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# Asymmetrical Innovation; AI as educational disruptor or as ethical-ecological tinderbox?

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## Abstract

Artificial intelligence (AI), in particular generative AI, which has emerged in the 2020's, promises to significantly disrupt across education and society. AI is truly transformative across virtually every aspect of society; medicine, manufacturing, military applications, media, and in the nature and world of work. It also challenges traditional modes of education, and the important activity of assessment, in particular continuous assessment.

While AI can undoubtedly deliver societal good on a number of levels and for specific applications, this paper seeks to take a step back and look at the bigger picture, including the trajectory that AI and generative AI is leading society on in its actual use in the context of the metacrisis. It takes a critical approach, and considers possible implications, including ethical implications. It thus questions the value and acritical use of generative AI, in particular in an educational context, while seeking to consider some alternative approaches.

## 1 Introduction

Artificial Intelligence has been conceptualised by a key goal in the development of the computer by its key architect, Alan Turing, who in 1947 proposed to the London Mathematical Society that '*what we want is a machine that can learn from experience*' (Press, 2017). Ironically, Turing's work on the development of the computer and its conceptual notional twin, what became known as the Turing machine ('*there can be no [such] machine*', (Turing, 1936)), and hence the problem of machine undecidability, and what became known as the 'halting problem' (Davis, 1958), was merely a concretization of the ground breaking findings of logician Kurt Gödel, whose papers on incompleteness theorems (Gödel, 1931) showed that mathematician's David Hilbert's 1928 *Entscheidungsproblem* (Hilbert, 1928) is in fact, unsolvable. By this work, Gödel had proved that even in pure logic and mathematics, there is no fully closed system; that is, there is always something outside which, while known to be true, cannot be proved. Hence 'unknowingness' or uncertainty is inherent to every system, and truth is not based on logic and reason alone.

This ground breaking finding would suggest that computers and AI, as they are both driven and underpinned by logic, are incapable, as per Gödel's incompleteness and its implications, in accessing truth in all its wholeness, as they rely solely on closed systems of logic, without the additional significant value that is endowed by other sources of truth such as imagination, intuition and common sense (i.e. '*the ultimate embodied skill that is acquired effortlessly through experience*' (McGilchrist, 2021, p.746). Truth is understood here not in the (left hemisphere brain) understanding of being '*certain*' and '*single, timeless and correct*' (McGilchrist, 2021, p. 389), but, while very real and accessible (and thus '*not to be abandoned*', as "*relativist*" versions suggest' (McGilchrist, 2021, p. 388)), is in fact a relational *process* of ongoing

discernment. It is thus *'uncertain not because it is empty but because it is full – rich, complex, manifold'* (McGilchrist, 2021, p. 389). In this context, AI, which has been defined as *'the ability of computers to imitate human cognitive functions such as learning and problem-solving [which] uses math and logic to simulate the reasoning that people use to learn from new information and make decisions'* (Piloto, 2022) can by definition, only be a (very) partial and 'inhuman' intelligence.

In practical, and indeed societal and educational terms, AI came to the fore with the launch of ChatGPT, a generative AI model, in November 2022. Generative AI models are those which have learned to generatively produce text, images, videos or other data based outputs. They are seen as precursors to the ambitious project of the likes of Google (Patel, 2023), Meta (Heath, 2024) and others around achieving Artificial General Intelligence (AGI). AGI is a contested concept, but it is generally understood to involve producing machines with human cognitive abilities (and all the attendant implications and existential risks that this would likely entail). Human cognitive abilities however include those associated with right hemisphere activity (McGilchrist, 2022), such as common sense knowledge and reason to make judgements (wise, pragmatic and balanced) in the context of complexity and uncertainty. Human (right brained) cognitive traits also extend to the use of intuition and imagination, and is grounded in metaphor, as our cognitive foundational basis for understanding and language (Lakoff and Johnson, 1980; McGilchrist, 2009; Byrne 2022). Given its lofty aims, however ascribed, the jury is out on how close the emergence of AGI may be, or if can ever be possible, in particular given the limitations of computers and the essence of human cognition. Indeed, we are not (complicated) machines, as McGilchrist puts it, nor can machines be (complex) organisms, since within organisms, relationships must take precedence over the entities (genes, molecules, etc.) that make them up, whereas (unlike machines) *'the very existence of an organism is from beginning to end, one of unceasing flow of matter and energy'* (McGilchrist, 2022, p. 443)

