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Engineers as advocates for Sustainable Development: countering misinformation and the need for Aristotelian Rhetoric

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Abstract

The paper argues that engineers need to take action as advocates for sustainable development, and for spotting and correcting fake news and mis-information. The spread of counter factual information is reviewed and its impact on encouraging denial of globally important issues, such as climate change is highlighted. Strategies for responding and correcting misinformation are presented and the importance of understanding and engaging in persuasive arguments through the application of the ethos, logos and ethos of Aristotelian rhetoric is explored. The paper presents examples of classroom exercises where these concepts are considered and developed with engineering graduate students and concludes by calling for such students to develop a voice as advocates for sustainable development.

1 Introduction

A core skill required by engineers in pursuing a sustainable development agenda is to be able to articulate and convince a wide audience with reasons why much of the engineered products and services of daily life need to be delivered in new ways. Traditionally this would be done by having familiarity with the sheer weight of supporting evidence which points clearly and with scientific consensus to the nature of global problems, such as in relation to anthropogenic climate change. But relying on such substantial evidence bases, coupled with strong communication skills, is now no longer enough in a world of post-truth and misinformation where experts are frequently simply derided (such as the entire UK Environment Agency by senior Government ministers). Increasingly responses to these inconvenient truths are simply dismissed as "fake news" and a chorus of denial.

This is perhaps one of the biggest and most insidious challenges to have arisen since the instigation of the EESD Conference series in 2002. For engineers to articulate sustainable responses to global challenges they need to go beyond just being merely experts about whatever issues they are dealing with but to engage using communication skills that also connect with the emotional and moral qualities of their professional and public audiences. Equipping the next generation of engineering graduates with this skill may prove to be the most important challenge of all. The World Economic Forum has ranked the spread of mis-information online as one of the 10 most significant issues facing the world (WEF, 2013).

In her book "Stop Being Reasonable" Eleanour Gordon-Smith argues people are often unmoved by dispassionate logic, peer-reviewed research and statistics, but in fact are swayed by ego, emotion, self-interest and identity. Therefore if we want our engineering students to succeed in implementing change we have to ditch our idealised, sterile picture of persuasion and be more sensitive to how people behave in real life. In embracing this, further steps can be taken to ensure that future engineering graduates have the necessary skills to go beyond the logos,(the hard science and engineering theoretical framing of issues) but to utilise the ethos and pathos of Aristotelian rhetoric in their arguments, if they are to convince a wider world of the need for change. This involves appealing at a moral and ethical level whilst consciously building trust and credibility as well as using approaches which provoke an emotional response in their audience This paper explores how these concepts can be introduced as essential ingredients in engineering education as it is no longer enough just to be "right".

2. Misinformation in a post truth world

We increasingly live in a world where experts, including those holding an engineering brief, are derided as elitist or untrustworthy if the knowledge and understanding they possess threaten the prejudices of the uninformed. Instead opinions are formed by those who are most influential and vocal on social media. We are already seeing how such mis-information can have devastating consequences where unsubstantiated and thoroughly discredited claims of a link between childhood vaccinations and autism, have resulted in many parents choosing to not immunise their children. This is leading to increases in disease such as measles in the wider population. Thus, an opinion on Twitter becomes the arbiter of behavioural choice

Oxford Dictionaries define "post-truth" as: "relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief". Being misinformed is often conceptualised as believing in incorrect or counterfactual claims. However, Sheufele and Krause (2019) observe: "The line between being misinformed or uniformed – that is simply not knowing – has long been blurry".

There is evidence that the presence of misinformation causes people to stop believing in facts altogether (Lewandawsky et al, 2017). For example McCright et al (2016) found that when accurate information about climate change was "balanced" by an opposing mis-framing of the phenomenon this was able to cancel out valid climate information in the way many perceive the problem. The need to give equal weight to both sides of the argument ("false equivalence") is borne out of the media's traditional need for scrupulous fairness in relation to political debates, but is highly damaging and dangerous when this approach seemingly skews overwhelming scientific consensus.

But misinformation is about much more than simply being misinformed, and this goes to the heart of our ability to take action on Sustainable Development. Even when such misinformation is corrected many continue to have faith in information they know to be false (known as the continued-influence effect (Lewandowsky et al, 2012)). If the correction challenges a person's world view, their belief in false information may even increase (a phenomenon being witnessed daily in the UK over the fractious and divisive Brexit debate). Correction to misinformation only works if this doesn't directly challenge peoples world views, and an explanation is provided why the misinformation was circulated in the first place.

This is closely linked with the notion of confirmation bias which involves favoring information that confirms previously existing beliefs, which can range from regularly buying a newspaper whose editorial pages reflects one's own political leanings to sinister profiling and targeting of information direct to individuals through social media. The latter has allowed people to select their preferred "echo chamber" in which the contents reinforce pre-existing attitudes and biases. These "filter bubbles" allow the creation of custom–designed information environments, reflecting back our own likes and behaviours and the empowering of people to chose their own reality. The dangers this presents (e.g for achieving Sustainable Development) is captured by Lewandowsky et al (2017) who state:
"*Misinformation...implies a blemish on the information landscape – our mirror of reality- that can be cleared up with a suitable corrective disinfectant.....But the post-truth problem is not a blemish on the mirror. The problem is that the mirror is a window into an alternative reality*" .

