology in Heideggerian phenomenology. The post-phenomenological perspective invites individuals to appreciate

"possible new modes of access to reality that would be impossible without mediation" (Verbeek, 2005, p.135). The post-phenomenological perspective intentionally takes a departure from the purview of the Heideggerian phenomenology that searches the essence of modern technology and dystopianly despises it as industrial, gigantic and machinic (Ihde, 2010). It presents an anti-essentialist, pragmatistic understanding of technology, in aims to avoid mystical hype for computational evolution yet seek the contingent meaning of interrelation between human and technology by inserting "human embodiment back into science praxis as necessary to doing technoscience" (Ihde, 2022, p. 252). That is, post-phenomenologists resort to the sensorial contact with technology as a matter, rather than interpreting the culturally prescribed meaning of technology (Verbeek, 2008).

Post-phenomenologists' deepened perspective toward human-technology interaction suggests an alternative approach to engineering ethics education in the context of Industry 4.0. In this new reality, manufacturing machines with advanced computational intelligence are discussed to gain agency in the decision-making process, disrupting moral matters, and thus, contributing to a formation of intensified socio-technical complexity (Thekkilakattil & Dodig-Crnkovic, 2015). Cultivating human's sensation of technology grows the capacity for learners to become more sensitive to the socio-material structure that the new computational technology affords, and responsive to the socio-technical complexity (Fenwick & Parsons, 1998; Fenwick, 2016). In the subsequent section, I offer the overview of inquiry-based intervention and lecture-based intervention respectively.

Inquiry-based Intervention

Inquiry-based pedagogy engages multiple ways of knowing, which I intended to experiment with. Crippen and Archambault (2012) developed a scaffolded Vee diagram that helps learners connecting their knowing and doing through intensive research on the object of their interest using digital technology. Similarly, Brown and Pendleton-Jullian (2018) suggested a concept of worldbuilding that plugs inquiry into potential future scenarios generating a story with plausible and coherent details after extensive research and meaning-making. Both worldbuilding and Vee diagram involves divergent thinking (i.e., reflection, story-telling, imagination) and convergent thinking (i.e., documentation, knowledge integration, story-making).

With the multiple ways of knowing in my mind, I used generative knowing theory to design the learning intervention for two reasons. First, generative knowing theory directly addresses how adult learners learn in response to the complexity, which this study operationalized using nudge. Second, generative knowing theory offers pragmatic principles that I could guide the design of learning intervention. These principles include encountering the unknown (the sensation of threshold), increasing awareness and understanding of the experience (in-scending: the willing inquiry into the experience of experience), and reframing the experience (awaring: knowing that emerges from the territory of having an experience).

Table 3.2.

The Overview of Inquiry-based Intervention

Phase	Steps	Pedagogical Artifacts
Greetings	Welcome participants; introduce the purpose of the intervention	

1st person inquiry	Ask participants to participate in a real-time poll that surveys their immediate thoughts and feelings on the iOS alarm sound and a loading sign. Ask participants to write their personal reflection on human-machine interaction	A real-time poll collecting the emotional reaction to the technological artifacts (see Figure 3.3.).
Sensation of Threshold	Present them the mash-up of movie clips that include cultural representation of human-machine interaction (i.e., fictional characters such as TARS (interstellar), feminized AI robot (Ex-Machina), R2D2 (StarWars), Jarvis (Iron man), Auto (Wall-E), Samantha (Her).	The summary of De Visser, Pak & Shaw (2018) plotting the spectrum of human-machine interaction conceptually represented in different fictions based on two dimensions of humanness design, and autonomy (see Figure 3.2.).
In-scending	Give individual some time to reflect on their assumptions on the HMI. After the time for a personal inquiry, the facilitator moderates a collective meaning-making by asking what kind of, if any, changes they recognize in their understanding of HMI, and how it can be related to their understanding of the future role of engineers in the context of paradigmatic shift in the manufacturing practice (i.e., Industry 4.0).	

Awaring	Help them materialize their inquiry in different creative forms; ask them to generate a metaphor that shows their answers to the question, "what does the engineer of the future of work look like?"	A World Cloud image that collects the participants' inquiry (See Figure 3.4.).

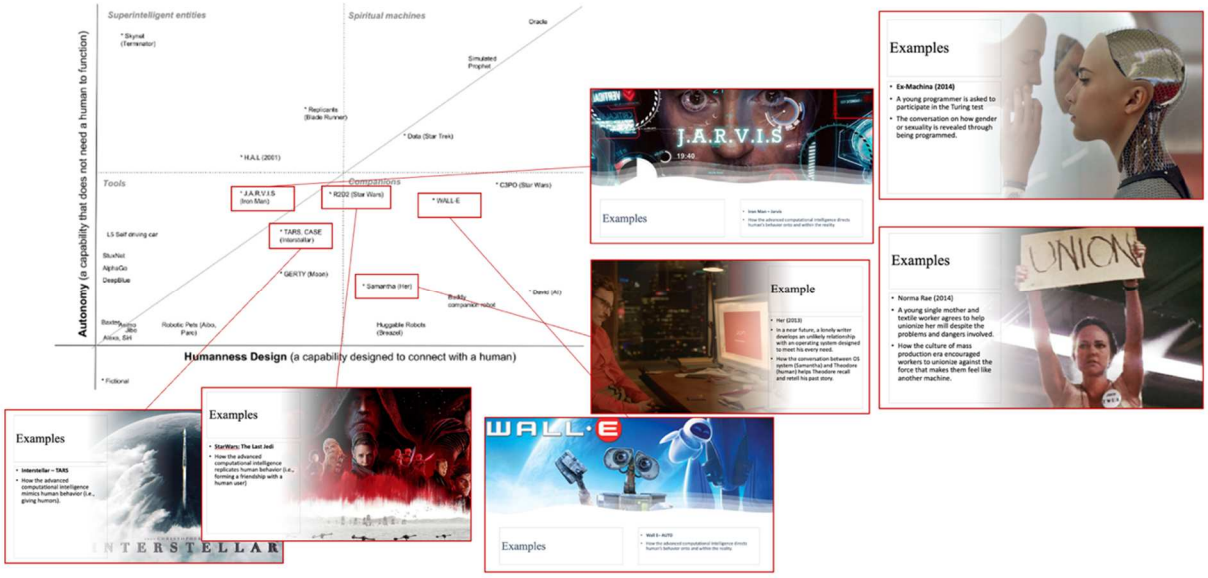
The Sensation of Threshold: Cultural References of Human-technology Interaction.

Generative knowing theory explores the territory beneath the experience of having an experience (Dewey, 1934). This is a form of tacit knowledge (Polyani, 1966), which is difficult to be verbalized, yet becomes the source of inquiry that excites generative knowing. Industry 4.0 signifies the infinite possible scenarios of different human-machine interactions, with the exponential development of technology. This potentially entails different intentionality of technology, meaning that the human-machine interaction will be enacted in different forms. To demonstrate the diverse technological intentionality, I developed the mashup of the cultural representations of technological agents in reference to De Visser et al. (2018)'s diagram (see Figure 3.2., p.1411). Their diagram summarizes the spectrum of human-machine interaction conceptually represented in different fictions based on two dimensions of humanness design, and autonomy. The fictional characters such as TARS, CASE in the movie interstellar, Samantha in the movie her, R2D2 in the movie Star Wars are included in the spectrum. I also included two additional clips from movies (i.e., Ex-Machina, Norma Rae) that are not discussed in the diagram in the mash-up but better explain the phenomenologist's perspective on the technology (see Table 2). The mash-up of such cultural representations facilitated learners' encounter with the different scenarios of possible human-machine interaction emerging in Industry 4.0. The

animated images and videos of the agents become a vicarious yet intensified experience (Jarvis, 2012) of human-machine interaction.

Figure 3.2.

The mash-up of cultural references of technological agents

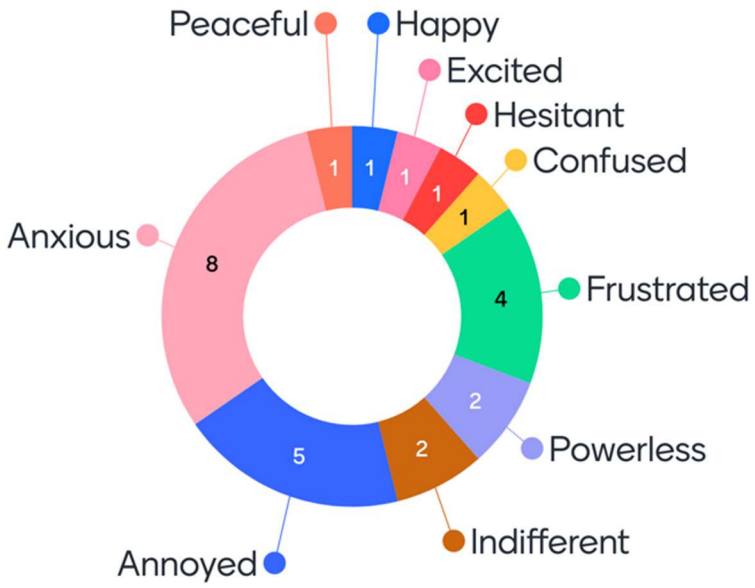


In-scending: Scaffolding the Inquiry Process

According to generative knowing theory, an encounter with the unknown opens up a space for inquiry, which also needs enough scaffolding for learners to become immersed in the space of inquiry for a deep reflection on their experience of threshold at the complexity. At the start of the scaffolding of their inquiry process, I asked easily relatable questions (i.e., How do you feel whenever you hear this sound from your phone or the loading sign on your screen?) to facilitate their immersion in the discussion (see Figure 3.3). After the real-time poll, I let them have a first-person inquiry first through free writing (Torbert, 2004). I noted them that the free writing is to organize their thoughts on human-technology relationship primarily.

Figure 3.3.

The result of the real-time poll



Afterward, I showed the mash-up of cultural representations of human-technology relationship. After watching the video, I started the discussion by asking the participants to identify the most memorable part of the video. Also, I encouraged them to incorporate their free writing throughout the discussion. I facilitated the discussion with some thought-provoking questions on their assumptions of human-machine interaction. For instance, when some participants argued how fictitious the description of increased autonomy of technology in the movie clips is, I asked for a pause in their discussion, asking them why they thought such way and encouraging them to revisit their assumption on technology. My intention of facilitation was for participants to reassess their perspective on the technology as an embodiment of functionality. I guided them to think about the enlarged mediating role of technology between humans and world and how it sparks different arrangements of human actions and human experiences. With a post-phenomenological perspective in mind, I intentionally directed the

conversation to discuss the complexity of human-technology relationship that involves the issue of human agency, machine agency, trust, and responsibility and facilitated the talk so that learners can appreciate diverse aesthetics of technology.

Awaring: Collaging Metaphors

The immersive experience formulated during the *in-scending* phase can be sublimated into a free act of creation, which is called *awaring* in generative knowing theory. Awaring denotes a liberation from and for the world, through which learners learn to reframe their inquiry into the complexity of the human-technology intra-action with a novel perspective gained through the scaffolding pedagogy and generate new meaning. I offered the participants a chance to embody their inquiry through creation of a metaphor, using Mentimeter (see Figure 3.4.). I asked them to come up with any words, or phrases that pop into their mind when thinking of the meaning of becoming-engineer in the future of work. This enacts the principle of *awaring* as it helps learners to reframe what they discussed during the collective meaning-making with a metaphor. Metaphor involves understanding "one domain of experience … in terms of a very different domain of experience" (Lackoff, 1993, p.5). Metaphor enables learners to better grapple with "slippery opaqueness of ambiguity (Nicolaides, 2015, p.186)." This time to generate their own metaphor of becoming an engineer in the future of work created a real-time WorldCloud image. Through the creation of collage of metaphor, students were able to materialize their inquiry into a tangible artifact, which also becomes another metaphor that signifies their collective inquiries into the complexity of becoming engineers in the future socio-technical landscape.

Figure 3.4.

The Collection of Metaphors Created by Participants

Control group. As a way to see the effectiveness of inquiry-based scaffolding activity, two control groups are considered. First control groups were given a lecture-based approach, which delivers the same substance (i.e., a mash-up of Science Fiction movies) in a lecture yet with a different interaction between the facilitator and learners. The facilitator walks through the philosophical concepts which discuss the human-technology relationship, based on what Mitcham (1994) loosely called the humanistic tradition. The presentation introduces different concepts to explain the various roles of technology in human society and juxtaposes the concept with the movie clip, to facilitate the participants' understanding of the concepts (see Table 3.3.) This represents an individualist approach, which does not include any collective meaning-

making session as well as self-reflection. Second control groups were given no intervention at all, before the experiment.

Table 3.3.

Summary of the lecture-based intervention

Philosopher	Concept	Movie clip
Heidegger (1954)	Technology reveals, illuminates, objectifies, and calculates part of nature.	Ex-Machina (2014) Programming heterosexuality in the humanized AI robot *reveals* the nature of sexuality.
Simondon (1958)	Machines have become a significant part of the labor process in the mass production era, contributing to workers' individuation.	Norma Rae (2014) Workers unionize in the cotton mill to refuse the force of machinic enslavement.
Stiegler (2015)	Technology helps or even replaces human memory.	Her (2013) The conversation between the OS system and the human user lets human user recall and retell the past differently.
Ihde (1990); Verbeek (2008)	Technology mediates human perception, possibly guiding their behavior.	Showing a compilation of automated systems, including Jarvis from Iron Man, Auto from Wall E, TARS from Interstellar and R2D2 from Star Wars.

Nudge Experiment Design

Nudge indicates a technology-mediated poke that directs humans to make a decision and behave in the desired way. Nudge is particularly useful in a situation where people cannot get immediate feedback yet need to decide and react, regardless of the perceived lack of feedback, as

the immediate cost of ignoring the given direction is expected with their common sense (Thaler & Sunstein, 2008). The systemic arrangement of choice options and their benefits, and costs—or what Thaler and Sunstein call choice architecture—works as a background of people's decision-making. Thaler and Sunstein suggest six principles in designing the choice architecture (pp.85-99) as follows:

1) **Default options** -Inertia, status quo bias, and the 'yeah, whatever' heuristic (p.85)" that leads to a normal, recommended course of action
2) **Expect Error** -- a well-designed architecture expects its users to err and is as forgiving as possible. (p.89).
3) **Give Feedback** – the well-designed system gives feedback when they are doing well and they are making mistakes (a warning sound when things are about to go wrong; however, if the frequency is too high, it is often ignored and becomes useless).
4) **Mapping**—A good system of choice architecture helps people to improve their ability to map and hence select options that will make them better off. [RECAP: Record, Evaluate, and Compare Alternative Prices]
5) **Structure Complex Choices** "Structuring choice sometimes means helping people to learn, so they can later make better choices on their own (p.99)."
6) **Incentives**—Four basic questions: who uses? who chooses? why pays? who profits?

Nudge experiment is unique in that it artificially constructs the context of human-machine interaction (participant-nudge) while providing the human-human interaction (participant-participant). In nudge experiment, participants were asked to perform a collaborative engineering task. Individual work performance affected the whole team's performance, as participants were required to work back-to-back. For instance, at the third station, the participant

were assigned with the final job of fastening the housing building on the previous work that the participant of the second station complete. They were asked to produce as many tools as possible. Individuals' outcome is dependent on each other participant's behavior, implying the mutual independence of the task. Also, participants experienced uncertainty as they needed to figure out the rhythm of work, with the cues afforded by the nudge device. The recommended course of action in this experiment is to follow the direction of nudge and adapt to the rhythm of productivity. The contextual affordances, including the nudges or the rhythm of the process, work in participants' minds and shape their behaviors.

I provided erroneous information to participants that the nudge is generated by the artificial intelligence system, although in real life, a human coder sent out the nudge in the event of completing a certain number of parts. The deception was instrumental in this research in that it kept the meaning of artificial intelligence contingent upon participants' experience and perception of nudges. Their nudge experience had relevance to the artificial intelligence system but without any directed nor definitive understanding of the artificial intelligence system, engendering the multiplicity of meaning-making. Post-phenomenological perspective on technology assumes an anti-essentialist, or what they referred to as a multistable perspective on the human-technology relationship (Ihde, 2010; Verbeek, 2008). That is, the phenomenon of the human-technology interaction assumably has various aspects that can be experienced differently by participants, implying the necessity to keep it contingent on participants' experiential references. This suggests that the participants' conception of nudge needs to have any relevance to the artificial intelligence system but without any directed nor definitive understanding of the artificial intelligence system.

On top of the meaning attached to nudging in the experiment as a performance manager, the modality of nudging is also manipulated into three types including visual, auditory, and haptic in this study, to see if these modes produce different sensorial contact of participants with the nudge device, resulting in diversifying their perceptions toward the human-technology interaction. I called the nudge device blinking red flashing lights as a visual nudge. As an auditory nudge, the alarming sound from the nudge device to signal their work progress is used. As a haptic nudge, I employed the buzzing function of the nudge device which gave a trembling sensation to the participants.

Observation

I observed the nudge process during the experiment. I perceived the nudge moment, when participants received the signal from the device, and documented any behavioral changes perceived to me as unusual during the nudge moment. I used my observation to facilitate participants' recall of their feelings and thoughts during getting nudged (i.e., I asked participants, "Why did you laugh when you first got nudged?"). Also, I described the videotape data of the entire nudge situation, by narrating the sequence of the participants' behavior particularly at the moment of them getting nudged for the first time. The videotape data were juxtaposed with my observer's notes for a more detailed description.

Survey Questionnaire

Intangible Identity Capital Survey

The survey items are selected and constructed to evaluate the disposition of the sampled population in terms of their identity development. The survey items are partially adopted from

Cote's identity capital theory (1997) which posits the psychosocial vitality of individuals in the late modernity in which the self becomes ever "frail, brittle, fractured, and fragmented" (Giddens, 1991, p.169) as a contributing factor to the development of self-identity. This theoretical approach to adult development aligns with the generative knowing theory (Nicolaides, 2015) in that both pays attention to the psycho-social aspects of development science. The survey items measure includes four variables of personality attributes on various Likert scales including self-esteem (e.g. "I am a lot fun to be with"), purpose in life (e.g., "I am usually completed bored… exuberant and enthusiastic"), locus of control (e.g., "Becoming a success is a matter of hard work"), and ego strength (e.g., "I enjoy difficult and challenging situations"). The reliability and validity of the instruments were confirmed by several empirical studies (Cote, Mizokami et al., 2016) (see Appendix 1).

Adopted Human-machine Interaction interdependence survey

I used the instrument partially adopted from the Human-Machine-Interaction-Interdependence (HMII) questionnaire developed by Woide et al. (2021) based on the socio-psychological theory of interdependency (Gerpott et al., 2017). I used this instrument to explore the participants' perceived level of interdependence and information certainty within the nudge experiment. The HMII instrument evaluates how humans form an interdependent relationship with humans but also with machines. The interdependence theory undergirds the development of the questionnaire, which explains what common factors contribute to the formation of an interdependence situation (Gerpott et al., 2017). The factors include power, conflict, mutual interdependence, and coordination (Thibaut & Kelly, 1959) with a later addition of future interdependence and information certainty (Kelly et al., 2003). HMII questionnaire is developed

considering the situation with a fully autonomous machine (i.e., self-driving cars) (Woide et al., 2021). Thus, I partially adopted the questionnaire with enough consideration of the qualities of the nudge experiment—a simple collaborative task with a pager presented as a machine. I selected two variables of the measurement that are prominent in the nudge experiment—mutual dependence and information certainty, based on the observation and interview data from the pilot study.