At any rate, the risks of AI are very substantial. Regardless of computers versus human cognitive abilities, AI risk expert and computer scientist Roman Yampolskiy puts the existential risk ('p(doom)') to humanity of evolving AI and superintelligence to be over 99.99999%, as against *just* 20% for Elon Musk (Tangalakis-Lippert, 2024), while arguing that *'in general, for anyone claiming that the problem of AI control is solvable, the burden of proof is on them. Currently, it appears that our ability to produce intelligent software far outstrips our ability to control or even verify it.'* (Yampolskiy, 2024). Moreover, *'we believe, considering the stunning advances in AI in recent years, that we are already in the endgame and now is the time for crucial and likely irreversible moves concerning AI ethics, risks and computational frameworks. However, we notice lacking awareness of these issues, exacerbated by the fact that the progress in AI has outpaced the development of critical policies and regulations'* (Ziesche and Yampolskiy, 2025, p.1).

In all the above context, it is pertinent to note that nobody has ever asked humanity collectively or societally if we wish for the developmental trajectory of AI (and its potential existential risks to humanity). Neither is there a societal clamour for, for example, self-drive cars. And like, climate change and its negative impacts, while nobody among eight billion of us would advocate for same, it nevertheless is a project deemed essential and unstoppable for human 'progress', by corporates and governments alike, driven by perverse incentives, for fear of falling behind, the so called 'Moloch Trap'. The 'Moloch trap' (as articulated by Liv Boeree and others (Ritchie, 2024)) is where goals for human well-being and flourishing and (AGI) system goals are misaligned, whereby local actions may appear optimal or rational (e.g. embracing AI so as not to fall behind and/or to gain competitive advantage) but which can have very have negative consequences for all ultimately and globally.

However, regardless of future potential existential threats to humanity (which our graduates may have to engage with in their careers and lives to the end of this century and beyond), there are the current significant ongoing societal threats and challenges that face society, and of course engineers. PwC identified five interconnected megatrends in its September 2024 report (PwC, 2024) *‘Megatrends. Five global shifts reshaping the world we live in.’* These were identified under the labels: climate change, technological disruption, fracturing world, demographic shifts and social instability. The latter, they suggest, is feeding off and negatively impacted by the four others in an iterative manner: *‘Each Megatrend is exacerbating the social challenges the world faces, and the magnitude of the social challenges makes it difficult for societies to come together and fight the negative effects of climate change, technological disruption, demographic shifts, and a fracturing world.’* Moreover, *‘The five megatrends have already and will continue to change the world for many years to come. Each one of them implicates existential questions and has the potential to bring humanity to a tipping point.’* On the ‘technological disruption’ megatrend, there are five major implications identified for individuals, only one of which is positive (i.e. significant capacity enhancement), while the others are having negative consequences to vary extents (i.e. massive disruption of work; loss of privacy; increasing disinformation, misinformation and fraud; and growing mental health issues (involving in particular harmful effects on brain health.)). The authors make some observations on unintended (if not unforeseen) consequences of technological disruption: *‘there generally isn’t sufficient consideration of the unintended consequences of technology in the design process, and, given the ubiquitous nature of technology, those unintended consequences are likely to happen quickly, be more severe, and affect more people. Without intense focus on preempting those unintended consequences before they appear, there is great potential for negative implications of technology to outweigh positive ones.’* Overall, the report delivers a clear eyed, if disturbing conclusion: *‘There is no equivocating: Humanity is in a race against time.’* (PwC, 2024).

## **2 It’s here; Get with it!?**

Despite the aforementioned expert warnings, the largely acritical embrace of generative AI across society and education might cause one to just go with the flow and adopt, engage with and apply available technologies as educators and students best see fit. The general trust here is that just like to development of writing, the printing press, mass education, the internet, the smartphone, the cloud and so on, this represents technological advance, which can’t (and at any rate, likely perhaps shouldn’t?) be stopped, so we should just get on and embrace it, especially if it serves to promote the aforementioned capacity enhancement (e.g. doing things faster and more efficiently requiring far less time and human brain power). This however, is to neglect the ‘tipping point’ nature of the trend and the increasingly shorter ‘ $\Delta t$ ’ at play with ever quickening technological progress, and with it the increasing inability to keep up, not just in the regulatory field, as outlined above, but in terms of examining the ethical consequences, as ‘unintended consequences’ likely land before us before we have any satisfactory framework, perhaps with irreversible and ultimately existential consequences.