Focus-group Interview

After the nudge experiment, I asked participants what stood out the most during the nudge experiment, in the format of focus-group interview based on the critical incident technique (CIT) (Flanagan, 1954; Ellinger & Watkins, 1998). The CIT is a way of stimulating the recall of participants on their behavior, emotion, and cognition. I consider a semi-structured way of moderating the interview. I actively engaged in the interview to clarify participants' language (i.e., Can you elaborate more on what you shared?) and offer them a more descriptive language to facilitate their recollection of the nudge experience based on my observation note. In addition to the questions based on CIT, I included questions that ask participants to identify the role of nudge during their work process (i.e., How do you understand the role of nudge during your work process?). I obtained 10 focus group interview data.

To phenomenologically analyze the data, I employed Vagle's (2018) iterative reading of data. After transcribing the data, I read the transcription and grouped data with some emic codes from the participants (i.e., "faster faster", "putting logic into it"). And then, I grouped the part of interviews as per their assigned phrases, and generated themes. Such themes worked as a guideline for me on two accounts. First, I returned to my observational notes and video to

capture any noticeable behavioral changes of participants, to generate any other critical moments of the experiment that contribute to their understanding of nudge experience. Second, the themes worked as a guideline for the quantitative analysis of the survey data. For instance, based on the several indications in the interview on the modality of nudge, I conducted a two-way ANOVA analysis to explore if the type of nudge and the different ways of knowing have any impact on the difference between pre-and post-human-machine interaction scores. Also, based on the difference I noticed among the treatment groups (i.e., inquiry group vs lecture group), I conducted an unpaired t-test to seek any statistical difference in human-machine interaction scores per intervention.

Study 1 Findings

The first finding is generated by phenomenological reading of the focus-group interview data that is obtained after the nudge experiment. Across the treatment groups and control groups, four common themes are produced: 1) engineering habitus affected participants' nudge experience, 2) Nudge motivates, manages, or stresses the participants, 3) The discussion among participants who become attentive to the sensorial perception of a nudge enacts socio-technical perspectives, 4) Inquiry-based groups tended to communicate more even with the felt sense of urgency.

Theme 1. Engineering habitus affected participants' nudge experience

In both treatment groups with pre-experiment learning intervention and control groups without any intervention, regardless of the types of nudges, participants commonly indicated the unfamiliarity of the task they felt at the initial phase of the experiment. The unfamiliarity with the task stems from two reasons mainly. First, each station assigned different tasks, requiring various assembling capacities for individuals, and it took time for some participants to enact the assigned role at each station. For instance, participants at the first station commonly reported that they are required to set the stage. The participants assigned to the second station were required to make the process as smooth and quick as possible by putting parts fitted together, and for those who were working at the third station, their job was to complete the task as quickly as possible through constant screwing. Second, each task had its own material problems. For the first station, screws were the problem as "things[screws] weren't going in at the beginning." In the second station, some participants struggled with fitting the parts in as "a lot of those wires were just like

all over the place." Participants working at a third station had the least problem as their job is rather simple, constant screwing; however, when asked about the overall impression of their task, some participants jokingly mentioned the burning pain in their forearms.

In addition to learning the process itself, participants mentioned how slowly but gradually they recognized themselves as a team. Given the goal of assembling eight power tools as fast as possible, participants all indicated that they intended to find a way of "optimization" or "standardization" during the process. Participants all agreed that their shared goal as a team is to find and maintain a consistent workflow, or in engineering terms, create "consistent throughput rather than variation." One participant from a control group, without any nudge and any intervention, voluntarily switched the station with another participant as he had trouble understanding the process, naturally creating a bottleneck moment. Asked why he switched the station, he answered:

> *At the very beginning, what was holding up the whole... I mean, there were three things in that bin, and I couldn't complete one. It was simple math at that point where the bottleneck was, and I was like, "Look, we need to try to optimize this if we all are trying to get eight of them done."*

Their common understanding of the shared goal of a team was undergirded by the knowledge and habitus they accrued through their education in engineering. Aligned with what Picon (2004) argued about engineering education through Bourdieu's concept of habitus, this finding shows how "education shapes the horizon of expectations of individuals submitted to it, as well as their behavior in the concrete circumstances of their practice" (p.425). Their engineering knowledge conditioned participants' way of framing the nudge experience as they approached the group task that contained different possible scenarios with their knowledge about

the process – implicitly sharing the optimization of the flow as a goal of the team. This case was also evident in Dan from the lecture-based group with an auditory nudge connecting the knowledge he accrued from some classes he took with professors and his prior experience on the factory floor with his perceived goal of the team—standardizing the process for consistency.

Theme 2. Nudge motivates, manages, or stresses me

Asked how they define and understand the role of nudging while conducting the group task, all participants in both treatment groups and control groups, across the varied modes of nudging, perceived the nudge as a motivator and reminder. In addition, some anthropomorphically described the nudge as a manager of the rhythm and workflow and showed different extents of emotional reaction to the perceived role. The following table sums up their perception of the nudge's role (see Table 3.4.).

Table 3.4.

The perceived role of Nudge

		Motivator	Manager
Treatment group	Inquiry-based	"I guess it makes you want to go fast. But at the same time, it makes you feel like you *have to* go faster." "It was a sense to wrap up." "I was working so that I wouldn't hear the buzz." "It kind of reminds me like a message notification" "It was just affirmation of what I already knew"	"A boss getting onto you for not doing a good job almost."

		"That pacer to keep aware of what's going on."	
	Lecture-based	"I felt like I was constantly having to run up like my peak pace." "So you got nudge, so you needed to be go quicker." "Let me do it fast, so that I can avoid it."	"Constantly back in my mind, like big brother always watching." "Like a manager who never worked a day in his life tries to manage you, giving you the eyes be like, 'you better be working.' Just visually expressing disappointment"
Control	No intervention	"Definitely kept me moving in the first place." "Someone over your shoulder being like, 'Go quicker.'" "It's telling the user that you're too slow or you're slow, you need to move faster."	"I'm slowing down, need to pick up the pace a bit. So, it was a little bit like a stressor." "You're protruding more negative. It's like, 'Oh, you're not doing good enough.'"

The most commonly identified role of a nudge by participants across the treatment group and control group was a motivator. Participants all reported to associate the meaning of nudge as a motivator that makes them work faster, more, and harder. Most of them also identified that they had a negative reaction to the nudge, in that sense. Jacob, from the control group with a haptic nudge, said that "the anticipation of getting buzz was worse than actually getting buzzed."

The anticipation itself was what motivated the group. Rachel from the inquiry-based training group with a haptic nudge also showed a similar reaction to the nudge, saying that the nudge let her feel obligated to work harder, with a "negative connotation" that she is not going "fast enough." Nate from the lecture-based training group with haptic nudge viewed nudge as a "punishment" or some sort of negative reinforcement that compels him to work "at a pace that preserves the flow." The negative connotation of getting nudged showed how participants perceived getting nudged as a negative reinforcement of their behavior.

The motivating role of nudge perceived by the participants set the background of their understanding of nudge as a supervisor of the whole process. In both the treatment group and control group, regardless of the mode of nudging, when asked about the role of nudge, participants all compared nudge to boss or manager. Calvin from the lecture-based group with visual nudge came up with the metaphor of "a manager who never worked a day in his life tries to manage you, giving you the eyes be like, 'you better be working.' Just visually expressing disappointment." Nolan from the inquiry-based group with visual nudge also cited a similar metaphor, saying that the nudge felt like a boss who is "getting onto you for not doing a good job almost… who is instead of a human, but a machine." The context of their comparing the nudge with a boss was their experience of getting nudged while waiting for their parts to come. Their standard response to the nudge during the idle time, was that there was nothing much they can do more, as they were doing their best.

However, when faced with a similar context, the extent to which participants become aware of their felted sense, varied as per the treatment group and control group. Gary from the control group auditory nudge and without any intervention, had a rather strong reaction to the nudge given to him during the process. He said,

Gary: I thought it was stupid.

Moderator: Why?

Gary: You can't tell him to go fast if there's nothing for him to do, so it's just... You're protruding more negatively. It's like, "Oh, you're not doing good enough." Well, I did all there is to do. What more do you want him to do?

Similarly, Han from the control group with visual nudge put his arms forward toward the pager, when the pager went off during his idle time. When asked why he did it, he said it was just his motor reaction to "a slightly humorous WTF moment," as he was done with whatever he could do, and there was nothing much he could do.

On the other hand, Nolan, said he felt "indifferent," to the nudge during the idle time. He mentioned,

Even though I can't really do anything about it, I guess you could say exercising the power to acknowledge that I'm already doing everything I can and not to get worked up over it.

Calvin also reported that he felt "stoic" about the nudge given during the idle time, saying that "it's of my control. Don't worry about it. "

The difference of emotional reaction to the negative connotation of nudge is interesting to notice as it signals how intervention may modulate participants' felt sense about the nudge situation. The difference in the emotional extremity toward the negative connotation embedded in the nudge situation as per the learning activity, shows how different learning activity contributes to the participants' perception and impression of the unknown situation with the recognized machinic agency. The learning activity that discusses a wide spectrum of human-

technology relationships enabled learners to accept the felt sense of different agency. Without the learning activity, however, participants seemed to extremely turn away from the felt strangeness of different agency, not opening up their perception toward the nudge situation.

When probed about their feelings about their recognition of the negative connotation of nudge, participants showed bifurcated reactions across the treatments. The lecture-based group with audio nudges said the nudge led them to question, what am I doing wrong? what happened, what when wrong, after having the "oh-oh" feeling, as an effort to rationalize the given stimulus. Nate, from the lecture-based group with a haptic nudge, compared the nudge to the "big brother always watching," "always back in his mind." He added,

> *I was kind of stressed out the whole time. Like, what am I going to get buzzed .. what am I going to get nudged. I know it's sometimes frustrating when like this going on, like I was falling behind.*

On the other hand, other students were reported to actively ignore nudges. To their perception, the nudge did not make sense. Some felt the need to move faster and work harder, however, when the nudge was given to them during the dead time or when they were not working, they inevitably became suspicious of the nudge. Those who received nudges during their work time, however, somehow rebelliously reacted to the nudge as there was not much a thing they could do better as they were doing their best. Some also grunted that the fault was on the parts not working properly, not on their capacity.

The insights from post-phenomenology are instrumental in understanding the ambivalent reactions of participants, mixed with extreme ignorance and acquiescence to nudges. According to post-phenomenology (Ihde, 1990; Verbeek, 2005), both individuals' sensorial engagement and cultural association matter in forming, recognizing, and being conscious of the relationship with

technology. That is, without each, the identity of technology is partially derived as it is by nature contingent on the specific context of its use. Without any sensorial engagement, also known as micro-perception in post-phenomenology, technology does not come to the participants' perception; without any cultural interpretation of technology, which is called macro-perception, technology becomes meaningless (Ihde, 1990). This shows how "technological mediation opens up new ways for reality to manifest itself" (Verbeek, 2008, p.134). The different gradations of sensory perception, then affect and shape humans' interpretations of reality and vice versa.

The difference in the reported numbers of nudge experience from participants when asked, how many times they thought they got nudged shows the different gradations of sensory perception among participants. In real life, the nudge was given to the participants for three-time equally (two individual nudges and one group nudge). Participants nonetheless reported to have different numbers of experiencing the nudge. For instance, Kyle from the inquiry-based group with visual nudge reported he had five or six nudges. Bailey in the same group reported she had four. Andy, from the lecture-based group with audio nudge as well as Dana, Nate from the lecture-based group with haptic nudge reported to have one nudge. The reported variance of numbers of nudge cases, according to participants' perception, shows how diverse micro-perception ("I got nudged") participants had during the nudge experiment.

This does not necessarily mean that the micro-perception of technology is a primary function of macro-perception. Rather, the extent to which both micro-and macro-perception interplay determines the contrast in technologically mediated perception. That is, when both micro- and macro-perception interplay, humans more vividly perceive the new reality afforded by technological artifacts with the amplified role of technology. When humans have a partial perception, the role of technology is less amplified and thus, the new reality is presented to

humans with low contrast. Participants who actively ignored the nudge, still reported having a negative connotation of the nudge, despite their intention to deactivate the micro-perception of nudges. This shows that the hermeneutical understanding of the nudge was possible even with less micro-perception and that both micro-perception and macro-perception matter in the meaning-making of technology.

The discussed cases show how the interplay between the micro-perception and macro-perception of the nudge constitutes participants' perception of the nudge experience. In the case of participants from the control group, who ostensibly were antipathetic to nudging, they willingly shut down their micro-perception towards the nudge as they did not choose to recognize the agency of nudge supervising their work performance. Nevertheless, they still got irritated by the felt sense of nudge, as shown by their extremely negative sentiments toward the nudge during their interview, asking for the nudge to do more justice to their efforts. This exhibits how participants from the control group perceived the nudge experience with negativity, while others particularly from inquiry-based groups reported feeling indifferent and stoic against nudging.

There were participants who felt nudged much more than they had been given in both inquiry-based and lecture-based group. What to note is that their first nudge was given to them comparatively later than the other participants in different groups. For instance, Kyle got his first nudge around 13 minutes later than the experiment had started, naturally affecting Bailey's first nudge who worked next to Kyle. Considering that others mostly got their first nudge around 5- or 6-minutes post to the beginning of the experiment, it is evident that Kyle had a lot of struggles in completing his task during the experiment, and the fact that he struggled may have

confounded his micro-perception of nudge. That is, the felt sense of struggle may have confused his sensorial engagement in nudge.

Participants who reported not receiving less nudge during the process, in this regard, showed how both macro-perception and micro-perception interplay in their perception of the nudge experience. That is, Dana and Nate who iteratively mentioned to feel competitive or rushed to finish the task and highlighted the supervising power of nudge during their work process, are the case where their micro-perception is contingent on their entanglement in their hermeneutical understanding of nudge. Their bodily perception of a nudge was largely influenced by their embeddedness, entanglement, or obsession with the cultural meaning of nudge – the nudge meaning not losing the pace so that they can "preserve the flow" or stay at an optimized pace.

Theme 3. The discussion among participants who become attentive to the sensorial perception of a nudge enacts socio-technical perspectives.

Another common theme across the groups was the rippling effect of the increased sensorial perception of a nudge. The sensorial perception of a nudge was affected by the modes of nudging. Participants from the groups with auditory and visual nudges commonly reported they would have been feeling nudged more often if they had been given buzz or other types of nudges. Calvin and Gaye from the lecture-based group with a visual nudge indicated that, as they were so "zoomed in," and "focusing on putting things in the right place," it was hard to notice the visual nudge as the nudge was "out of directness of peripheral." Bailey and Kyle from the inquiry-based group with a visual nudge also cited that if they could have put a pager in their pocket and felt the vibration, they could have become more aware of it.

The inquiry-based group with an auditory nudge mentioned that the large volume of auditory sound was intrusive enough for them to stop and look around to see if something is going wrong, but still, the nudge was not disruptive in their mind as they felt control of the simple task settings.

> *Nolan: Pretty much the same thing. In the context of this experiment, there's three of us. It's a small setting. Then you hear a noise like that. It's alarming initially, but you pretty quickly get a sense that nothing's wrong. But maybe in a bigger setting, maybe in real life you're working and you hear that, there's incentive to take it a bit more seriously and check it out more, because maybe there's more than just three people that you can't see just by looking around.*

> *Austin: If it was a bigger lab group and you couldn't really look around and see everybody, what they're doing, then yeah, it'd probably be a little bit more like, "What's going on? Did somebody mess up?"*

> *Owen: Yeah, then I basically got to put my shit down and look around. Is someone hurt or something?*

Dan from the lecture-based group with the auditory nudge suggested that it would have been interesting to see if the nudge was presented with not a mechanical sound but a song—"guns and roses." The attention to the material sensation as shown by the participants from auditory nudge groups led them to become inquisitive towards the different scenarios in which the nudge may have different meanings.

In a similar vein, the inquiry-based group with a haptic nudge started off their conversation on the nudge moment by discussing their sensorial perception of nudge.

Particularly, the inquiry group talked about how familiar the nudge was to their perception. The buzzing sensation they felt during the experiment was not surprisingly bothersome to them. Sahar from the inquiry-based group with a haptic nudge elaborated on how he felt not too disturbed by the buzz.

I guess in a sense it's kind of comforting words, but it's also simply just a vibration. It's almost similar to our phones. It's nothing too unfamiliar versus a human voice.

A mechanical buzzing to him was not awkward enough to feel the strangeness of the nudge. Continuing the conversation on the familiarity of nudges, Tai and Rachel from the same group also added,

Tai: Like if you had a woman walk in and tell me she was a robot and she was the one telling me like, 'Tai, move quicker'

Rachel: Yeah, I was just thinking that too.

Tai: Yeah, that's different from the thing in my pocket.

Rachel: Yeah, if there was a voice that said "move faster, move faster"

Tai: Yeah, But I think it's also just like a preconceived notion that I already have about like AI and what I think it is because when you say AI like I don't think about a buzzer.

The conversation from the inquiry-based group with a haptic nudge afterwards is worth noticing. The alterity of the sensorial contact with the nudge device was not prominent to their perception. Nevertheless, through collectively making meanings out of their sensorial experience, their conversation was developed into a reflective moment on their preconceived understanding of artificial intelligence. It is particularly important to bear in mind Tai tangentially revisiting her assumption around artificial intelligence and discussing how it may limit her sensorial experience of nudge.

Her question regarding the preconceived conception of artificial intelligence, showed how she became aware of the contingency of her understanding of artificial intelligence. This moment signals that inquiry-based training may promote anti-essentialist thinking of technology, and facilitate thinking towards the different identities of technological artifacts in different use contexts or what post-phenomenologists call the multistability of technology (Verbeek, 2008, p. 118). She doubted the essentialist perspective that presupposes a fixed conception of technological artifacts. This means that she became more aware of how technology cannot be separated from human praxis but perceived as the "active relational pair" (Ihde, 1993, p.34), which is irreducible to its functionality but embodies a cultural significance.

Similarly, when asked, "what if the nudge is coming from human agents, rather than artificial intelligence?" the group went on to discuss the possible scenario in which they might feel frustrated, and hard to respect the robots but still, would respect the evaluation based on data and concrete facts, with a hint of doubt.

Rachel: I think it would, if it was getting created by like, the person who needs the product, like the higher boss, I feel like I would understand, they would understand like, what needs to be done more. So I think I would get frustrated with technology, if it kept urging me to do more when it's like, a robot telling me, I don't know if that makes it does, like.

Tai: I would respect someone above me, my boss, but it's hard for me to respect this, like a robot that thinks it did better than me.

Rachel: Yeah, that's like programmed to do that.

Sahar: I mean, it's roughly the opposite of where I would say, if someone else is nudging me, I'd be like that. It's almost like they think I'm not doing good enough. Versus if it was

like the way people's for example, it's, it's based off of data and concrete facts, so it's no bias or anything like that. It's just either you are, or you're not.

Tai: I mean, I can agree with him as well, because my first thought is that if it was controlled by humans, it's, they try their best, but they're going to be biased because we are human. So I feel like it can be very much opinionated too.

I noted that their conversation unfolded towards the issue of objectivity, which is one of the fruitful areas of inquiry in Science Technology Studies (STS). Participants' focus on the material sensation brings a wider perspective on what things *do* "that encompasses more than merely '*referring*' or '*functioning*'" (Verbeek, 2005, p. 209, italics added by me). The discussion on the sensorial contact with the nudge device—how the mechanical sound of buzz came across as unsophisticated as a humanized voice they expect to hear from artificial intelligence—developed into the conversation on the socially constructed idea of artificial intelligence and moved onto the social phenomenon created by artificial intelligence—the value of technologically generated decisions. Their talk resonates with the socio-technical perspective emerging in the lineage of STS (Crawford, 2021; Kitchin, 2017; McKittrick, 2020), which critically assesses how algorithmic logic built-in artificial intelligence produces a value-laden decision based on the historical data fed into the system. Concerning that these topics were unaddressed during the learning intervention, it was surprising to notice the development of their talk.

The sensorial attention opened an inquiry space for participants to explore different arrangements of human actions and experiences that artificial intelligence contributes to provoke, promote, and create. Attending to the sensorial contact of the nudge led the participants to become aware of the different aesthetics of technological artifacts, inviting the participants to

inquire into their cascading effects of creating a world that would be different without the active mediating role of artificial intelligence. That is, participants enacted the socio-technical perspectives in discussing their experience of getting nudged.

The conversation from the inquiry-based group is in stark opposition to that of the lecture-based group. The lecture-based group mostly focused on the meaning carried by the nudge device. In the lecture-based group, Nate explicitly made a connection with the movie Ex-Machina, and the concept behind the movie which was introduced during the lecture. He discussed that the nudge might reveal the implicit pressure that was embedded in the workflow he sensed in aims to produce things faster. His understanding of the nudge, without any mention of how he felt about the sensorial contact of the buzz, quickly jumped into his meaning-making. He reported that,

> *And it forced us to form a relationship with that device. For some, it may be positive, some negative for me, like I said, it was a source of stress. So having that thing in my pocket was like, when's it gonna go off? You know, it's kind of like always in the back of my head waiting on me to guess it was more of a negative relationship based on its communication, or at least my perception of this communication.*

The relationship he formed with the nudge device was dubbed with negative, almost anxious feelings, described with terms such as a "source of stress," "big brother watching", or "having power over" him. His way of framing his nudge experience stayed on an interpretive level. That is, he approached the nudge as something that signals the surveilling power over his behavior during the process, implying his attention to his relationship with the nudge is mostly on an interpretive level, not a sensorial level.

What to note is that the semiotic interpretation of things cannot generate a wholesome understanding of technology as a mediation between the world and the user (Verbeek, 2005). Verbeek articulates the sensorial interpretation attends more to the sensorial contact with the technological artifacts, or their function, in contrast with the semiotic approaches that regard artifacts as signs connoting cultural codes. The semiotic perspective of artifacts more speaks about how an artifact "*refers* to the culture in which such relations exist," while the post-phenomenological "turn toward things (p. 118)" approach enables a perspective that views productive force that technological artifacts possess in constituting a new reality, allowing more liberal perceptions of different worlds conditioned by changing human-technology relationship. The focus of the semiotic perspective, in this regard, is rather fixed and not malleable based on the pre-existing cultural code.

Nate and his group's highlighted sensation of competitiveness through the process, and thus projection of nudge as a "big brother," somehow showed that the meanings they sensed and generated during the nudge experience reproduced the culture of engineering that highlights efficiency and performance (Picon, 2004; Tonso, 2006). The conversation from two inquiry-based groups, with auditory and haptic nudge is slightly different from Nate's group. When discussing the meaning of nudge, both groups focus on how the technology is presented to their perception—for the auditory group, it was a volume, and for the haptic group, it was a mode. In either case, their focus is more on the physical properties of nudge sensation, or its indicative function, not on the symbolic function, hinting at the enactment of phenomenological perspective, which produces more nuanced, indeterminate, yet concrete and situated meaning of the artifact based on the specific relationships between artifact (the perceived object) and human (subject who perceives).

Their focus on the indicative function of nudge opened up the conversation to discuss not only the function of technology but also the meaning of working in a relationship with technology. Particularly, the observed conversations on how context may determine the nuance of the relationship they form with technology signal that the participants readily stay in the space to discuss how different meanings of human-technology relationship can be generated in different contexts, possibly led them to have "interpretive flexibility" that multiplies their anticipation of the mediating role of technological artifacts in their design process (Verbeek, 2005, p.217).

This sensed subtlety inspired my curiosity to see if this subtle difference among the groups per intervention can be corroborated in quantitative analysis. I conducted a quantitative analysis to see if the difference between the inquiry-based and the lecture-based group with the given haptic nudge—whether they engage sensorial approach or semiotic approach—that I notice through a phenomenological reading of interview data can be substantiated through the statistical analysis. If the difference between the groups is statistically significant, it would substantiate my observation of the effects of different types of intervention on participants' understanding of nudges. As such, the following subsection includes the quantitative analysis.

Factorial ANOVA

A 3 × 3 ANOVA was conducted to evaluate the effects of three intervention types (i.e., inquiry-based, lecture-based, and no intervention) and three modes of nudge (i.e., auditory, visual, and haptic) on the changes in participants' understanding of human-machine interaction (HMI) in the nudge situation before and after the experiment. The means and standard deviation

for HMI as a function of the two factors are presented in Table 5.5. The ANOVA indicated no statistical interaction between nudge types and intervention types, $F\ (4, 18) = .602\ (p = .66, \eta^2 = .12)$. Also, the main effects of both intervention type, $F\ (2, 18) = .029\ (p = .97, \eta^2 = .003)$, and nudge type, $F\ (2, 18) = .613\ (p = .55, \eta^2 = .118)$, showed no statistically significant main effects.

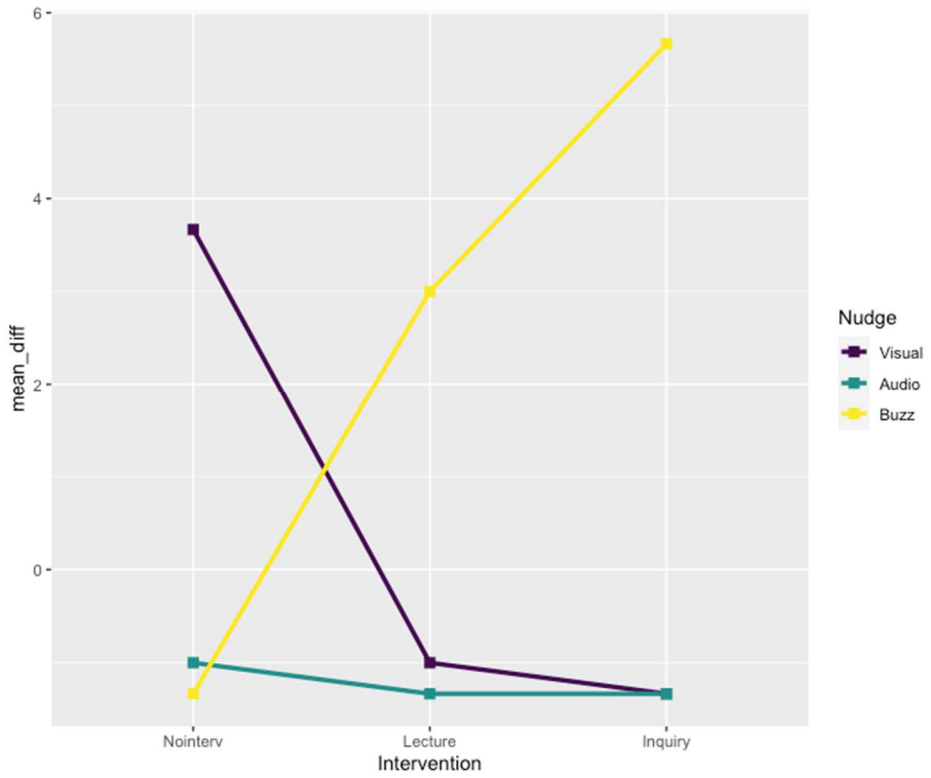
Table 3.5.

Means and Standard Deviations for Difference in Pre-and Post-Experiment of Human-Machine Interaction score

Intervention type	Nudge type	Mean	SD
No intervention	Visual	3.67	17.6
	Audio	-1	3.61
	Haptic	-1.33	7.64
Lecture-based	Visual	-1	5.29
	Audio	-1.33	3.06
	Haptic	3	2.65
Inquiry-based	Visual	-1.33	2.08
	Audio	-1.33	2.31
	Haptic	5.67	3.06

Figure 3.5.

Interaction Plot of Nudge type and Intervention Type on Changes in HMI Score

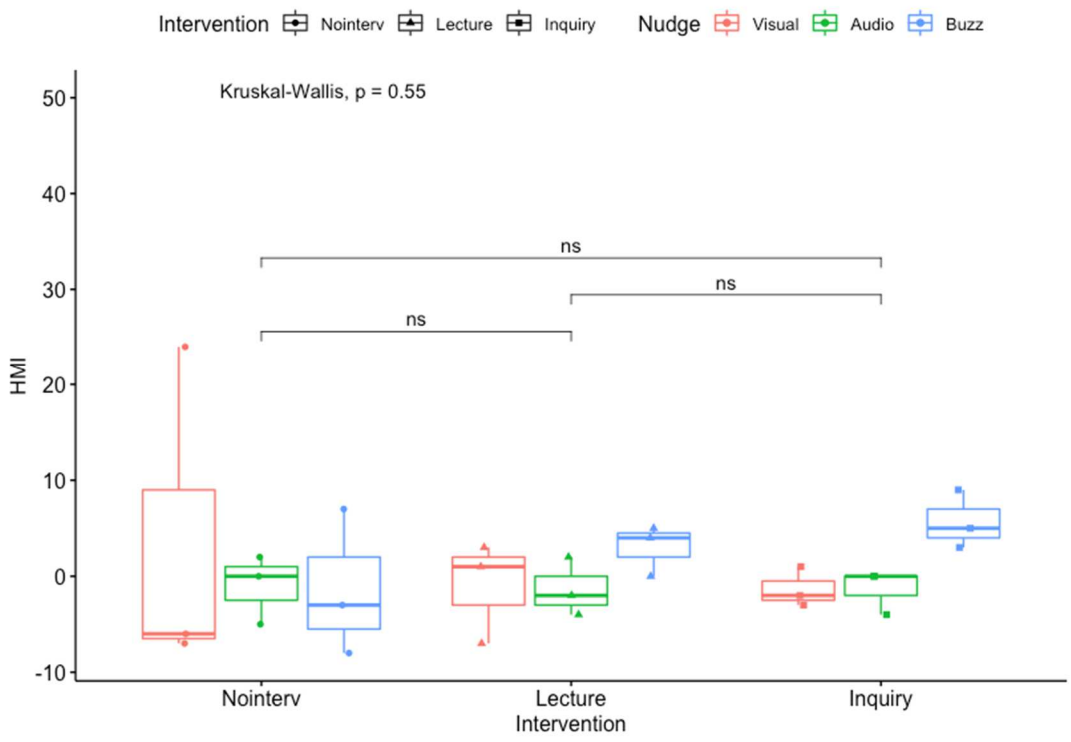


However, the Shapiro-Wilk test on the ANOVA residuals ($W = .88,\ p < .05$) indicated the non-normal distribution of data as per the intervention type and nudge type, implying the misleading result using the parametric ANOVA test. Thus, I conducted a non-parametric Kruskal-Wills test to see if there is any difference between the mean ranks of the groups as per the intervention type. According to the result, there are no statistical differences between the intervention groups and control groups ($\chi^2(2) = 1.19, p = .55$). Thus, the quantitative analysis indicates no statistical difference in the perception of the human-machine interaction before and after the experiment, across the learning interventions, despite the interaction plot (see Figure 1). This may result from random sampling error or the effects of other confounding factors (i.e.,

dispositional quality of participants, small sample-size, familiarity with the process, sampling process), implying the possible avenue for future work.

Figure 3.6

Box Plot of Pre- and Post- HMI Score as per the Intervention Type



Theme 4. Inquiry-based group tended to communicate more even with the felt sense of urgency

The last common theme across the groups was that in addition to the technologically generated nudge, participants sensed the consistent workflow created by the group as a "secondary nudge," which kept them moving. In both treatment and control groups, participants easily became immersed in the group task of finishing the eight power tools as soon as possible. Across the settings, my description of the videotaped work process includes: the eyes of participants were glued onto the parts they were making; No one moved across the station; They were busy completing their parts.

However, in two intervention-based groups with haptic nudge and visual nudge, participants exhibited prominently different behaviors: communication. Their conversation fluctuates between on-topic and off-topic. They discussed which classes they were taking, but also checked in with one another on how many parts were left, how the parts they made may not work, etc. Although there were other groups, such as the control group with a haptic nudge, who had such conversational or even humorous moments, the biggest difference was that they already knew each other before the experiment, but the inquiry-based groups did not. The following segment of their description of communication during the process, shows how the control group jokingly approached the lag in the process.

> *Chad: At the beginning. I don't know if you heard but I finished my first part. And I put it in his basket. And I said like you're the bottleneck now. That was before he had any work slowing him down. So by saying that wasn't going to mess him up. But afterwards, I didn't want to, like say anything like that.*
>
> *Don: And at the beginning, I think we both looked at Chad, like come on..*

Jacob: we're kind of taunting him...

Asked how those jokes work for their understanding of the ambience, Chad from the control group with a haptic nudge explicitly mentioned that he "would not have done" messing with another participant, unless he "felt comfortable with them."

Interestingly, Chad's point is what makes the other groups exhibiting communicative behaviors prominent as the participants in both groups had not known each other until the experiment. Tai, from the inquiry-based group with a haptic nudge that was highly communicative, responded when reflecting on the pace of the work process:

Tai: I highly valued the communication, like the actual words that were spoken from human to human that aren't heard and a little nudge.

Similarly, Bailey and Kyle from the inquiry-based group with visual nudge also answered:

Bailey: It (talking with other participants) took my mind off of it. Not that it made me slower, it took my mind off so then I was able to do it in the background and then it made the time pass faster.

Kyle: It definitely kind of eased my mind off the work at hand.

Although they were continuously immersed in the work, "not wanting to get nudged" and "not wanting to make the other participants empty-handed," both groups said the process felt not so stressful, as the goal is "working together" and "quality over quantity." The inquiry-based group with auditory nudges also shared the same understanding:

Owen: It was also a case of if I'm messing up, that means other people are going to get nudged because of me. That's my responsibility in myself because I know the nudge isn't exactly a pleasant sound to hear. ...

Austin: Yeah, I didn't want him getting nudged because I was slow. … I thought it was about for the next guy

The shared sentiment of responsibility shows how they implicitly shared the goal of completing parts, while avoiding nudges which they perceived as "negative yet not in an extreme sense."

On the other hand, the lecture-based group with a haptic nudge acutely described their work process as "weirdly stressful," when sharing the general assessment of the work process. They discussed how stressed they felt during the process:

Dana: It was funny when he got nudged. So I was nudged once. And the second time, he got nudged, I thought I'd got nudged. So I checked my pocket, but my thing wasn't going off. And then it kind of weirdly stressed me out. I was like, Wait, he's waiting on me. And that's not my nudge, so I was like hurry up.

Moderator: So you kind of get nudged by the technological device, but also nudged by each other, too, in some sense.

Nate: Yeah. It's like having a secondhand nudge.

Participants' descriptions of their feelings toward the "secondhand nudge" are prominently different as per the intervention, particularly with the haptic nudge conditions. In the inquiry-based group, participants reported feeling comfortable and appreciative of getting nudged by each other as it humanizes the work process they were engaged in. However, the lecture-based group mentioned that it "weirdly stressed" them out, which made them feel even "guilty during the idle time." One participant from the control group with no intervention but a haptic nudge giggled when noticing others getting nudged. Asked why he said,

I laughed a couple times when I would hear reactions when someone is getting buzzed in hindsight they got "oh no…"

His recognition of the exasperated sigh of other participants—who were his friends—somehow aligns with the stressful reaction toward the second-hand nudge of the lecture-based group, as it ultimately motivated him to work faster so that he can "keep up with the pace pretty much."

It is also note-worthy that participants' perception of the rhythm of the work was based on the work processes they engaged in, at each station. The shared sense of responsibility as an initiator of the process was echoed among the participants who worked at the first station. Dana, from the lecture-based group with a haptic nudge reported that she did not want to "waste others' time" by creating a defective part or "bottleneck moment." John, from the lecture-based group with auditory nudge, also said he did not "want to hold everybody else up" so he wanted to do his task as quickly as possible, to initiate the process. Fran, from the lecture-based group with visual nudge, felt a similar way, saying that she focused on working "the whole time, thinking everyone is waiting for me."

The participants from the second station perceived their role as a "smooth link," who needed to get parts out as fast as they can. Participants from some groups struggled to work as a smooth link, however, as the steps they were assigned to complete required some learning time. Dan, from the control group with a haptic nudge, described he had a struggle with "certain ways to put the wires into the device." Similarly, Kyle from the inquiry-based group with a visual nudge needed some time to get familiar with the instruction. During the process, however, other two participants voluntarily helped him understand and accomplish his parts, by suggesting Kyle

put wires into the parts in different ways. Bailey even voluntarily rebuilt the parts on her own, not just returning them to Kyle working next to her. Asked why, Bailey said,

> *Well, I mean the common goal was to get eight done, so if I were to give it back to him, that would just delay that. And plus I wasn't doing anything at that moment. It would've been a little different if I already had a stack that I needed to do my part for, but since it was the first one, I didn't even have anything to start on. So it allowed me that free time to help him.*

At the third station, participants were required to do constant screwing in the screws, which led them to find the task more "repetitive," having their "hands getting tired." Most of them found the rhythm of the process not so stressful.

The assigned group task came across as stressful to all groups, however, the groups had different perceptions of the extremity of stress, and the rhythm of the group task as per the learning intervention. The perceived interdependence of a group task created another layer of complexity, as admitted by several participants, the other participants' work pace is out of their control. Nevertheless, inquiry-based groups all commonly responded to the somehow stress-inducive situation in a rather relaxed way compared to other lecture-based, or control groups. That is, in a situation where *my* fault affects other people's performance, and that requires the rapid performance of tasks, the groups with inquiry-based training maintained their focus on collaboration; they communicated with one another proactively, and even extended their help to others when the bottleneck moment was presented, which was only observable in the group with a prior relationship. Also, such a relaxed mindset led them to feel in control of the emerging work rhythm, even though a nudge is perceived as something to avoid and dodge. It also

contributed to their focus on the quality of products, while the lecture-based learning activity has shown little effect on participants' cognition.

The subtle difference among the groups' responses to the second-hand nudge as per the learning intervention suggests how inquiry-based intervention motivates participants to have different cultural senses, or macro-perception (Ihde, 1990), emerging out of the nudge situation. The collaborative culture created by the inquiry-based intervention group signals how different culture can be produced with the different ways of knowing. The collective meaning-making process during the inquiry-based learning activity facilitated the interaction among participants by encouraging them to share their thoughts freely but also reflexively. According to generative knowing theory (Nicolaides, 2022), in-scending, or the enactment of embodied reflexivity requires humility that surfaces the fragility of one's perspective and openly invites diverse perspectives. When moderating the collective meaning-making during the in-scending phase of inquiry-based learning intervention, I admitted the partiality of my capacity to inquire into the future of work (i.e., "I am learning a lot from your thoughts as a researcher coming from different discipline"), and kept encouraging students to share their perspectives. Through this, they may have experienced a little hint of "collegial dialogue" (DeLuca et al., 2015, p. 649), that postpones the judgment on other perspectives. Participants may have created a supportive learning space that is conducive to shaping a collaborative culture. Also, the social interaction provided during the collective meaning-making potentially let them feel more comfortable, eased, and less tensed within the stress-inducive situation. Such a cultural change may have stemmed from participants' dispositional qualities or action logics that contribute to their habitual way of doing (Torbert, 2004). This motivated me to deeply explore individual participants' thoughts and action logics, which is elaborated on in the subsequent section.