### *2.1 Meaningful climate action; AI or not AI?*

AI and its re-presentation of reality serves to draw us ever away from our connection with nature. The climate and biodiversity crises are symptoms of this separation. AI has accelerated environmental degradation through its negative impacts in terms of massive growth of energy demand, water consumption

(Barratt, 2025) and e-waste (Wang et al. 2024). One convenient narrative, put out by big tech, and supported by many, is that AI development is essential as a means of actually mitigating against climate change and indeed helps reduce carbon emissions. In its sustainability report 2024, Google suggests that *'According to an estimate from Boston Consulting Group, AI has the potential to help mitigate 5-10% of global GHG emissions by 2023.'*, while quoting Nicholas Stern on a Google Sustainability guest post article: *'the world has in its hands the potential to apply artificial intelligence (AI) and machine learning (ML) to drive forward the net zero transition and give us a chance to stay within 1.5°C.'* (Stern, 2024) The role of Google Sustainability, it claims, involves *'boldly accelerating AI for climate action while responsibly managing its environmental impact'*. (Stern, 2024). Despite a commitment *'to reach net zero emissions across all of our operations and value chain by 2030'* (Google, 2024, p30) and to *'reduce 50% of our combined Scope 1, 2 (market-based), and 3 absolute GHG emissions'* (Google, 2024, p.31), they actually report emissions firmly trending in the opposite direction: *'In 2023, our total GHG emissions were 14.3 million tCO<sub>2</sub>e, representing a 13% year-over-year increase and a 48% increase compared to our 2019 target base year.'* (Google, 2024, p30). Addressing this discrepancy, Google cite AI and associated data centre development, as if that were something beyond its control, especially *'as we further integrate AI into our products'* (Google, 2024, p30). Thus *'reaching net-zero emissions by 2030 is an extremely ambitious goal and we know it won't be easy ..[it] will require us to navigate significant uncertainty - the uncertainty around the future environmental impact of AI, which is complex and difficult to predict.'* (Google, 2024, p30). The report also leans in on policy makers, exhorting them to promote *'environmentally responsible AI deployment'* (Google, 2024, p.13) while exhorting the EU to support *'a fundamental enabling framework that fosters the general uptake of AI solutions'*, and its policymakers to *'focus on encouraging deployment of [AI] solutions that support the EU's climate goals.'* (Google, 2025). Meanwhile, in the educational sphere in the US, Google offer college students *'the best of Google AI — and 2 TB storage — for free'* (Google, 2025a). 2 TB of data storage is estimated to come out at 200 KW hr, for reference (Saftie, 2024). Meta meanwhile, reported a 107% increase in its scope 3 total greenhouse gas emissions (CO<sub>2</sub>e) over the three years to 2022 (Meta, 2023).

In the context of the reported substantial increases in energy and water consumption, it is instructive to seek out Google's cited 5-10% reduction claim. It transpires that this emanates from a co-published BCG and Google Report entitled *'Accelerating Climate Action with AI'*, published on Google Sustainability (Dannouni et al, 2023). This in turn, in a rather circular manner, cites an earlier 2021 BCG article which, without any proposed methodology or supporting evidence, merely postulates that *'In our experience with clients, using AI can achieve overall emissions reductions of 5% to 10% — the equivalent of 2.6 to 5.3 gigatons of CO<sub>2</sub>e if AI were applied to all emissions.'* (Degot et al., 2021). Meanwhile, though it is the most significant and expanding factor in AI's emissions footprint, the increased projected emissions associated with end users of generative AI, and adoption and usage is deemed in the report to be *'unknown'* (Dannouni et al, 2023).