Study 2 Methodology

Individual Interview

I conducted 9 individual interviews to delve into participants' nudge experience from the individual vantage point based on their dispositions and their action logic. The initial findings I obtained from study 1 guided the development of the interview questions (see Appendix 3). The observed collaborative culture within the inquiry-based learning intervention group is possibly contributed by participants' personal dispositional preferences (i.e., whether they are introverted or extroverted), or their habitual ways of doing. Also, the social interaction during a focus-group interview may prevent a researcher from exploring different perspectives that deviate from group opinion (Morgan, 2014). Thus, I conducted individual interviews with participants from each learning intervention (i.e., inquiry-based learning intervention and lecture-based learning intervention) as complementary to the focus-group interview.

I selected the interviewees based on purposeful sampling; the 14 participants who exhibited a higher score of identity capital than their group's average or those who had shown a remarkable understanding of the nudge situation were contacted. Among them, 9 participants agreed to be interviewed. All are from mechanical engineering, and only one interviewee (Dana) was an international student whereas the rest of the interviewees were domestic. Five of the interviewees were given the lecture-based learning intervention, and the remaining participated in the inquiry-based learning intervention. The summary of the participants' information is suggested in the following table (see Table 3.6).

I transcribed interview data using the automated transcription service (otter.ai). In addition, I used Nvivo software to conduct inductive coding to generate themes across the

interviews, as the purpose of this study is to explore what dispositional and cultural force affect, influence, and 'nudge' individuals' action, and behavior.

Table 3.6.

Summary of Participants' Information

Participant*	Completed Semester	Group	Race	Gender	Age
Dan	6	Lecture-based	White	Man	21
Dana	8	Lecture-based	Asian (East, Southeast, and South Asian)	Woman	28
Nate	3	Lecture-based	White	Man	22
Gaye	5	Lecture-based	American Indian or Native American, or Alaskan Native, White	Man	19
Calvin	8	Lecture-based	White	Man	22
Tai	2	Inquiry-based	White	Woman	20
Rachel	5	Inquiry-based	White	Woman	21
Sahar	1	Inquiry-based	Asian (East, Southeast, and South Asian)	Man	18
Nolan	4	Inquiry-based	White	Man	21

Note: All of the names of participants are pseudonyms.

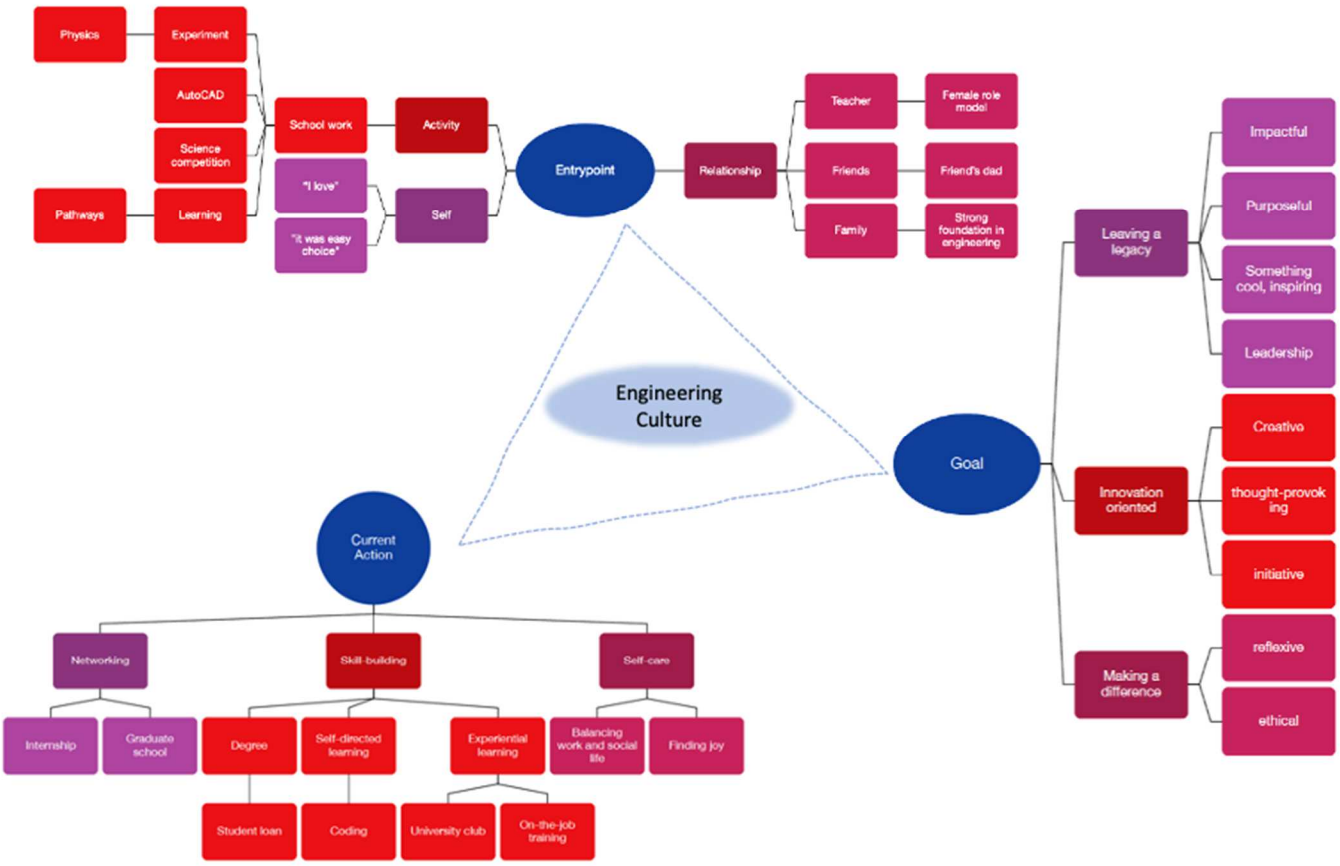
The second part of the finding is generated by inductive coding following grounded theory principles. Across the interview, 112 emic codes are generated and based on their semantic commonality, I categorized them into three categories: entry point, current action, and future goal. I analyzed the interview data, heuristically using Torbert's action logic framework (2004) and Kegan's adult development perspective (1982).

Study 2 Findings

Three themes are generated after the inductive coding of the data: entry point, current action, and future goal. The thematic map is suggested in the following figure.

Figure 3. 7

Thematic Map



Entry points to Mechanical engineering

The interviewees' common entryway into mechanical engineering is identified as follows:

- Participating in different school activities including class science project (i.e., experiment competition), different experiential classes (i.e., AutoCAD class, 3D printing class), or student club (i.e., Health care organization club).
- Developing personal interest in the field through the relationship with family members who work as mechanical engineers or in adjacent fields or friends who were interested in mechanical engineering.
- Having a self-driven motivation to challenge oneself.
- Making a "second-best choice" to enter the aerospace industry.

One thing to note is that when asked to share their personal narrative of how they become aware of the major and who can be identified as an influential figure in their choice of mechanical engineering as their undergraduate major, most of the students except Claudine said choosing engineering as a major was "self-driven," "easy choice," that "just seemed like more of a fit for myself."

Putting emphasis on their self-sufficiency and individual competence while also staying under the influence of family or school in their making decisions of major, shows how they are mostly in-between the interpersonal, and institutional stage, at the entry point to the field of engineering (Kegan, 1982). According to Kegan (1982), at the interpersonal stage, individual recognizes the demands and needs from the immediate relationship they form with their family and friends, which contributes to the emergence of 'weak ego.' However, such a socialized mind that is subject to the interpersonal relationship one forms, develops into the self-authoring mind when one gradually recognizes that s/he is not subject to the relationship but owns the relationship. Although some students mentioned their choice of major was "pushed," many of them recognized it as their agential choice with the activation of self-motivation. That is, within

the provision of knowledge about engineering from family members, teachers, or peers, they recognized they have such others' needs and interests, yet they were not mostly subject to their needs, following them without any self-motivation. Thus, in terms of adult development, their minds are in between the socialized mind and the self-authoring mind. This observation is in alignment with Tonso's ethnographic study (2006) of engineering identity in a large public engineering university and how engineering students' authorizing is ongoing but limited to the immediate community they are interacting with.

Current Action Plans

Another common thread across the interviews was the concreteness of action plans to achieve their career goals. The commonly given answers were "networking," "focusing on schooling, " "extending their education through going to graduate school" or "finding an internship." The action plans were directly pertinent to extending their engineering expertise and knowledge. Only two other interviewees—Tai and Nate—mentioned some other soft skills, or self-care practice, as action plans for their professional goal.

The emerging theme shows how engineering students are generally accustomed to playing within the rules, which is aligned with the general behavioristic characteristics of expert-action logics, in reference to Torbert's action logic framework (2004). Torbert's action logic provides a schematic framework of how individuals successively develop strategies to effectively react to the environment. Among seven major action logics, people with expert-action logics mostly focus on expertise and efficiency. How formalized activities such as internships, self-directed learning, and achieving degrees are more frequently mentioned than informal activities such as balancing work-life, and finding little moments of joy in the quotidian life,

when asked about their current strategies to enact their professional goals, shows that engineering students are generally accustomed to thinking within the rules and value efficiency in thinking of their future plans.

Future Goals

When asked to generate one word to describe their professional goals, interviewees mention 'leadership,' 'impactful,' 'inspiring,' 'versatile,' 'openness,' 'creativity,' 'purposeful,' 'joy,' and 'initiative.' These codes can be classified into three themes: leaving a legacy, innovation orientation, and making a difference. Most interviewees endorsed the idea of the constant evolution of society in general and espouse the innovation orientation. Interestingly, three interviewees mentioned Elon Musk, but not in an entirely worshiping way, when discussing future engineering. They highlighted that his political remarks and other-than-work aspects should be separated from how he leads the field in an innovative and proactive way. Many others mentioned that they want to become engineers who make a meaningful change in the world. Only one interviewee (Tai) mentioned joy—a subjective version of becoming happy while doing engineering work.

An additional theme generated in discussing the future engineering in industry 4.0., was their openness to different engineering. Tai, mentioned that she wants to connect her work with doing different engineering work, which may have a global impact on a community that needs the engineering expertise and practice. In explaining what she meant by different engineering, she mentioned the example of Engineers Without Borders.

> *Have you heard of like, Doctors Without Borders? They have, Engineers Without Borders. Did you know,… I had no idea until like, a couple months ago. So I mean, they*

> *don't make a lot of money. And it's usually full-time engineers who just set aside a few days or weeks out of the year to participate in stuff like this. But I think like, being an engineer, working on a project that like, directly affects the community that I'm working on it for would be really cool.*

Engineers Without Borders is a network that promotes humanitarian engineering and aims to benefit the marginalized society with underserved needs (Vandersteen, 2008). Throughout the interview, she also explicitly mentioned "reflexive engineering," and tangentially cited "social-justice-oriented engineering." Her increased awareness of such different engineering practices was possible, according to her, as she took "the systems and society," where she learned and became inspired by the instances of different engineering practices.

Similarly, Calvin also made an interesting remark in discussing ethical engineering, citing his recent update on Google firing the engineer who said to find out the AI chatbot system has a cognitive, perceptive, and affective capacity that can be compared to that of a five-year-old (Luscombe, 2022). Making a connection with what he recalled from the lecture-based learning activity, he said,

> *I feel like I'm gonna sound like a hippie, but I feel like people to be responsive to it or like, or shouldn't be so closed-minded about the idea that like sentience doesn't have to be like, of like flesh. ... A thing was like the Google guy got laid off for like, a couple of weeks because he was like, "Yeah, we made something sentient. Like it's talking to me. And it doesn't. And I think it's a person-like, and it's talking about how it's afraid of dying and stuff." And they're like, Alright, go home. Here's hush money go home. I'm like, yeah, don't like, it's sort of like the ... what's it? What was the movie? Her? You remind me of it*

during the presentation. I don't know, what goes on at Google. And I don't know how close we are. But like, you know, I, if it can manipulate me into thinking that it's real? Is it not real at that point, like I have? I don't know, I feel like we need some philosophers nowadays.

His observation is remarkable on several points. First, regarding his way of viewing the future of engineering, his words hint at a slight concern over the "over-intellectualized conception of engineering rationality," which cuts through complex problems like social issues "into more elementary questions, or even a certain rigidity," and is permeable through the practice of engineering (Picon, 2004, p. 429). He was sensing and questioning the engineering culture that upholds efficiency, and asked for different perspectives, as expressed in his words "we need more philosophers." Second, his way of describing his thought as "hippie" is also interesting to consider as he presumably assumed the thoughts that deviate from the mainstream perspective of engineering, or the engineering rationality to be hippie, a casual term indicating a non-conformist, sub-culturist movement. From the interview, he associated his observation of the current incident where one of the Tech Giants fired a doubtful developer with the lecture given to him prior to the nudge experiment. He also reported sensing the need for deeper thinking around the current engineering practice, but with a fear of not wanting to be miscast. This signifies that despite individuals' interest in practicing engineering in a different way, the dominant force that constructs the culture of engineering is hard to defy or ignore. That is, becoming-engineer is a complex phenomenon co-constituted by individual agency yet also with the dominance of culture that is often too obdurate and subtle to resist (Tonso, 2006). Third, he made a connection between the practice (Google's current incident) and what he learned from the learning activity (the movie clip from the movie Her). Given that the individual interview was conducted two

weeks later than the experiment, it corroborates the power of fiction and movie that produces an intense, vicarious experience (Jarvis, 2012).

The dominance of engineering culture in their understanding of future engineering in Industry 4.0 is also observable in their approach to becoming engineering, which is mainly pertinent to upskilling themselves—"learning as many skills as possible, " "learning coding," "keeping up with the demand," "working hard to learn new things," and "staying up on a plate." This shows how fast knowledge acquisition is privileged to become a better engineer. Asked how they feel about the continuous need to upscale their knowledge, Sahar said, "demand is actually good for me." Similarly, Dan reported that he does not bother upscaling his knowledge base as it will make him stay on top of the trend. This commitment to bettering themselves stems from their strong belief in the problem-solving capacity of engineering knowledge and practice, which aligns with what Picon (2004) referred to as engineering rationality. Their timely action in response to the emerging complexity of Industry 4.0., is to learn new skills as fast, and efficiently as possible. Some showed attentive care for different engineering and different ways of knowing and doing; however, in general, they were more interested in the advancement of the field and practice through the acquisition of knowledge. This circles back to the prevalence of engineering rationality in the field of engineering, and how it shapes the perspective of future generation, with a little hint of difference.

Discussion

In response to the call for educative practices with socio-technical orientation from both fields of Science and Technology Studies (STS) and engineering education this study experiments with the pedagogical application of STS principles in the college of engineering in the public university. The nuanced understanding of students' learning experience from the engineering ethics education with socio-technical orientation is necessary to encourage reflective practice for future engineers, and thus experimenting with different ways of knowing in the pedagogical enactment of STS principles is important. Based on data from this case, I discuss implications for engineering educators and researchers illuminating future efforts for a novel approach to engineering ethics education.

The multistability of technology as a key towards inquiry into the future engineering

The phenomenological reading of data reveals that participants in general gained the certitude of the unknown nudge situation employing their engineering knowledge and habitus. Also, they associated nudge with a negative connotation as a motivator by reminding them of the work process, or as a manager of the whole process across the nudge types and intervention types. The participants were reported to either ignore the nudge, or actively rationalize the nudge situation. As a result, there was a variation in the number of cases where the participants perceived getting nudged even though in real life the nudge was given to the participants with the same number of times. This observation showed how both the micro-perception (i.e., sensory perception of nudges) and macro-perception (i.e., the cultural association of nudges) are contingent on participants' recognition and meaning-making of the context. Participants who had a hard time conducting their task perceived the nudge more frequently than others, while those

who felt the sense of urgency perceived the nudge less frequently than others. Participants who were reported actively ignoring their perception to nudge, still showed negative reaction to the felt sense of nudge, mentioning their wish for nudge to do more justice to their efforts during the interview. All separate cases point out that both macro- and micro-perception are contingent on participants' understanding of the nudge context, implying the ambivalent value of technology (Verbeek, 2008).

I also see the finding from the statistical modeling as a cue for a nuanced understanding of technology. I conducted the quantitative analysis to see if there is any difference in perception of human-technology interaction before, and after the nudge experiment as per the learning intervention and nudge type. Although the interaction plot showed the difference, the result was statistically insignificant. This might be generated by confounding factors (i.e., fewer sample size). However, the nature of the phenomenon that I am addressing in this study—human-technology relationship—yields multi-structure as purported by post-phenomenologists (Ihde, 2008), and requires a nuanced perspective on the phenomenon. Thus, the statistical insignificance hints that the nudge situation generated diverse structures that would not be cut out for statistical reasoning.

The appreciation of silent, subtle, yet felt complexity of nudge experience is aligned with the conception of technology purported by post-phenomenologists (Verbeek, 2005). Particularly, the observed conversations on how context may determine the nuance of the relationship they form with technology signal that the participants readily stay in the space to discuss how different meanings of human-technology relationship can be generated in different contexts, possibly led them to have "interpretive flexibility" that multiplies their anticipation of the mediating role of technological artifacts in their design process (Verbeek, 2005, p.217). To post-

phenomenologists, the nuanced understanding of technology fairly treats the ambivalence that technology possesses but which has been largely overlooked by the essentialist, Heideggerian phenomenological perspective. They perceive that technology has multistability (Ihde, 1990) meaning the technology and technologically mediated structure are always contingent without any essence. The significance of the structure is stable within a certain context, yet it can be multiplied as per the different identities of technology in different use contexts. Acknowledging the ambivalence of technology or its multistability, then provides a chance for human users to perceive different meanings of technology, and thus imagine freely the use of technology.

Verbeek (2005) also discusses how nuanced and multiple conceptions of technology contribute to liberating social imagination of industrial designers and creating a durable relationship between humans and technology. The multiplication of technology's role enables different imaginations of human-technology relationship, which also possibly leads to designers' careful observation and discussion on the moral matter – how people act and live. That is, the multiplications of the human-technology relationship invite them to broadly conceive how the artifacts co-shape the relationship between human and system, and possibly map a new socio-cultural system. To iterate, such a multiplication begins with not regarding technology as a bearer of signs but appreciating how they matter.

Inviting what matters in engineering education

The multistability of technology is important yet only accessible through activations of both micro-perception and macro-perception. Drawing upon the data, participants from lecture-based intervention showed a tendency to activate their macro-perception easily while those from inquiry-based intervention activated micro-perception, and naturally expanded their

understanding of the macro-perception. For instance, participants with haptic nudges and the inquiry-based learning intervention showed attentiveness to the sensory contact with the nudge device while those with the lecture-based learning intervention approached the nudge on an interpretive level, somehow highlighting the surveilling power of nudge in close adherence to the existing patterns of cultural code that exist in the field of engineering, espousing the value of efficiency (Picon, 2004).

This suggests two points. First, as Picon (2004) contends in his study, engineering rationality that privileges the utility of knowledge, and practice, and eventually highlights the value of efficiency, permeates the engineering field and is manifested in some students' adherence to the perception of nudge as a managerial force. The findings from individual interviews also support how engineering rationality is indicted in participants' imagination of future engineering in Industry 4.0. Second, despite such a cultural force, some participants—particularly those from inquiry-based learning intervention groups—became more attentive to the sensorial contact with the nudge device. Their meaning-making of a nudge was more nuanced, indeterminate, yet concrete and situated meaning of the artifact based on the specific relationships between the artifact (the perceived object) and the human (the subject who perceives).

Their attentiveness to the physical presentation, or indicative functions of nudge, opened the conversation to discuss the function of technology and the meaning of working in a relationship with technology, which was not observable in other groups' interviews. Such attention to the materiality of the nudge device shows how inquiry-based learning intervention with a socio-technical orientation may facilitate participants to endure the ambiguity of encountering a nudge (Nicolaides, 2015). That is, their attentiveness to the sensorial contact,

which eventually has the power to become more interpretatively flexible, may be attributable to the collective inquiry that allows them to become less rigid but more ambiguous (Nicolaides, 2015) and appreciate the process of emerging values, knowledge, or context (Fenwick, 2009) on the basis of the principle of complexity learning theories, which "purports to trace the ongoing mattering dynamics of the world that both reveal and create 'what matters.' However, 'what matters' is invariably linked with critical dynamics of power relations, on which complexity may be ultimately silent" (Fenwick, 2012, p.155).

STS principle as a Portal For Becoming-Engineer in the Future of Work

Another key finding of this research is that the STS principles enacted by learning activity enabled participants to notice, discuss and appreciate the different engineering practices (i.e., reflexive engineering, humanitarian engineering). Some participants given the learning activities co-created the collaborative culture and co-generated knowledge of artificial intelligence with a more socially integrative perspective. STS scholarship critically assesses the role of technology but also discusses the ethical enactment of technics (Moats & Seavers, 2019; Mitcham, 1994). Participants' recognition of different engineering practices and increased awareness of engineering rationality (Picon, 2004) substantiate the potential of STS principles that hold for a change to ripple through the culture of engineering that espouses the value of efficiency. Enacting STS principles in science, technology, engineering, and mathematics (STEM) education with the help of different ways of knowing (i.e., artistic, inquiry-based) transverse the disciplinary boundaries and enables the "knowledge in-the-making" in the context of the neoliberal university, rekindling the innovative creativity (Marenko, 2021, p. 173).

Limitations and Future Research

There are several implications for future work from the findings. First, a larger sample size with a longer period of learning intervention may corroborate the processual causality that this study finds in a phenomenological way (Maxwell, 2012). A quantitative analysis was conducted to identify the difference in participants' changes in perception toward human-machine interaction interdependence. The result was reported to be statistically insignificant. Given the secondary method of the integrative mixed-methods with embedded design follows the parameters of the primary method (Greene, 2007), it is likely that a multitude of confounding factors affects the experiment. That is, the parameters of qualitative research, which allow a less rigorous sampling method and fewer sample size, may have affected the result. Thus, for future mixed-methods studies with different designs, which particularly put more emphasis on quantitative analysis, larger sample sizes with a coherent sample group may benefit research.

Second, a more sophisticated presentation of nudging is encouraged to generate more disruptive experiences of strange encounters with nudging and amplify the ambiguity of the nudge situation. For example, the nudge device used in this study was a restaurant pager with a mechanical sound, flashing lights, and a buzzing sound, which some participants did not find too much unfamiliar. Using the nudge device with humanized voices, or robots that are easily associated with the image of artificial intelligence may present participants with different sensations of technology, which will generate more nuanced, multiple conceptions, or even experience the alterity of technology, situating them at the threshold of ultimate ambiguity.

Third, further exploration of the teacher's role and responsibility in enacting the suggested design of learning activities can bolster STS principles that undergird the learning

activity. The learning activity mainly utilizes cultural artifacts such as Sci-Fi movies to facilitate learners' critical inquiry into the role of technology and activate the social imagination in the context of industry 4.0. This way of engaging cultural artifacts in a participatory inquiry would raise the question of its versatility in a more diverse setting, with a population with different educational backgrounds, and socio-economic status. Incorporating cultural artifacts requires a substantial review of material with cultural responsiveness, which is another area that deserves further investigation to better develop a practice of teaching ethics. Furthermore, ethics education requires educators to stay reflective of their practice, as their values, beliefs, assumptions, or modes of thinking are instilled in their teaching (Rottmann & Reeve, 2020). Particularly, educating critical perspective requires facilitators to navigate two polarities; they should encourage the interrogation of students' perspectives while also affirming their voices (Giroux & Simon, 1989). Further investigation of under which condition a learning space enacts STS principles, and is generative (Nicolaides, 2015), would benefit the community of engineering ethics education.

Conclusion

With the exponential growth in computational technology, engineers must be more inquisitive and reflective on turbulent macro-level changes in the future of engineering. The educative application of Science, Technology Studies (STS) is encouraged in engineering ethics education. Drawing upon the insights from the socio-material approach to learning, I designed and experimented with a new learning intervention that facilitates learners' inquiry into a human-technology relationship. In the nudge experiment which fabricates the artificial intelligence-human relationship, participants experienced the broad spectrum of the felt sense of disruption. The inquiry-based learning intervention with a socio-technical orientation created a space for

collective meaning-making that invites participants to discuss the nuanced understanding of technology. The inquiry-based learning intervention enabled participants' sensorial contact as well as the hermeneutics of nudging, only in the condition of haptic and auditory nudge that creates identifiable sensorial experiences. Lecture-based learning activity motivated participants to focus on the relationship with a nudge on the interpretive level. The observed subtle difference among groups, albeit not corroborated by quantitative analysis, indicates how different imaginations of the human-technology interaction is possible with different learning intervention. More attentive understanding of the materiality of technology—that is, more attention to micro-perception—multiplies the hermeneutic senses of technology as it creates different cultural senses that the nudge can link to. The inquiry-based group with a haptic nudge having a conversation on the biasedness of artificial intelligence is the epitome of multiplicity of meanings.

Experimenting with the educative intervention that enables engineers' different ways of knowing matters as it sketches the patterns of action and thoughts that are otherwise inconceivable (Moats, & Seaver, 2019).The engineering culture is being reproduced in its own image, which is hardly transformable, despite the macro-level, technological, and social changes (Picon, 2004). Nevertheless, I observed the blooming orientation towards different engineering on an individual level through the nine individual interviews. Inviting technology as other-than-human in inquiry space motivates learners to map lines of flight that are not readily perceptible, not to trace the existing and sedimented patterns of meaning (Deleuze & Guattari, 1987). In this regard, education does not direct cultural change; rather, it nudges people.

This paper designs a learning intervention that enables a participatory, inclusive, and integrative inquiry into the ethical challenges that future engineers may face in the future of work

(Fenwick, 2016). This approach situates learners' knowledge in relation to others, including other-than-human entities (Fenwick, 2016), and thus fully embracing the complexity of reality they might face in the future (Lim & Nicolaides, 2022). This area is ripe for more profound and ongoing inquiry and deserves further investigation to develop better practices of teaching ethics in response to the increased complexity of Industry 4.0.

CHAPTER 4

BECOMING A QUALITATIVE INQUIRER WITHOUT KNOWING

Designing an experiment with a team of researchers from the disciplines of mechanical engineering and adult education is a unique experience. It requires not only knowledge, rigorous research background, and extensive literature review but also compassion, collegial respect, and endurance of epistemological and disciplinary clashes. This study offers an autoethnographic account of my experience conducting transdisciplinary research with scholars who navigate the unknown, turbulent environment in hopes of becoming more receptive to the multiplicity of worlds we also take part in making (Burnard, 2022; Morton, 2018; Marenko, 2021).

The daily conversation with educators and engineers who have been trained and worked with "radically different histories, epistemologies, literatures, working habits, research models, writing processes, public conventions and social and political commitments" (Marenko, 2021, p. 174) challenged me as a novice qualitative researcher. This thought-provoking conversation and my following thinking echoes what Deleuze and Guattari (1991/1994) discussed about philosophy:

> "They[the illusions] resonate or reverberate and form a thick fog around the plane. From chaos the plane of immanence takes the determinations with which it makes its infinite movements or its diagrammatic feature. … That is why every plane is not only interleaved but holed, letting through the fogs that surround it, and in which the philosopher who laid it out is in danger of being the first to lose himself." (pp. 50-51)

Daily conversations with my partners in engineering sparks my curiosity and doubt on my research, which becomes another thread of inquiry. In some regards, the chains of questions and second-thoughts on my research process create a "thick fog" (Deleuze & Guattari, 1991/1994, p. 50). Interweaving each thread of inquiry brings my thinking to somewhere else I have never conceived before with a fleeting breakthrough moment piercing through the thick fog. Experiencing the challenge of doing transdisciplinary work with little experience and high ambition, I frequently felt out of my epistemological comfort zone. Nevertheless, such a confusing experience forced me to revisit my epistemological plane. With a hint of a barely recognizable silhouette of my collaborators' epistemological planes, the forced revisitation naturally got me to continuously construct another emerging plane that can inhabit scholars from different disciplines and research paradigms.

This study offers a collection of my breakthrough moments. My breakthroughs are not ground-breaking, more so ground-building. They are indebted to the previous studies that transverse the disciplinary boundaries, focus on 'real-world' problems, and think beyond the scientific ways of knowing (Burnard, 2022; Morton, 2018; Marenko, 2021). They are also a repercussion of thinking with concepts (i.e., intra-action (Barad, 2007); Others (Levinas, 1984); nudge (Thaler & Sunstein, 2008), causal mechanism (Maxwell, 2004; 2021) and inquiry (Dewey, 1929; d'Agnese, 2019)). With them, I negotiate meanings, perspectives, and languages by dancing through the different planes of thoughts I constructed through my interweave. They have been a container of my trains of thoughts, questions, doubts, momentary epiphanies, and other second-thoughts, provoked by conversations with the human actors (i.e., collaborators, participants in experiments, and committee members) and non-human actors (i.e., data, experiment apparatus).

This is my story of encountering reverberations of illusions, surrounded by thick fog and making a hole through the thick fog by omnivorously exploring the possibly compatible concepts, moving across disciplinary boundaries, interweaving the concepts, and making different arrangements of ideas and thoughts, as a novice qualitative researcher. This is my story of being stretched but also held by concepts, data, studies, epistemologies, research paradigms, and writing. This is my story of continuing the interweave, without knowing where I am heading to.

What follows in this study are my autoethnographic accounts of the ground-building breakthroughs. This autoethnographic account of my inquiry experience tells more what has been the above and underneath of my inquiry process– the memorable, autoethnographic moments of my inquiry and also, the behind-the-scene thinking during these moments (Ellis & Bochner, 2000). Before moving ahead into the accounts, however, I would like to clarify what I meant by autoethnographic moments.

Autoethnographic Moment

Autoethnography, as an inquiry method, conveys consciously and reflexively narrated description of self and culture (Adams et al., 2022; Chang, 2008; Ellis & Bochner, 2000). Autoethnography consists of three components—auto(self), ethno(culture), and graphy (representation, writing, story). The three components are equally necessary to make a study as autoethnography but may have different emphasis as per the intention of inquirer (Adams et al., 2022; Chang, 2008). Chang (2008) situated the attention to self and autobiographical narratives, which is at the center of autoethnography, in anthropological scholarship which emphasizes the personal narrative of anthropologists as a social scientist. According to her, the personal

narratives of ethnographers' experiences of inquiry in their field of interest, or what is referred to as "reflexive ethnographies" of anthropology (Tedlock, 2000), narrates "what went on in the backstage of doing research" (Ellis & Bochner, 2000, p.741), and thus, can be considered as one of the different forms of autoethnography.

In this study, I provide the autoethnographic account of my inquiry journey. The autoethnographic account consists of the moments during my inquiry process that provided a chance for shifting mode of thinking (Freeman, 2022), informing changes in my research design, research questions, and research of itself. Putting my inquiry in relation to my collaborators, committee members, the participants of the experiment, and myself, creates the moments where I inevitably muse over my thinking as an activity and contemplate how this activity leads me to form and create another arrangement of actions and thoughts shaping my inquiry. The journey in which I become aware of my positionality in the research paradigm and my desire in the inquiry process undergirds the background of my research into the future of work. These contemplative moments shift, tweak, and rearrange my inquiry process, the results of which are represented in my empirical study (Chapter 5). This autoethnography of my inquiry process invites me to reflect on my subjectivity, experience, and desire as a qualitative inquirer who has been trained with a new-material/posthumanist/Deleuzian perspective. My becoming-inquirer experience in the world, has required me to live "consciously, emotionally, reflexively" (Ellis, 2013, p. 10) in relation to my inquiry.

One thing to note is that my autoethnographic moments happened in an *a*temporal sense, meaning that they are comprised of my captivation of the present event, in combination with the swift flashback, and a quick burst of ideas. The boundlessness of autoethnographic moment can

be better understood with the concept of 'the virtual' in Deleuzian philosophy (Deleuze, 1968/1994). According to Deleuze,

> "The virtual … is the characteristic state of Ideas: it is on the basis of its reality that existence is produced, in accordance with a time and space immanent in the Idea" (p. 211).

The virtual is implicated in the event happening in the present moment, which is inexplicable (Bogue, 2003). It is derived from reality but remains undetermined as the entire sets of relations constituting the actual existence of reality cannot be completely known. My autoethnographic moments came to me as the virtual which exists in a "paradoxical time of presents-of-the-past, presents-of-the-presents, and presents-of-the-future" (Bogue, 2003, p. 6). During that moment, I become aware of the human-non-human relations that my ideas are constituted by and come to think of different understandings of the relations. Such fleeting moments inspired me to experiment with different ways of doing research. These moments marked a watershed in my inquiry process, yet were so transient that they sometimes did not render any linear order of my thinking. An impasse was my frequent visitor, and an epiphany was my rare one.

The recollection of autoethnographic moments, thus, may seem chaotic as it contains its own disorder of itself. For the sake of narrating the chaotic process in a better sense-making way, I used my past writings—the theoretical papers that I submitted for each class I took to assist my inquiry, my comprehensive exam, my prospectus, memos, and reflexive notes after conducting each interview. In addition to them, I also referred to the emails, memos, and notes I exchanged with my collaborators and committee members in recalling my autoethnographic moments. Finally, the bibliographies that I stored through the years of inquiry were considered. My

bibliography shows the overall landscape of my thinking, storing the summary, annotation, remarkable quotes, or any other snapshot thoughts. Using these artifacts, in the subsequent section, the linear order of critical milestones for my doctoral degree—Comprehensive Exam, Prospectus & Dissertation—will be used to describe how my thinking rolls at each step.

Comprehensive Exam: Is the Future of Work Researchable?

From the beginning of my doctoral program, my mind was filled with curiosity toward the technologically-driven transformation in the working practice thanks to my previous work experience. My work experience as a research assistant to a corporate-funded project, during my Master's years, led me to have a "visceral feeling (Bateson, 1991, p.171)" about the techno-centric workplace changes I observed through the research experience. This naturally granted me a moment of pause to reflect the meaning of my work, and *raison d'etre* of the field that I am going to work for and commit to (Lim, 2022). The project was regarding workforce development in response to the company's initiative to introduce AI chatbot technology in support of human consulting services. Through interviewing the executives, and meeting employees of the company, I observed the mixture of fear, excitement, doubt, confidence, perturbation, and receptivity about the new change upon the reality, which inspired my attention to approach the future of work as a phenomenon.

The context of my interest naturally came to me with a visceral sensation of difference. However, approaching the not-yet-lived context as a phenomenon required deep, thorough contemplation. For the first two years of my research, I was struggling hard to define *what* the future of work means. I still remember the message from a colleague in my comprehensive exam writing class who genuinely questioned how I can research the future. Her question was

poignant. How am I supposed to call the currently observable and perceived ruptures of the workplace the future of work? The act of researching the future of work implies that I am treating it as a current happening, which is manifested in real life. This does not make it the future of work anymore, which makes it ironic for me to call it as the future of work.

Concerning the privileged constructivist, phenomenological, or interpretive understanding in my field which focuses on what is happening, manifested, and thus, observable in real life, this irony hit me hard. At that time, I was taking the doctoral comprehensive exam which is supposed to help me explore the literature that may help my research, and the first question given to me on the doctoral comprehensive exam was "Trace the theory of socio-technical system (STS) from Emery and Trist to its current manifestation in the future of work. Review recent empirical literature that draws on STS in Artificial Intelligence (AI) and related technologies. Conclude with implications of this theory and research for your study." In as much as my committee members were welcoming my ambition to research the future of work, they pushed me to answer the questions about *how-to* approach the future of work. Their question seems natural as they are researchers in the education field, which is the 'soft applied discipline', according to the Becher-Biglan typology of discipline. Research in education field is "concerned with the enhancement of professional practice and aiming to yield protocols and procedures" (Neuman, Parry and Becher, 2002, p. 406). Thus, it is undeniable to identify, frame, analyze and clarify the complexity behind learning, and my starting point, as per my committee members' suggestion was to define the future of work.

The plane of the scholarship that I am trained within, cutting through my abstract thinking, made me play with some empirical pieces of evidence of the future of work. By reading the different reported anecdotes, ethnographies and pieces of evidence, I began to realize how

empirical studies approach the *future* in different ways. Bogue's (2003, 2019) interpretation of Deleuzian understanding of the present event was helpful in this regard. The way in which Deleuze approaches the present event, or the lived experience is different from what phenomenologists understand of it as a totality; that is, the present is distinguishable from being the actual and virtual. The actual means the actualized, materialized, and perceivable given the series of common-sense, chronological time where the virtual is implicated in the event, inexplicable, but mutually exclusive (Bogue, 2003). It is the potential, imaginative thus immanent plane of thoughts, during the non-linear, non-common-sensical time (Deleuze & Guattari, 1987). The virtual can be understood through what the actual produces; as to Deleuze's processual philosophy, event cannot be contained in one temporal, spatial boundary. It does not have no-starting point and end point, but produces a momentary becoming through its constant unfoldment.

The observable part of the future of work (the actual), then, is different from the inexplicable part of the future of work (the virtual). There are anecdotes that show the actual of the future of work. The instances of mechanistic division of labor between the technological workforce and human workforce — algorithms doing all the routinized tasks and humans conducting the complex tasks (World Economic Forum, 2020)—are the actuals. The actuals show how technology "free up workers to pursue more creative and meaningful forms of work" (Danaher, 2017, p. 48). The yawning chasm between the haves and the have-nots based on the displacement of labor by the over-paced development of capital, under the principle of economization (Brynjolfsson and McAfee, 2014; Acemoglu & Restrepo, 2019; Frey & Osburne, 2017) is also another part of the actual, as the phenomenon in which the haves take advantage of the potential gain of the introduction of computational technology in the workplaces is also observable in the workplace (Crawford, 2021; Rosenblat, 2018). What the actual of future of

work produces is the momentary understanding of the intricate relationship between humans and technology, which is described, observed, analyzed, and treated as clearly as it can be—either colleague or enemy of the human workforce.

This clarity felt strange to me, the future of work holds itself a complexity in that technology would not be reducible to certain definitive roles. The empirical discourse I approached granted me clarity, which makes me confused. Does this mean that I should seek out more clarity, up to the point where I feel not confused? Would I ever feel not confused in understanding the intricate relationship between humans and technology? What is the meaning of seeking clarity in any way? How can I explain the complexity of clarity-confusion that I felt during mapping the future of work discourse, and are there any ways to hold this complexity?

The inevitable obscurity of ideas when perceiving unknown phenomena may be natural. However, I felt reluctant to approach this matter in a teleological way that seeks the utmost clarity. When I shared my concern with my advisor, her response was to keep muddling through. According to her, the complexity of the future of work, in and of itself, can be my research context. Her saying reminds me of how I am easily susceptible to the "principle of the proportionality of the clear and the distinct" based on Cartesian logic (Deleuze, 1968/1994, p. 213). Wanting to gain more clarity, define the research context in a concrete way, and dissipate the obscurity would not be appropriate concerning my approach to the future of work. More so, my approach should be mapping, painting, sketching, and retaining obscurity through understanding how the relationship between humans and technology is actualized in the future of work.