Others appear unconvinced of big tech's proposed narrative. The ECB report that median energy consumption of the 'magnificent seven; of the biggest US tech companies rose by 7% in 2023, while the energy consumption of data centre firms rose by 19% in one year (Burian and Stalla-Bourdillon, 2025). Most soberingly, by the WEF, it has been estimated that the computational power required for sustaining AI's rise is doubling every 100 days (Ammanath, 2024). Ireland has been an early exemplar of the power hungry nature of data centres, even before the emergence of generative AI. Some 16% of all electrical energy demand in the Republic of Ireland was due to data centres in 2022, and this is expected to rise to 30% of demand by 2032 (Eirgrid SONI, 2024), while in the period 2017-2023, new data centre energy

demand equalled all excess wind energy production in Ireland (Daly, 2024). This voracious appetite for energy is driving a resurgence in nuclear power use, in particular across the USA, such as the plans to restart the plans to restart the Three Mile Island nuclear plant following a power supply contract with Microsoft in September 2024 (IEA, 2025). Energy growth (even if it is 100% renewable) is not a free lunch without consequences; the second law of thermodynamics dictates that energy use results in entropy increase, which as Wessels has elegantly shown, is congruent with environmental degradation (Wessels, 2006). Moreover, a small percentage consistent levels of growth in energy dissipation leads to a phenomenon of ‘global heating’; i.e. an average global temperature of several degrees over time (a couple of centuries), as the earth is unable to radiate the amount of heat produced quickly enough (Chaisson, 2008).

While big tech firms are extremely reluctant to provide relevant and transparent data on energy consumption (Chen, 2025), AI researcher Anne-Laure Ligozat provides a cutting analysis; Fellow AI researcher Alex De Vries agrees, arguing ultimately that his *‘main argument is that AI should be used sparingly.’* (Ligozat and De Vries, 2024), while suggesting there is an imperative on developers to *‘critically consider the necessity of using AI in the first place, as it is unlikely that all applications will benefit from AI or that the benefits will always outweigh the costs.’* A single query on ChatGPT3 uses roughly ten times more energy than a typical Google search (De Vries, 2023), while generated images and video generate over three orders of magnitude more equivalent carbon emissions than text classification (Sasha Luccioni et al., 2023), who conclude in the context of generative AI searches, that *‘we do not see convincing evidence for the necessity of their deployment in contexts where tasks are well-defined, for instance web search and navigation, given these models’ energy requirements’.*

Like any technology, AI is used for a range of purposes and ends; for example, apart from more potentially benign uses, it finds use to support a ramp up of oil production capacity, and for targeting individualised adverts to boost consumption of all sorts of stuff, such as fast fashion, through extended globalised supply chains (Coleman, 2023).

The social and environmental impacts of a seemingly unstoppable technological advance are all tied together in the deeply interconnected ‘polycrisis’, a term now commonly used (Tooze, 2002; WEF, 2023), and as coined by Edgar Morin at the turn of the century: *‘There is no single vital problem, but many vital problems, and it is this complex intersolidarity of problems, antagonisms, crises, uncontrolled processes, and the general crisis of the planet that constitutes the number one vital problem’* (Morin and Kern, 1999, p.74). It also feeds into its relation, the ‘metacrisis’, a crisis of *meaning* in the context of the polycrisis which *‘impacts on our ability to live meaningful lives’* by impacting on *‘the social dynamics and affective experience of crisis’*. (Damiani, 2023)

## *2.2 Hyper concentration of wealth and power*

The socio-economic impacts of AI and political implications are a real concern of those who study its effects, in particular how it supports increasing concentration of wealth and power at the expense of marginalised in society. Leavy et al. (2020) consider bias in AI, and advise that it has the potential to exacerbate societal bias and set back decades of advances in equal rights and civil liberty. Notwithstanding the unprecedented wealth and associated political power that the ‘tech bros’ have quite rapidly accumulated this century, it has been postulated that the further progress of AI may be accompanied by either *‘massive increases in human inequality’*, and/or perhaps a *‘return of Malthus’*, whereby *‘humans will lose the Malthusian race in the long run’* to AI as *‘AI entities, living for themselves, absorb*

(i.e. “consume”) more and more of our resources. Eventually, this may force humans to cut back on their consumption to the point where their real income is so low that they decline in numbers.’ (Korinek and Stiglitz, 2017). Danaher (2024) considers the impact of AI on equality norms, whereby AI risks disrupting norms both around equality of opportunity and outcomes. This has implications for education and assessment; recent work is cited (Choi and Schwarz, 2024) which reported that in evaluating legal reasoning skills among some US Law students, the use of generative AI benefitted less able students more than skilled ones, while similar findings were made among the value to experts and non-expert writers in producing ad copy (Chen and Chan, 2023).

### *2.3 Becoming better humans (McGilchrist)*

Neuroscientist Iain McGilchrist’s seminal work (McGilchrist, 2009; 2021) on the hemispherical differences between both sides of the brain is instructive in informing sustainability narratives (Ehrenfeld, 2019, Byrne, 2022), and ultimately on the dangers posed by the increasing dominance of the left brain across society and its tendencies for breaking down (reductionism) and mapping out (abstraction) in the service of seeking control and power while promoting increasingly individualistic and narcissistic tendencies with are cut off from nature. This is a critique of the ‘machine metaphor’ over one of ‘ever becoming flow’. McGilchrist contends that *‘the opposite of life is not death – it is the machine – so focus your energies there!’* (McGilchrist, 2024a). He goes on: *‘We don’t need to be more machine like. We need to be better humans, and none of that [AI] will help us become better humans.. ..I think AI is like putting machine guns in the hands of toddlers, because in order to use it properly we need to have wisdom, and wisdom is plummeting at the same time that power is growing. So it is a servant or a tyrant. Well its always presented as your servant, but I might point out that any harmful innovation you like to name was, without exception, presented as for your benefit.* (McGilchrist, 2024).

## **3 Implications for Engineering Education?**

So what has all this to do with Engineering Education or EESD? Well if we accept that the *‘generative AI revolution’* (Ligosat and De Vries, 2024) represents a pivotal moment in the history of humanity and our engagement with technology, with potentially existential impacts, or at least in a way which seriously threatens human wealth distribution, power, and democracy, then it has to have something to same to both engineering and the education of engineers. Given that the latest technological revolution is implicated in the polycrisis and metacrisis, including around our unsustainable societal construct, it certainly has significant import for EESD.

This poses profound questions if one fails to see how AI can be ethically engaged with or promoted for most routine learning tasks, and whose rapid development and hubristic rollout (without any serious debate on its merits or otherwise) seems to be injurious to any sort of genuine rapprochement between ourselves and nature. Given the profound and rapid changes that generative AI have been bringing, as universities and institutions grapple with this emerging ‘revolution’, it is unsurprising that I can’t offer any definitive or well developed ideas. However, in the absence of all out embrace (and I must say, I have desisted from knowingly using AI to date), and while knowledgeable that it is nevertheless being increasingly prevalently used by students, staff and institutions, I might propose the following tentative suggestions for EE/EESD, while bearing in mind that these may be more time consuming than (pre-gen AI) popular assessments;

- In EESD/sustainability/engineering ethics fora/modules, explore and engage critically with the topic of AI, promoting student reflection.
- Re-design assessment (in particular continuous assessment) to promote the development and assessment of deep learning – to this end, pivot to in-class face to face presentations (from online generated/uploaded content), viva style exams, verbal debates, design studio exercises, and in-lab workshop style lab reports that students can fill in during labs, over having to generate and submit electronic reports. (indeed move away from elec. reports).
- Maintain closed book examinations as part of the assessment toolbox, where appropriate.
- Discuss and explore with academic peers (and students) on how best to navigate assessment and learning on an increasingly mediated AI world.
- Engage with philosophical and pedagogical questions around the value and nature of education, and to develop a learning environment which can help the development of critical thinking, right hemisphere engagement and human wisdom, all the time seeking concrete and pragmatic interventions in the service of learning and engineering education (/and EESD).

#### **4 Conclusions**

*The research question is about whether it is ethically appropriate to use AI in our teaching considering the energy demand that it would require and potential climate change it would cause. ..I do not think that this research question is relevant for this conference and not for any other education conference either.*

The above quotation represents the views of a reviewer of the abstract for this paper. While this may perhaps be typical of the views of educators, given the largely acritical embrace of generative AI across the education sector, despite some misgivings around potential for cheating and surface learning, etc., nevertheless, I personally feel that it is vitally important that educators critically assess the ethics around the tools and technologies they use, or promote/facilitate/encourage around students, when developing their materials and assessment. This is particularly so in the context of EESD, in particular if educating engineers; engineers with an ethical imperative to help develop flourishing societies who appreciate the importance of a healthy human relationship with the natural world. And if technology, and in particular AI is subverting that relationship and sabotaging sustainability-as-flourishing, and even threatening human wellbeing and potentially human (and other) existence itself, then I would argue that then it is absolutely relevant to a conference on EESD. We live in interesting times! As educators of engineers, and in the context of EESD, we have a particular obligation to facilitate them seeing the bigger picture, as they start on their personal and professional journey in an uncertain 21<sup>st</sup> Century.

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