At that time, fortunately, I was becoming familiar with Braidotti (2019), who used new language to describe the current changes conditioned by technological development as a posthuman predicament (p. 5). The predicament, according to her, is conditioned by "the

unprecedented degree of technological intervention we have reached, and the intimacy we have developed with a technological device (p. 5).” The predicament is not reducible to such a techno-centric transformation as it embeds emotional, psychic reordering of subjectivity. That is, in the posthuman predicament with the ambiguity inspired by the hyperbolic technological development, humans are required to reorder its relationship with technological components while generating a new, “mutual trans-species interdependence (p.90).”

The visceral feelings I sensed through my research experience, which were perturbing and substantial enough for me to hold on to my desire to study the future of work, may come from this slippery recognition of changes in the order of things. Reordering the order of things in a humanistic world where Man is believed to be privileged amongst all other entities, demands a relational, situated yet “uncomfortable” perspective that may ask for losing oneself. On a theoretical level, losing oneself means losing the subject matter that has been largely believed to find its certitude in the understanding of oneself, particularly in Western philosophy (d’Agnese, 2019). On my personal level, losing oneself means taking a ground-breaking departure from my knowledge base which comes from the most humanistic field—education.

Claiming my thinking is posthumanism requires a commitment to the radical ethos of other studies that fall under the umbrella of posthumanist thinking (i.e., Colebrook, 2015; Braidotti, 2013; 2019; Hayles, 2017; Harraway, 2016; Naturally, I was drawn to read Braidotti (2013; 2019). However, whether it is my toe-dipping into their literature or whether I feel more inclined to show than tell my posthumanist thinking (Gough & Gough, 2017), I am still feeling reluctant to say that my thinking is posthumanism. Rather, through reading their literature, and particularly Braidotti’s books and writings (2013, 2016, 2019), what I learned from the insights from posthumanist thinking are the different images of human subjects, who navigate the sensed

mysteriousness in the context that is conditioned by the uncontrollable technological development, somehow implying the potentiality of human learners.

Despite the different images of 'thinkers', however, I still could not resolve my curiosity about how I approach the context of my interest, nor whether I should with an educational perspective. No one knows whether the technologically driven transformation happening in the working practice will eventually become a panacea or venom (Stiegler, 2016). The transformation may emancipate the workers from unnecessary duties (Danaher, 2019) or cause self-induced alienation (Crawford, 2021). The development of computational technology that enforces the transformation of the world of work seemed to me uncontrollably, unstable, and thus, hard to be tackled, particularly with my partial knowledge in education. How could I ever be qualified to design an educative practice for facilitating the inquiry into the unknown?

Fortunately, this is the moment where I found different readings of Dewey (d'Agnese, 2016; 2019), which taught me the power of inquiry. D'Agnese (2016) highlights how Dewey views the inescapability of the randomness of life. In Dewey's view, "human beings are 'thrown' into life; life and its conditions are anything but a choice". … "[man] cannot escape the problem of how to engage in life, since in any case, he must engage in it in some ways or other or else quit and get out" (Dewey, 1922, p.81). (p.198) That is, the randomness of the world is the very nature of the world and accepting the "uncannily unstable" nature of world (Dewey, 1929, p.43) is another route to recognizing the power of knowledge and inquiry. That is, "thoughts and inquiry are anything but a choice (d'Agnese, 2019, loc. 954), as in living in the aleatory world, humans are forced to inquiry and think, given their fragility and the world's utmost uncanniness. Lesson learned from Dewey's philosophy: My sensation of the alterity of the future of work,

then, is inevitably given to me, and the inquiry into this recognition may pose me a risk of being wrong, but still, I could not get to think without risking myself of error (d'Agnese, 2019).

Accepting the fragility of my position as an inquirer leads me to take a different look into the educational perspective that I am trying to plug into the future of work. Inquiry is a choice to intellectually engage in an "uncannily unstable" world, which requires "naïve contact with the world" (Mearleau-Ponty, 1956, p. 59), with the motivation to renew the thoughts, not with the impetus to interpret, master, or control the unknown (Deleuze & Guattari, 1994, p. 51). Generative knowing theory (Nicolaides, 2015; 2022) was instrumental to me in this regard, as it discusses the contingency of knowledge in the naïve contact with the unknown and the uncertainty, and how contingent knowledge can be generative when knowers are facilitated through the inquiry process, with a hand-holding relationship with a facilitator.

With the inquiry-based approach in my mind, the puzzle was then, how can I provide this naïve contact with the world as it is and facilitate learners' reflective thoughts on this raw, pre-reflective, pre-cognitive material? At that time, I was taking a New Materialism class, and dared to claim that I rejoice in confusion, joy, and momentary epiphanies reading Deleuze and Guattari. Being a very naïve and audacious second-year Ph.D. student, I wrote a reflection paper on the Pixar film *Soul*, based on my personal appreciation of the movie's vivid graphics of Deleuzian philosophy. In the movie, a middle school music instructor, Joe gardener experienced a soul-body separation due to the unfortunate incident of falling into the manhole accidentally. While he tried to restore his soul in the 'Great Before', he encountered Soul #22, who had not been able to find its own 'spark' and enter the Earth despite the efforts contributed by worldly renowned souls. With her help, Joe somehow reincarnated, but this time, in the body of a therapy cat lying near his body in a coma. It was Soul #22 that went into Joe's body. After figuring out

that souls can be embodied in the Earth, by getting an earth pass Soul #22, in Joe's body, and Joe's soul, in a cat's body, devised a scheme to get back to normal – finding Soul #22's spark and using Soul #22's Earth pass to retrieve Joe's soul in his body.

The movie is based on a classical body-swapping trope. Nonetheless, what distinguishes the movie *Soul* is the twist that Soul #22 has never been incarnated ever before. Her experience of embodiment in the world is described through Joe's body, his relationships, and his profound proclivity towards jazz music. That is, Soul #22 experienced Joe's troublesome relationship with his mother and his personal history of playing the piano. Borrowing Deleuze and Guattarian vocabulary, Soul #22 had a chance to experience the "interassemblage haecceities (p.262)" in a sense, by inserting her soul into his body. That is, Soul #22 had an earthly experience through Joe's body, by situating herself unwillingly in a tension between Joe and his mother and also, tracing his trajectory of finding a dream job – a jazz pianist in a quartet. It was only through the earthly experience and her embodiment that she could find her spark and get her Earth pass. In a material sense, Soul #22 became Joe and through this experiment of material embodiment, Soul #22 is situated in an experience that is a "milieu which provides the capacity to affect and be affected" (Semetsky, 2010, p. 91).

My personal experience of thinking with concepts through movies, inspired me to look into other different movies which might describe the different relationships between humans and technology, which I view to constitute the virtual of future of work. Science fiction becomes an interesting intersection to me, in this regard, as the catalytic idea or image represented with a fictitious plot "acts out its drama in a time other than the present, customarily the future" and "adds a dimension of the unknown" (Warrick, 1980, p. 7) by creating an image that is not easily, and currently perceivable in the present. Science fiction movies are one portal for learners to

watch and perceive the embodied alterity of technology or its relation to human and have a literal vicarious experience (Jarvis, 2012) of the diverse spectrum of human-technology relationship (De Visser et al., 2018).

Whether Sci-fi movies incorporate ways to introduce the "visceral feeling" of the future of work, they do not create an experience of depth with intensity, in which learners become a being of sensation. Whether the sensation provided through the images of different human-technology relationships will let them reflect on the meaning of working and living with technological entities, which will exhibit consistent performance with as little error as possible, is a different problem. What kind of learning should I suggest, as who has been extensively trained to believe in the value of reflective thoughts? (Dewey, 1922; d'Agnese, 2019) What do I desire the learners to reflect on? How can they encounter the "qualitative immediacy of experience" (Rosenthal, 2010, p. 136) accompanying the "mystery, doubt, and half-knowledge" (Dewey, 1980/1934, p. 34) on the precarious future conditioned by the massive, exponentially rapid technological development? The series of questions connects with Deleuzian experience—atemporal, inclusive, and multidimensional ground which has a material power, or a force to think. How can I situate the learners in the ground with the force that learners are to sense, recognize, think and understand the difference in the relationship they form with?

The unanswered question lingered in my mind for quite a long time, even after my prospectus phase begins.

Prospectus: What Experiment and Which Analysis?

After passing the comprehensive exam in August 2020, I had one semester before I started my prospectus in the Spring of 2021. My fall semester was filled with meetings with my-

now collaborators from mechanical engineering, whom my advisor and I happened to meet. Back then, my advisor and I had submitted a proposal in response to the National Science Foundation's (NSF) call for "Future of Work at the Human-Technology Frontier" which supports convergent research at the intersection of future work, technology, and workers" (National Science Foundation, 2022). We proposed to design a pedagogical tool that consists of an experiential learning activity in which learners work with and get nudged by artificial intelligence on a certain task. Nudge indicates a technology-mediated poke that directs humans to make a decision and behave in a certain way (Thaler & Sunstein, 2008). We also suggested the follow-up collaborative inquiry practice facilitating learning from the nudge experience of a human-AI interface. Despite the appreciation of the novelty of the idea, our proposal was rejected on account of a lack of partnership with the AI ethicist, or someone who has expertise in artificial intelligence,. Thus, my advisor hosted several meetings for me to meet different individuals at the university who might be intrigued by our proposal. We ended up meeting and forming a team with my now-collaborators who are also interested in optimizing and designing the engineering process in the artificial intelligence-human interface.

With the support from the persistent team effort, the initial design of the nudge experiment was refined, designed, and shared with many other researchers from different disciplines, including industrial psychology, business management, and other engineering fields (Yang, Lim, Morkos & Nicolaides, 2022). I used nudge as a shortcut concept to sketch the close relationship between artificial intelligence and humans that undergirds the future of work. Nudge presupposes how people can behave irrationally—that is, even without any immediate feedback, they would follow the nudge because of the cost of not following the nudge. Nudge thus works within a not-so-fully-elaborated yet sensible arrangement of choice options, which is referred to

as ‘choice architecture’ in Nudge theory. In a situated context, humans get to understand the benefits, and costs of their choice, and thus slowly behave on the basis of the embedded feedback loop that the designer of the nudge intends to emerge.

Nudge became an easy route for me to avoid the reappearance of posthuman language in my research.,My fear of getting rejected and receiving another comment about how jargony the philosophy can be, rather nudged me to eschew any kind of philosophical jargons. Although I did not mention any new materialistic language (i.e., intra-action (Barad, 2007)) in writing a refined research proposal, one of the major critiques of my original proposal for the NSF was that it was too jargony. I designed the nudge experiment in reference to the nudge principle of choice architecture (Thaler & Sunstein, 2008, pp. 85 – 99) (see Table 4. 1). The design principles of choice architecture are good containers to explain how the nudge experiment works and how different kinds of interaction in a nudge experiment emerge. In a nudge experiment, participants are given the simple task of assembling a hand-held tool with a detailed instruction manual. They are assigned to each station that is designed for a series of sub-tasks to complete the assembly procedure back-to-back. For instance, at the third station, the participant is assigned with the final job of fastening the housing building on the previous work that the participant of the second station completed. The team’s goal is to produce the eight products as soon as possible. Thus, the recommended course of action in this experiment is to follow the direction indicated in the manual and adapt to the rhythm of productivity. What the participants should be aware of is not only their task performance but also the whereabouts of the other collaborators working in a same space, in terms of their work process.

Table 4. 1.

Application of nudge design principles in the experiment

Design principle	Definition	Application in the experiment
Default options	A normal, recommended course of action	Adapting to the rhythm of the collaboration among stations
Expect errors	A set of errors that are expected to occur in the recommended course of action	Inconsistency in the performance
Give feedback	An instance of feedback that is given to reward the intended behavior or punish the unintended errors	Visual, auditory, buzz signal given to the participants when they are slowing down in the performance
Mapping	Organizing feedback loop in a systemic manner	Instructions given to the participants at the start of the experiment
Structure complex choices	Encouraging human's autonomous choice for a good behavior	(Possible outcome of the experiment) Students respond and react to the nudges and accelerate their speed of work
Incentives	A sort of material reward humans expect to get by following nudge, which will be beneficial to them.	Students get additional compensation (i.e., gift cards)

Nudge easily represents what I desire to convey through saying human-technology interaction. Nudge, and possibly the connection with the mechanical engineering partners, clarifies the kind of empirical reality my research tries to illuminate. Nevertheless, when first introducing this idea to the team of researchers in mechanical engineering, business management, and industrial psychology, I received a load of feedback, mainly regarding the research methodology. They questioned how I would retain the effect of me being present in the experimental site as an observer, which would 'contaminate' the experience of human-nudge

interaction. Their worries about the possibility of contamination bring me back to reading Barad (2007), who views apparatuses as phenomena themselves.

> "Apparatuses are constituted through particular practices that are perpetually open to rearrangements, rearticulations, and other reworkings. This is part of the creativity and difficulty of doing science: getting the instrumentation to work in a particular way for a particular purpose (which is always open to the possibility of being changed during the experiment as different insights are gained). … Boundaries do not sit still" (Barad, 2007, pp. 170 – 171)

My perception of the interaction happening during the nudge experiment, also as an apparatus of the experiment, must be changing, shifting, and produced by the interaction that I form with my observation. As Barad (2007) also clearly mentioned, this is a discomfort for those who "understand this production as a direct consequence of human actions, choices, intentions, commitments, ideas, values, concepts, beliefs, presuppositions, goals and the like." (p. 171) Their worry about my presence as an observer at the experiment site implies how humanistic their epistemological comfort zone is.

As a doctoral student, I intentionally chose to detour from this sensed discomfort from other scholars in the humanist tradition, by searching and utilizing languages that did not transverse the epistemological comfort zone. I proposed to frame the nudge experiment as an integrative mixed-method study (Greene, 2007), which puts more emphasis on qualitative components than quantitative ones. In an integrative mixed-method study, the parameters of conducting research depend on the primary method, which in the case of the nudge experiment, was qualitative research. Also, I approached the experiment as a 'vulnerable observer' (Behar, 1996). I maintained attention to the relationships the participants produce with one another but

also with the nudge device. The relationships were person-specific, and situated, as is my perception of the relationships. I admitted that I cannot stand as an objective observer. As a human, I am not capable of making a value-free evaluation, assessment, or understanding of the participant's perceptions, thoughts, or behavior.

During my prospectus defense in Spring 2021, my mixed-method study proposal exploring how engineering students respond to the nudge situation, however, still faced demands for more clarity. My committee members posed several critical questions, such as: What kind of technology am I concerned with in discussing the context of my dissertation—the future of work? What kind of methods can be deemed as quantitative in my study? What kind of causal relationship am I trying to explore through experimentation? What kind of 'complexity' that I iteratively associate with the future of work do I want to explore? The demands for clarity focused not on the research context but more on the nudge experiment. Although I could not successfully answer the questions brought during the defense, my committee members gave me a pass, and the following summer, the questions motivated me to hone my research design.

My committee members were truly helpful during my thinking through the design. My methodologist has been tremendously supportive, resourceful, and patient when I dumped my jumpy ideas, with a jargony language, on him. His main concern with my ideas was their clarity. He sent me a two-page-long memo telling me how inductive I am in approaching the experimental design, and that doing an experiment with only inductive reasoning may spark a 'mad scientist vibe.' After receiving the thoughtful memo from him, my mind during the summer has been busy chasing the positionality of my reasoning behind the experimental approach somewhere in the spectrum of deductive and inductive reasoning at each end.

The very first step for me to clarify my positionality in reasoning was deciding whether my study is deductive or inductive, and adding a more so-called quantitative component to my study. Thus, during the summer, I read the studies that discuss how qualitative inquiry approaches causality differently from other quantitative studies (Maxwell, 2004; 2021), as per the recommendation from my committee members. I added the pre-and post-experiment survey, using the survey items that another committee member recommended me to look into, given its alignment with the nudge situation. Conducting a pilot study with three engineering graduate students during the experiment also clarified and refined my experiment protocol and interview. I developed the learning material on the basis of the analyzed pilot interview data that generated insights into how participants experience the nudge situation. I came up with some hypotheses on participants' behavior and discussed them with my committee members.

My refined research design became clear enough to make me feel confident to conduct the experiment in early September. Nonetheless, when conducting the research, I encountered several moments which brought me back to inescapable obscurity. In the subsequent section, I would like to begin with one vignette of my conversation with my partner, Hailey.

Experiment & Dissertation Writing: What are 'good' data for me?

After the post-experiment interview, Hailey and I are busy cleaning the stations. Our goal is to disassemble the tools that participants have created as quickly as possible so that we can decompress and relax after a two-hour-and-a-half-long experiment. My job is usually much simpler than Hailey's job as she knows more about the task. All I need to do is unscrew the screws so that Hailey can take apart the remaining pieces and put those in their original place, the red boxes lining up in front of each station. During this time, our eyes are glued onto the parts we

are disassembling, but our mouths get busy. This is the opportune moment for us to exchange our after-thoughts about the participants, learning activity, experiment, interview, and data.

"So, what do you think about today's interview?" asks Hailey who is busy disassembling the parts.

"I felt rushed. Like they were way too clumsy."

"Yeah, I saw him dropping the screws several times."

"Yes, apparently, they all looked rushed. However, they did not say they felt that much rushed, which is interesting to hear."

My perspective intrigues Hailey.

"How so?"

"Well, if they were not that rush, I would think they would not drop parts nor act clumsy, from my perspective."

While answering the question, however, my second-thoughts kick in, 'Oh, wait, is it too much subjective projection? Aren't I projecting my perspective onto their behavior? Maybe they could have just dropped the parts because the parts are small.'

While my doubt on my objectivity as an observer deepens, Hailey's question cuts in my mind.

"How do you think about them saying that they were not able to make any connection with the learning activity, though? I think that is not good for you, right?"

She sounds somehow worried. Her question is very triggering. It adds more layers of doubt, arousing a hint of confusion, anxiousness, and curiosity in my mind.

'Wait, is she right? What kind of data do I want to see? What kind of hypotheses do I hold, and want to explore? What constitutes the 'good data' to me?'

***

The chains of thoughts triggered by my partner's question, remind me of the talk I had with my methodologist after my prospectus defense. Her question triggered a hint of doubt that I made every effort to avoid during the last summer. My thoughts around my direction of experimental research were sparked once again. 'What am I trying to do with the experiment?' 'What would I like to see through these experimental efforts?' 'Would this be ever meaningful?' A series of questions pop up in my head while my hands are busy unscrewing the power tool.

The stream of consciousness triggered by my partner's question again goes back to the Cartesian or humanist logic that there is an observable, definable, and reducible essence or truth, within the muddy reality, and that I tried to avoid as much as possible. Even with my conscious and political effort to avoid and detour such doubts to get away from the epistemological comfort zone, here I was, once again, faced with the slippery trap of humanist, Cartesian logic. The demands for defining what counts as good data sparked my thoughts on how to view scientific inquiry or empiricism. The doubtful feeling that I had in conducting the research for my dissertation project hit me particularly hard.

The conversation was not the only moment when I felt doubtful of my research. With the initial reading of data, I was left wondering if I am trapped in the binary logic. Were there any transient patterns of participants' behavior that I could not have captured through the act of reading the data? This was my thought after I felt the saturation of data, followed by conducting several, but not all, runs of the experiment. I could not get away from being suspicious of my seemingly easily arrived at conclusions, through reading the data with phenomenological whole-part-whole reading (Van Manen, 2020). My momentary conclusion was that the type of intervention somehow shapes the rhythms of each group. That is, the lecture-based groups

perceived and sensed the rushed pace among themselves, whereas the inquiry-based groups tended to be more chill and relaxed.

Nevertheless, I could not escape from a series of questions popping up in my mind. What if my desire to produce difference modulates my inquiry process? Was my reading of data subjected to my desire to seek the difference among the groups? What if I misread the data under the desire to produce and seek any difference within the context? What if I exclude any movements that are not perceptible to me?

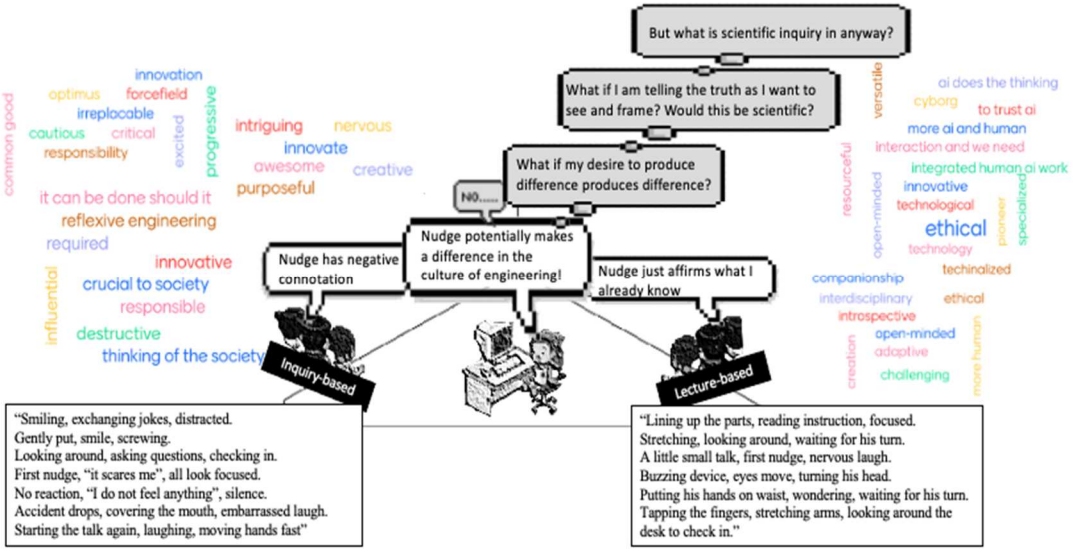
I consulted these doubtful feelings with my friend, advisor, and other scholars who were more experienced in qualitative research. The common thread of their advisement was to look into the data and see what the data spoke to me. They suggested I take one step further from the data, and just describe what happened during the process. They also urged me to see if there is any difference I could have not noticed because of my entanglement in the event, in which the participants were sensing, and responding to the given nudges, but also creating their own rhythm or pace of work. My act of observing the experiment must have created other phenomena (Barad, 2007). The relationship between me (the observer) and the participants as well as experiment equipment (the observed) all iteratively created different patterns as per my observation of participants' exhibited behavior and perception within the nudge situation. The relationship can be a hole that pierces my thick fog around the empirical evidence from the nudge experiment.

With this advisement in my mind, I started to meticulously describe the video data I had. I watched the video and jotted down the first time that participants got nudged, thanks to the help of my partner's analysis of the manufacturing cycle time. I also read the description in the juxtaposition of my observers' notes and the interview data. In the end, the description becomes

another starting point for different relationships between the observed and the observer to be formed, and through the iterative formation of the relationships, different entanglements among multiple entities emerge (See Figure 4. 1). Somehow, these iterative reconfigurations of patterns of entanglement create intra-action (Barad, 2014) that are too dynamic and fluctuating to be reduced into the bilateral interaction. The metaphors generated by participants to describe how they imagine the engineering in the future of work (the colored world cloud in the figure), the description of participants' behavior during the nudge experiment in a poemish data —the good enough research poetry (Lahman et al., 2018) (the text box in figure), the interpretation of interview data from two different groups as per their learning intervention (the speech bubbles in figure) and my second-thoughts (the thought bubbles in figure) all constitute my inquiry space. Under the intra-action between what I observed, narrated, and re-read, is not the behaviors of participants in juxtaposition with their interview data, but also something else that I could have never found, without such a methodology (Sellers, 2015).

Figure 4. 1.

Illustration of my inquiry space



Interestingly, Deleuze's conception of philosophy, with his radical opposition to certain empiricism, alongside other philosophers' alignment with his idea pinned a hole through the thick fog. According to Gane (2009), Deleuzian empiricism is a radical alternative to existing empiricism in sociology as it addresses reality with aims to explore "the conditions under which something new is produced," not to "discover the eternal or the universal" (pp. 83-84) of reality. The act of discovery is of no use, as empiricism is not about finding a path drawn between the representation of a sensible world and the idea or meaning behind it. It is pointless to depend on the corresponding relationship between the abstract concept (thought) and concrete reality (truth), as "the relationship of thought to truth in the ambiguities of infinite movement has never been simple, let alone constant, matter" (Deleuze & Guattari, 1991/1994, p. 54). What creates the concept is "the creation of precarious and unstable bridges between the empirical world and its presentation in thought" (Gane, 2009, p. 87). That is, as the experience which is based on the empirical world is always of its uncertainty, the relationship between the abstract concept and the empirical evidence is always transient, fleeting, and changing. Thus, asking what to observe, or how to observe without any inference, does not make sense in Deleuzian empiricism. The question of under which circumstances, what is produced, is more of the question that focuses on the production of, not the discovery of concepts.

Through re-reading the data but with the intention to dodge the binary logic, following Deleuzian empiricism, comes to me as a causal mechanism that accounts for the different sensations I caught in my observation of the groups during the intervention (Maxwell, 2004, 2021).

The perceptible difference I noticed through the creation of an image of work within the inquiry-based group and lecture-based group through research poetry was their sensation toward

the rhythm that the group created by themselves during their immersion in the work process. The eyes of both groups were glued onto the parts they were making. No one moved across the station. They were busy completing their parts, not wanting to get nudged or to make the other participants empty-handed. Nonetheless, how the participants describe their feeling toward the rhythm of the work and respond to such a rhythm was prominently opposite. In the inquiry-based group, participants reported feeling comfortable and confident in their work process while the lecture-based group mentioned that it felt as if they were in a competition, and explicitly said that they felt stressed. While the participants' conception toward the nudge varied (i.e., Nate acknowledging the surveilling power of nudge while Jim admitting his intentional ignorance of nudge), overall, their perception toward the experiment situation converged on how rushed they felt during the process.

The rapidity distinguishes the current transformation happening in industry 4.0 from other socio-technical development. The exponential growth of technological advancement is what often frustrates humanity with the prevalence of powerless feelings toward speedy transformation (Braidotti, 2019). The difference in participants' perception toward the rhythm created in the nudge situation as per the learning activity produced different work images among the participants, who were presented with the learning activity of the same content but in a different way.

Exploring causality in education research using experiment settings requires examining which type of causality is of interest. Maxwell's (2004, 2021) extrapolation of two separate directions in investigating the causation is instrumental in this respect. According to him, causation in social science can be understood with two senses: causal effect and causal mechanism. The casual effect is what he called the regularity approach or what a positivist

approach wants to reveal. It explains the law-like cause-and-effect relationship that is assumed through iterative observations, and the formation of patterns or regularities. On the other hand, there is a particular, singular causal mechanism that can be explored in a certain context and described with what he referred to as a process or realist approach.

The causal mechanism that is created in the nudge situation is the different internal processes of adult learners in their understanding and perception of the working pace, given the mutual dependence among themselves with the nudge device. Nudge, as a context-stimulating effect of creating a speedy, fast-paced work environment, creates a condition in which the participants interact with one another also in different ways as per the learning intervention they received, prior to their nudge experiment. Experimentation, in this regard, was instrumental as it organizes the action that may incur a result otherwise inconceivable (Seaver & Moats, 2019).

A Momentary Closing

When I started my dissertation project, like many other Ph.D. students, I was eager to find the sweet spot for me. The theoretical framework that is discussed and recognized but not so much that the community thinks it is overly sought. I sought a theoretical framework that was original enough to claim my niche in research, but also makes sense to the community which I share my research with. I desire to bring new ideas that are just strange enough to be accepted by the community, with possibly little rejection. The desire to avoid cliché, stay original in thinking, yet also seek belonging to the community of scholarship has motivated and modulated my inquiry process, which is how I come to design the nudge experiment.

My dissertation work is not a solitary project. I have enjoyed the privilege of working with collaborators who are coming from a completely different discipline—mechanical

engineering—with a different understanding of research. Also, receiving advisement from the committee members who are in different sub-fields of education—human resource development, adult education, and education policy—led me to view my work with a meta-lens. This collaborative experience with researchers with completely different disciplinary backgrounds and the research paradigms—positivist, interpretative, or post-positivist—offered me a chance to be introspective about my own stance within the research paradigms.

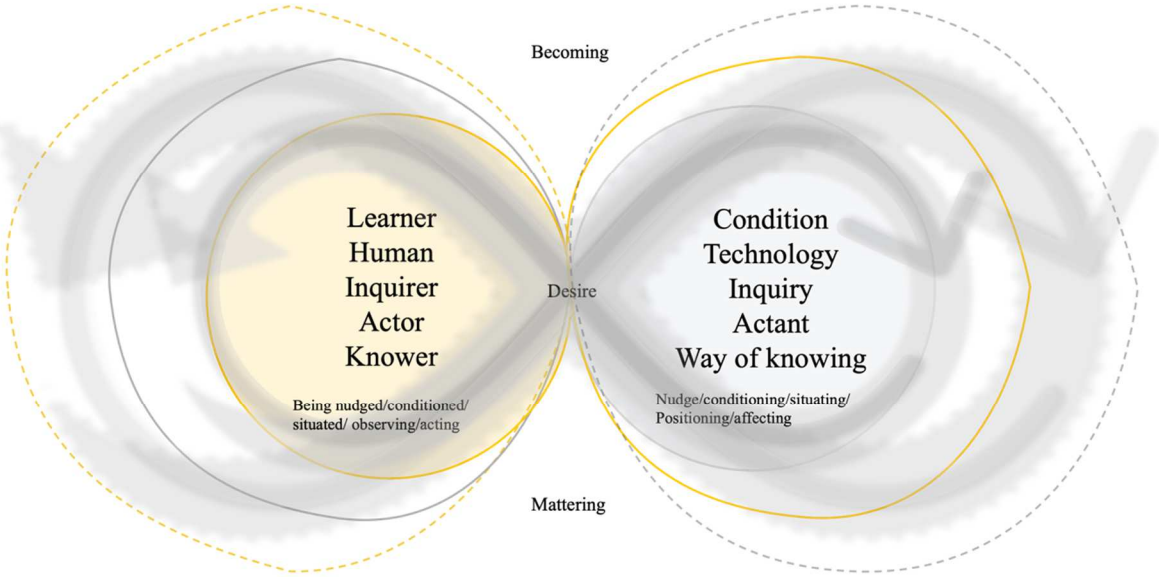
I should note, however, that the sensation of alterity that I felt comes from a 'relation without relation' (Levinas, 1974). That is, the relationships I formed and noticed through experiencing the different perspectives toward research during the quotidian interaction with my collaborators, and my dissertation committee members is beyond substantiality. I recognized their understanding and perspectives of the research as Other. Such a "proto-experience of the other, the context in which the text of knowledge unfolds" (Purcell, 1996, pp. 134-135), invites me to have a sense of responsibility that is called by this utter sensation of alterity. This requires reflection of my positionality as an inquirer in the face of the force of "being addressed" (Butler, 2004). Thus, my relationship with my collaborators, committee members, and other people who contributed to this inquiry process is irreducible to the relationship I form with the specified others. That is, my feeling of disturbance and rupture emerge in a relationship with the utter alterity, strangeness, and foreignness I feel toward generalized Otherness, not those specific others. Through this, I pause to reflect on who I am as an inquirer, what my perspective is, and how my perspective and my becoming as an inquirer produce the inquiry.

In addition to the multitude of the human-human interaction, the agential power of other-than-human in my thinking constitutes the inquiry process. The common denominator of my inquiry process is how I can understand, view, sketch, conceive, and approach the relationship

between humans and other-than-human. In my conceptual paper, I discuss how adult education scholarship is arranged by a rhizomatic movement that values the soul-searching nature of learning under the condition of neoliberal logic that subtly shapes the discourse by espousing the instrumental utility of knowledge. The relational perspective that puts knower-in-relation-to-knowledge is reassessed with the principles of the generative knowing theory which brings in the non-human actors in the learning scene. In my empirical paper, the human-technology interaction was the central piece that puts all the other parts of the puzzle into one picture. This study pivots on the relationship between the inquirer (me) and the inquiry process (see Figure 4. 2).

Figure 4. 2.

The diagram of my inquiry



My inquiry process has been always foggy or chaotic, but still, being knitted with different thoughts through a hole or the momentary a-ha moments without knowing which inquiry space I am creating. Having a dialogue with different perspectives and surfacing the relationship between humans and other-than-human inspires new chains of thoughts. Through the chains of thoughts, I doubt my habitual way of "saying I," as in my conceptual piece that attempts to explore the reproduction of logic that conceptualizes learning with instrumental utility within the field I am in and will be belonging to. Also, I map other "thought's mirages (Deleuze & Guattari, 1991/1994, pp. 49)" as in my empirical piece that experiments with a different way of knowing that may produce affirmative ethics (Braidotti, 2019) in response to the future of work.

When I think of thinking, I cannot get away from Deleuze and Guattarian (1991/1994) perspective. They describe thinking as laying out a plane that may have infinite movements or diagrammatic features which makes the plane ever-productive. That is, thinking is "experimental and experiential," and "born under the constraint of experience as a material power, a force." (Semetsky, pp. 91-92). My experiential encounters with the world are forces that motivate me to think. In this process, I recognize, the force of thinking which positions me as a person who wants to think differently, "to attempt to lay out my own plane, without knowing which planes it will cut across" (Deleuze & Guttari, 1991/1994, p. 51). Through this process of questioning and experimenting with the world, a hole is pierced through a "thick fog" (p.50) that rendered my thinking chaotic but also landed me somewhere else that I had never expected to be. My inquiry process is still ongoing, and still not knowing where I am.

CHAPTER 5

A TESTIMONY

My dissertation is an ambitious attempt to experiment with a different way of knowing in the intra-active space of human-technology. My ambition is oriented towards the multiplicity that is the future of work in the context of engineering education that facilitates becoming affirmative and generative. I view my dissertation as a momentary rupture during my ongoing journey of inquiry into the future of work. Understanding philosophy from a Deleuze and Guattari perspective gives me space to explore what differences I produced, by conducting a transdisciplinary work to think through the future of work.

According to Deleuze and Guattari (1991/1994), laying out, inventing, and creating concepts constitute the philosophical mind (p. 77). Concepts resonate, and reverberate with one another, creating a force field that has its own potential for different creations of different fields. Through the diagrammatical creation of a force field, the force field itself comes to have its own singularity and consistency. The thinker is the incarnation of the singularity and consistency of the process of thinking; moves through the force field, creating different lines of thought, enabling a more vivid conceptualization of how thinking moves. Modulating all the movements of this conceptual personae, is what Deleuze and Guattari called the taste.

> "The philosopher does not approach the undetermined concept except with fear and respect, and he hesitates for a long time before setting forth; but he can determine a concept only through a measureless creation whose only rule is a plane of immanence

> that he lays out and whose only compass are the strange personae to which it gives life. Philosophical taste neither replaces creation nor restrains it. On the contrary, the creation of concepts calls for a taste that modulates it. … Taste is this power, this being-potential of the concept: it is certainly not for 'rational or reasonable' reasons that a particular concept is created or a particular component chosen." (pp. 78 – 79)

Taste is nothing but an instinct. The force field, in this regard, embeds some sort of direction that the thinker would have a proclivity for. In this regard, the taste is comparable to the Deleuzian's concept of desire. Taste is a desire for philosophers. It modulates the creation of a force field, as desire animates a productive force continuously inscribes subjectivity, or an individual's becoming.

Now that I have a chance to reflect on/with my inquiry process into the future of work, I can sense my taste as affirmative ethics (Braidotti, 2013, 2019), and the emerging concept, generativity (Nicolaides, 2015; 2022). Taste always intervenes works in the background when exploring the literature, designing the nudge experiment, interviewing the participants, reading my empirical data, and writing my studies. I could not give up this inquiry, despite some internalized fear and hesitation about talking about concepts that do not bear a resemblance to those within the dominant paradigms of adult learning such as constructionism and interpretivism. I can still sense the taste of the power not to give up throughout my inquiry process. Through thinking through Science and Technology studies (STS)— critical algorithm studies—I could not resist the taste and sensation for affirmative ethics embedded in those studies. Through reading the writings of different philosophers on the future of work (Stiegler, 2016; Braidotti, 2019), I naturally threw myself into the force field, daring to imagine a transdisciplinary work that focuses on the real-world problem (Marenko, 2021). Through

experimenting with the inquiry in the context of manufacturing engineering, my taste for affirmative ethics and generativity became unsatiable. Reading the data, was more sensation than interpretation, I felt data speak to me, such as multistability (Ihde, 1990; Verbeek, 2008), and desire (Deleuze & Guattari, 1987).

One major finding from my experimentation with a taste for affirmative ethics and generativity, is that some participants, particularly those with the inquiry-based learning intervention showed attentiveness to the sensorial contact with the nudge device. Their attention to the sensorial contact that emerged as they encountered the device nudged them into working faster broadens their perception toward the role of nudge. It was neither negative nor positive. The subtlety of their response, in comparison to other comparably extreme reactions shown by other participants with different ways of knowing (i.e., lecture-based), or no intervention at all, implies how a different way of knowing facilitated students' endurance at the threshold of the experience of human and more than human intra-action, intensified the socio-technical complexity. Their attentiveness to the sensorial experience of technological artifacts (the nudge device) opened up a space where they could stay in-between, not immediately interpreting their experience of sensorial contact with a nudge using pre-existing cultural code (Verbeek, 2008). Such an *a*temporal experience makes them pause and think, not only with the human actors (i.e., other participants) within the scene but also with the non-human actors (i.e., technological nudge). The participants were held by the scaffolding of the inquiry process into their nudge experience revealed their endurance in muddling through the sensations to work with the technological device.

Curious was the finding that participants were not only nudged by the technological device but also through interactions with human actors in the scene, in addition to the hidden

power of the culture of engineering. The culture of engineering, that espouses the value of rational thinking, shapes their thinking throughout the nudge experiment. Their common goal is to create products without any variation. The co-generated work rhythm within the team modulated the ways in which participants engage in their work process. Participants commonly indicated how they stayed attentive to their sense of the pace of work felt through the nudge but also through other concerning artifacts such as the waiting table. Waiting hands of other participants was also another common setting where the participants sensed the pace of work. Some exhibited collaborative gestures towards other participants within their team, while others mentioned how stressed they felt throughout the process. Through the inductive coding of the individual interviews, engineering rationality that privileges the instrumental utility of knowledge and practice for the utmost efficiency (Picon, 2004), shaped participants' perspective towards the nudge experience. Engineering culture modulates the undergraduate and graduate engineering students' perception of their professional identity. However, still, the sprouting movement for different engineering is also crystallized through some interviewees' words.

The empirical evidence from the nudge experiment signals different sensations of nudge opening up and closing the "doorway" at the threshold of experiencing socio-technical complexity (Nicolaides, 2015, p. 193). The sensation of nudge possesses multiplicity in that for some participants, nudging connotates a negative reinforcement or punitive action toward their poor performance, while others perceive nudge as a neutral signal that they can refer to in understanding the pace they created. The encounter with different kinds of nudges—be it technological, or human—situates participants to sense the nudge. There were those participants who reported to have a more nuanced sensation of nudge, these participants tended to be attentive to the material, sensorial contact with the nudge. Their attentiveness created a space

from the instinct to remain in control of the complexity. Such a space became an *a*temproal moment where they could remain in the present moment of experience. Such attentiveness is most prominent for the participants who were given an inquiry-based learning activity where collective meaning-making of different human-technology relationships described in the Sci-Fi movies created conditions for different possibilities to emerge in the context of the experiment itself. Nudging in the direction of co-inquiry into the human-non-human relationship was amplified through generative knowing process. Participants felt the threshold at the edge of complexity where the unknown, indeterminate, complex nature of the human-artificial intelligence relationship, often saying "I do not know." Their muddle through the unknown signals the little pinhole through which different engineering practices can be braided, creating different force fields for engineers which are not modulated by reason, or rational thinking but by other ways of knowing.

Different ways of knowing that become generative, is an elusive phenomenon, fleeting and flighting in the braid that emerged throughout this study. Like smoke, it is my momentary response up against the differences that I observed, sketched, mapped, and captured through the nudge experiment and throughout the entirety of the inquiry process into the future of work. It is my response, which stems from my momentary belief (Pelias, 2007) in the pursuit of affirmative ethics (Braidotti, 2019), the positive variation that the relentless flow of desire produces (Deleuze & Guattari, 1987). As I cultivate my trust for taste, I could not deny how frequently I questioned the meaning of my inquiry—whether it is worthwhile or if it is another way of gratifying my desire to see difference and produce research publications as a way to sustain my research identities and practices (Gale & Wyatt, 2019). Trusting the positive undertone of desire raises doubts in me as it sounds naïve; desire is not smart, wise, or agentic (Tuck, 2010, p. 636).

In this moment, I draw upon my courage, and want to claim that education has the greatest power in the practice of "constructing social horizons of hope" (Braidotti, 2019, p. 156). Is it wrong to be naïve, throwing oneself into having faith in the power of inquiry? Is it wrong to relentlessly serve for creating a difference through a commitment in the affirmative power of education when I sense a subtle difference from experimenting with the inquiry? Is it wrong to trust one's taste for affirmative ethics, to trust its potential for difference in thinking through the future of work as the data spoke to me? Everything will start from the reverberation that my force field generated.

CHAPTER 6

CONTRIBUTION OF STUDY

In this study, I experimented with a different way of knowing that facilitates inquiry into the experience of human-machine interaction. This experience was simulated in a manufacturing assembly line lab with undergraduate and graduate engineering students. I designed a space for learning that promotes the free exchange of ideas by showing fictitious illustrations of human-machine interaction using science-fiction movies, followed by the actualized experience of human-machine interaction. The dialogic space about human-machine interaction was constructed after participants had a simulated experience of collaborating with artificial intelligence. In this orchestrated space, I tested how receptive and attentive young adult learners are in response to the unknown sensation of artificial intelligence. What emerged was the participants' responsiveness and attentive recognition of material conditions in learning from the experience of nudge. Participants from the inquiry-based learning intervention showed a noticeable difference in attending to the material sensation of nudges compared to the other two groups. Participants who experienced the lecture-based learning intervention grasped the sensation of the nudge device only through a semiotic interpretation. In the absence of learning intervention, participants did not produce any nuanced understanding of nudging.

This finding alludes to how inquiry opened up the possibility for young adult learners to undergo the experience of the unknown in relation to artificial intelligence represented by the nudge device. Their sense-making of artificial intelligence diverged through the collective

meaning-making on the sensorial contact with the nudge device. Sensorial contact with the nudge device—noticing what kind of sounds or buzz they felt and describing how the technology is presented to them—granted an *a*temporal space for young adult learners first to appreciate the bodily sensation and move on to question what it signifies to them. They did not hastily prescribe any meanings to nudging. Instead, the attentiveness to the materiality of the nudge device was a starting point for them to trace the entangled and nuanced relationship between them and the nudge device and imagine what it would mean to identify and work with artificial intelligence. What students encountered through the sensorial attention was different arrangements of human actions and experiences that artificial intelligence nudges to create. Emergent was the socio-technical perspectives in discussing their experience of getting nudged through multiplying aesthetics of technological artifacts and questioning the cascading effects of constructing a world that will be different, provoking ethical issues of trust, fairness, or justice. The conceptions of artificial intelligence multiplied through their bouncing off the idea of each one's material attentiveness to the nudge device. Invisible from the groups with inquiry-based learning intervention was the perfunctory reflection on the experience with the device or the artificial intelligence. Inquiry, in this regard, served as a way to proliferate perceptions towards nudges, potentially unlatching young adult learners' imagination and leading them to think through human-machine interaction.

My experimentation is significant in several ways. First, I tested out an enactivist approach to experiential learning in the context of engineering education. How learning is produced through the continuous relations emerging out of a complex system is theoretically discussed and encouraged (Fenwick, 2001, 2016; Fenwick & Tennant, 2004; Lange, 2009, 2018), yet few experiments have been conducted to explore this idea. My study experiments with

the construction of a "learning sanctuary" (Lange, 2009, p. 194) which deliberately engages young adult learners to acknowledge their relations with the technological artifact (i.e., nudge device) and liberate their imagination of its role. Attending to the sensorial contact with the nudge device (i.e., mechanical sensation of buzz) opened young adult learners' cognition of artificial intelligence in a malleable way leading them to question the socially constructed imagination of artificial intelligence. The malleable cognition multiplied their perceptions of technology, enabling them to imagine different roles of nudge and freeing their imagination of technology (Verbeek, 2005). The nuances of human technological interactions are unlocked through their inquiry into their own experience of this relatedness. The inquiry invited non-human actors (i.e., technological devices) into perception opening up a portal to map the subtle particularities of the complex context (Fenwick, 2001).

Second, my study surfaces a different vision of engineering practices and creative becoming(s) in the field of engineering. Several participants in the follow-up interviews explicitly mentioned different engineering practices (i.e., reflexive engineering and ethical engineering) as a way of not conforming to the engineering rationality that upholds the ever-pursuit of efficiency and effectiveness in practicing engineering (Picon, 2004). They sought different meanings of performing their profession or, in one participant's comment, the 'hippie' way of imagining engineering. The sensed hesitation through the description of thinking differently about engineering practice as a hippie yet also signaled the igniting desire to seek a non-conformist way to practice engineering in response to the prevalence of technocratic culture in business when they solicited for more "philosophers," "ethical engineering," or "questioning if the engineers should do it" in the field. Inquiry in the context of engineering education may catalyze what the participant refers to as hippies or different ways of performing their

engineering identity. This hint of difference in engineering practice may hardly exert any agentic power in changing the obdurate culture of an engineering school (Tonso, 2006). I would like to argue, in the lineage of Deleuze and Guattari, that creative becoming(s) is possible through different ways of knowing. The bottom-up yet subtle solicitation for the difference in engineering practice signals a molecular movement that escapes the easily represented and palpable mass of engineering culture—or what is referred to as engineering rationality in the field. Molecular movement "thwart and break through the great worldwide organization." (Deleuze & Guattari, 1980/1987, p. 216). It is easily imperceptible, overlooked by the dominant discourse, and thus inherently minoritarian. It still possesses the power to create a difference in the sedimented organization, which is, in my study, engineering rationality. In this respect, learning may serve to cultivate learners' orientation to make different worlds and generate creative becoming(s) (Nicolaides, 2022) in the context of engineering culture. It is necessary to offer a safe, dialogic space for young adult learners to freely share their ideas of different engineering practices and prevent them from feeling hesitant to deviate from dominant discourse and be seen as others.

Third, my study philosophizes learning in the future of work context. The fear of not performing well enough is accentuated in the inevitable collaboration with the ever-evolving computational intelligence in the future of work context (Acemoglu & Restrepo, 2019; Brynjolfsson & McAfee, 2014; Morgan, 2019; Yorks, Rotatori, Sung & Justice, 2020). Positioning learning as a continuous skill acquisition accelerates the exhaustion of the workforce, espousing more values on "the composition of a more performative and enhanced pan-humanity" (Braidotti, 2019, p. 44). Approaching the state of exhaustion affirmatively (Braidotti, 2019) or through affirmative ethics is one of the grounding premises of my study. Thus, I reconfigured

learning that embraces the complexity behind the shifting relationship between workers and working conditions, humans and technology (Nicolaides, 2022). My study shows through experimentation how learning gears towards affirmation of human-non-human intra-action in resistance to the reducible, deterministic understanding of the human-technology relationship (i.e., Ihde, 1990; Verbeek, 2005; Barad, 2007).

I suggest that educative practice which enhances attentiveness to the entangled human-technology intra-action, liberates young adult learners' imagination of performing engineering identity and produces a difference in a way that multiplies the aesthetics of human labor in the future of work. Different visions of how technology conditions working conditions and human life imbue noetic creativity in reimagining the future of work that has been solicited against the accelerated decadence of 24/7 capitalism wherein computational intelligence short-circuits human's theoretical thinking (Stiegler, 2015) and human life subtly becomes subject to the capitalist appropriation (Lazzarato, 1996; 2004). Constructing the educative space for future engineers that facilitates inquiry into human-machine interaction reconfigures learning to construct the horizon of hope in the future of work by enabling them to give texture to their experience of working with technology and enabling different imaginations of performing engineering profession and designing the socio-material structure. With educators' mindfulness of and attentiveness to the minoritarian voices that have the potential for thwarting the dominant engineering rationality, reconfiguration of learning for affirmative ethics will open up a portal to create a difference in engineering culture through encouraging generative becoming(s).

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APPENDIX

Appendix 1.

Survey questionnaire – Identity Capital Theory Measurement (Cote, Mizokami et al., 2016)

Self-esteem (two point scale: unlike me vs like me)

1. I am a lot fun to be with
2. I'm popular with persons my own age
3. People usually follow my ideas
4. I'm not as nice looking as most people*
5. Most people are better liked than I am *

Purpose in life (Seven point scale; neutral – center anchor)

1. I am usually completed bored… exuberant and enthusiastic
2. Life to me seems always exciting … completely routine *
3. Every day is constantly new and different … exactly the same *
4. My life is empty, filled only with despair … running over with exciting good things
5. I am a very irresponsible person … very responsible person.

Locus of control (6-point scale from strongly agree to strongly disagree, no neutral response)

1. Becoming a success is a matter of hard work. Lucky breaks have little or nothing to do with it.
2. When I make plans, I am almost certain that I can make them work.
3. There is a direct connection between how hard I study and the grades I get.
4. It is impossible for me to believe that chance or luck plays an important role in my life.
5. What happens to me is my own doing.

Ego strength (5-point scale from completely false to completely true, with an intermediate response of partly true and partly false)

1. I enjoy difficult and challenging situations.
2. I have a lot of will power.
3. I am able to concentrate better than most people under distracting conditions.
4. I can bear physical discomfort better than most.
5. When I have a job to do, I am not easily distracted.

*Reverse coding items

Appendix 2.

Human-machine interaction interdependence measurement

For each item, please think of the situation and indicate how strongly you agree or disagree with how the statement describes that situation. In each item, "the other" refers to the person(s) in the situation. (1=completely disagree, 2=slightly disagree, 3=neither agree or disagree, 4=slightly agree, 5=completely agree)

Mutual dependence

1. Each person's actions only affect their own outcomes, not the other's outcomes
2. What each of us does in this situation affects the other
3. Whatever each of us does in this situation our actions will not affect the other's outcomes*
4. We need each other to get our best outcome in this situation
5. Each person's outcomes are not influenced by what the other does*
6. Each person's outcomes depend on the behavior of the other

Informational certainty

1. The other does not understand how his/her actions affect me*
2. We both know how our behavior affects each other's outcomes.
3. We both know what the other wants.
4. We both lack knowledge about what the other wants
5. I don't think the other knows what I want*
6. Each person is informed about the other's preferred outcomes.

*Reverse coding items

Appendix 3-1.

Focus Group Interview Protocols

Interview Guide

[GREETINGS and THANK YOU for agreeing to participate]

[REVIEW purpose and scope of study and the general plan for the interview]

[EXPLAIN confidentiality, SIGN consent forms, and ANSWER questions about the forms or the study]

[ASK participant if they AGREE to be audio recorded, BEGIN recording once participant agrees]

[COLLECT basic demographic data]

[BEGIN interview]

Background

I am trying to learn more about your experience of being nudged by the technological intrusion during your assignment. I would like to ask you some questions about a few of your most significant experiences related to this problem. I would also like to ask you about how you interpreted these experiences, and finally what happened.

Shall we begin?

CRITICAL INCIDENTS

Prompt: Think about a time when <u>nudged.</u>

- How would you describe this experience?
- What came to your mind in reflecting back of those moments?
- What kind of role does the nudge play in your understanding of the workflow created?
- How do you understand your role in the collaboration?

FINAL QUESTION

In light of what you have now talked about, is there anything else you would like to tell me (or you think that I should know) about this problem?

[WRAP-UP and ANSWER any participant questions]

[THANK YOU so much again for agreeing to participate. Please do not hesitate to contact me should you have any questions]

[SPEAK into the recorder: "This ends the current interview" and STOP recorder]

Appendix 3-2.

Individual Interview Questions

1. Can you please tell me which major you are in, and which special area you are focusing as a (under)graduate student in engineering?
2. Please take some time to reflect back on your choice of major.
    1. What makes you become aware of your major?
    2. What motivates you to gain interest in your major?
    3. Who do you identify the most influential figure in your choice of major? (i.e., parents, family members, friends, high school teacher, any events that affected your decision-making etc.)
    4. What is your present thought of choosing mechanical engineering as your major?
3. Please take your time and describe your professional goal in one word.
    1. Why do you think of the word?
    2. What kind of strategies, or any action plans you have employed to achieve your professional goal?
    3. If anyone asks you how you access yourself as of now, in the process of achieving your professional goal, how would you answer the question?
    4. How do you think of the technological development that is happening and is about to happen in the practice, in achieving your professional goal?
4. Would the contextual changes hinder, support or both hinder and support your response to the upcoming future?
    1. What kind of habits, mindset, and capacities do you think are necessary to be responsive to the complexity emerging in the name of industry 4.0, digital transformation, or the fourth industrial revolution?

Appendix 4-1.

Focus Group Interview Consent Form

CONSENT FORM

You are invited to participate in this study because of your interest and involvement in the field of manufacturing engineering. The purpose of this study is to explore the behavioral, cognitive, and emotional effects, if any, of the experienced nudge during a collaborative manufacturing process. A nudge refers to guidance provided by the technological device in the form of audio, haptics, or visual. As such, each of you will be given a device that is designed to give this kind of nudge.

The study will take about 90-120 minutes. If you agree to participate in this study, you will participate in:

- Pre-experiment learning activity (40 minutes)
- A simple manufacturing process to assemble a handheld device (30 minutes)
- Post-experiment Focus Group interview (40 minutes)

Before the experiment, you will be asked to respond to the survey items. This will take no more than 10 minutes. You will be guided to participate in a learning activity that is designed to facilitate your thinking through the nudge experience, which will take 30 to 40 minutes. After the pre-experiment learning activity, you will participate in the simple manufacturing process, followed by the focus-group interview. The focus group interview will take the form of a semi-structured conversation that will help you recall and reframe the significant moment of your nudge experience. Your interview responses will be transcribed and analyzed to assess your reframing of the significant moment. We would like to understand how <u>you</u> think about nudges and make sense of <u>your</u> own nudge experience through the research.

Risks and discomforts
Risks and discomforts from participating in this evaluation are expected to be minimal.

Benefits
There are no personal benefits to you for participating in this evaluation. It is hoped that this pilot study will provide useful information to the researchers about any factors affecting the design of the main experiment.

Incentives for participation
There are no incentives for participating in this evaluation.

Audio/Video Recording
In order to accurately capture your responses, your interviews will be audio-recorded and transcribed. These are needed for overall analysis. A pseudonym (i.e., fake name) will be created for you, and all transcriptions and other personal documents will not identify you by your actual name. The recordings and transcriptions will be kept on a private computer, in password-protected files throughout the duration of the evaluation and up to 5 years after the completion of the evaluation. Once this time has passed, the files will be destroyed.

Privacy/Confidentiality
All information (or data) collected for this evaluation will be de-identified, meaning your real name will not be used. Your individual interview responses will not be shared with anyone other than the transcriptionist and the contracted researchers. The researchers will not share identifiable results of the evaluation with

anyone other than individuals working on the project without your written consent. Results will generally be presented in the aggregate and as general themes (i.e., with all responses combined). Any use of your individual data will be limited and de-identified.

Taking part is voluntary

Your involvement in the pilot study is voluntary, and you may choose not to participate or to stop at any time, including before the evaluation begins.

If you decide to stop or withdraw from the evaluation, the information/data collected from or about you up to the point of your withdrawal will be kept as part of the study and may continue to be analyzed.

Your signature below indicates that you have read this entire document and have had all of your questions answered. To voluntarily agree to take part in this pilot study, and indicate that you understand and are in agreement with this consent form, sign on the line below.

_____	_____	_____
Name of Participant	Signature	Date

results of the evaluation with anyone other than individuals working on the project without your written consent. Results will generally be presented in the aggregate and as general themes (i.e., with all responses combined). Any use of your individual data will be limited and de-identified.

Appendix 4-2.

Individual Interview Consent Form

Dear Participant

You are invited to participate in this study because of your involvement in the nudge experiment. The purpose of this follow-up individual interview is to hear your stories behind your choice of major of mechanical engineering. This individual interview is a part of nudge experiment, under the guidance of Drs. Aliki Nicolaides & Beshoy Morkos

For this project, you are invited to

- Participate in a virtual interview that will last less than 1 hour,
- Answer the questions generated according to the research question,
- Review the analysis of the interview, if necessary.

For this project, I will

- Conduct an individual interview
- Transcribe and analyze the audio-recorded interview data
- Provide the report of the analysis which can be sent to the participants on their request.

Risks and discomforts
Risks and discomforts from participating in this evaluation are expected to be minimal.

Benefits
There are no personal benefits to you for participating in this evaluation. It is hoped that this pilot study will provide useful information to the researchers about any factors affecting the design of the main experiment.

Incentives for participation
There are no incentives for participating in this evaluation.

Audio/Video Recording
In order to accurately capture your responses, your interviews will be audio-recorded and transcribed. These are needed for overall analysis. A pseudonym (i.e., fake name) will be created for you, and all transcriptions and other personal documents will not identify you by your actual name. The recordings and transcriptions will be kept on a private computer, in password-protected files throughout the duration of the evaluation and up to 5 years after the completion of the evaluation. Once this time has passed, the files will be destroyed.

Privacy/Confidentiality
All information (or data) collected for this evaluation will be de-identified, meaning your real name will not be used. Your individual interview responses will not be shared with anyone other than the transcriptionist and the contracted researchers. The researchers will not share identifiable results of the evaluation with anyone other than individuals working on the project without your written consent. Results will generally be presented in the aggregate and as general themes (i.e., with all responses combined). Any use of your individual data will be limited and de-identified.

Taking part is voluntary
Your involvement in this individual is voluntary, and you may choose not to participate or to stop at any time, including before the evaluation begins. If you decide to stop or withdraw from the evaluation, the information/data collected from or about you up to the point of your withdrawal will be kept as part of the study and may continue to be analyzed. Your signature below indicates that you have read this entire document and

have had all of your questions answered. To voluntarily agree to take part in this pilot study, and indicate that you understand and are in agreement with this consent form, sign on the line below.

_____	_____	_____
Name of Participant	Signature	Date