Such beliefs extend, for example, to President Obama being born in Kenya, climate change being a hoax created by the Chinese, the UN trying to install a World Government, or the US Democratic Party

running child sex trafficking from a Washington pizzeria, (Lewandowsky et al, 2017). Such views are surprisingly mainstream in the USA and not easily undermined by empirical evidence or correction by "elitist" experts.

The response is not to improve how contentious information is better communicated, but to understand the mechanisms and societal contexts by which such misinformation unfolds. The emergence of a post-truth world has been attributed to a decline in social capital (Aldrich & Meyer (2015); growing inequality linked to political polarisation (Andersen & Curtis, 2012); declining trust in science and politically asymmetric credulity (where opposing political views are differently susceptible to misinformation). Generally trust in scientists has been found to be lower among the conservative right than on the liberal left (Hamilton 2015). Dunlop et al (2016) have pointed to the polarisation of the climate debate arising from a sustained effort by conservative think-tanks to cast doubt on the overwhelming scientific consensus that the Earth is warming from anthropogenic greenhouse gas emissions. The denial of climate change is more than just an alternative knowledge claim but an organised process deliberately intended to create uncertainty in the public's mind to justify a continued business as usual approach and to frustrate attempts at mitigation. The technique is not concerned with establishing a coherent alternative explanation of observed phenomenon, but simply to grind down trust in facts and objective science, to the point where facts no longer matter or are not even acknowledged to exist.

The result is facts and objective evidence are trumped by existing beliefs and prejudices. A consequence of this is it is hard for an individual to change what he wants because opposing evidence fails to achieve a purchase (and may simply reinforce what he accepted before). A further factor is that people tend to hold on to views they think are commonly held, irrespective of whether or not this is the case.

One solution proposed to counter these tendencies is to borrow from behavioural economics to "nudge" against the spread of mis-information (Tahler & Sunstein, 2008). Lewandosky et al (2017) suggest "even a few dissenting voices can shift the perceived social norm (i.e the perceived range of acceptable views) thus legitimising opposition and encouraging evidence-based discourse". However some may see advocacy and science/engineering as fundamentally incompatible manifesting a tension between subjective and objective narratives. Thus science/engineering is concerned with objectively observing and describing how the world works, whereas advocacy is rooted in subjective values about how the world ought to be (Kotcher et al (2017). Mitchell, Carew and Clift (2004) contrasted how engineers might switch from being merely narrow technical advocates for often predetermined solutions to honest brokers of technical information, extending beyond the bounds of a technocentric perspective in three ways: moving away from singular prescribed technology, enaging with problem formulation, and considering problems in a wider context. These are critical skills for future engineers who must go beyond being merely "correct" on an issue borne out of a rigorous understanding of the physical sciences but to engage in ways that are more empathetic in communicating solutions that are rooted in rational analysis.

Concern has been expressed that progressively higher levels of advocacy may result in a scientist or engineer's perceived credibility being reduced (Donner 2014). Negative judgements about an engineer's credibility or character if countering misheld views may occur, as it takes less effort to denigrate the individual than to counter-argue the content of the message (Wright, 1973). However. a study by Kotcher et al (2017) found there was no evidence to suggest that the credibility of engineers and scientists engaging in advocacy was compromised.

It should be recognised that misinformation in an individual does not occur in a vacuum, but misperceptions emerge as part of dynamic group interactions, and are shaped by political campaigns and other multi-level forces. A systems approach to understanding the effectiveness of science communication is therefore required (Scheufele & Krause (2019).

McCright and Dunlap (2017) offer a conceptual space of misinformation along two dimensions of realism to constructivism, and formal to informal deliver styles. These are summarised in Table 1:

	Informal Style		
Strong Realism	**Truthiness** Feeling something is true without the need for reasoned argument or rigorously collected and analysed empirical evidence	**Bullshit** The liar cares about the truth and tries to hide it. The Bullshitter doesn't care what they say is try or false, but only cares whether or not their listener is persuaded	Strong Constructivism
	Systemic lies Carefully constructed fabrications or obfuscations intended to protect and promote material or ideological interests with a coherent agenda.	**Shock and Chaos** Misinformation intended to destabilise social relations and societal institutions so that its proponents may consolidate power and force unpopular decisions on a confused or distracted public	
	Formal Style		

Table 1: Key Types of mis-information (adapted from McCright & Dunlap 2017)

Effectively combating misinformation will require an understanding of these different characteristics and dynamics, and in particular how synergies develop between them to have even more complex and unmanageable consequences.

3. Strategies for responding to counter factual thinking

Engineers may fall into the misconception that that public misperceptions arise from a lack of knowledge and that the solution is more information. Engineering students need to appreciate *how* people process information, *how* they modify their existing knowledge and *how* world views affect their ability to think rationally. People are less likely to accept debunking when the initial message is just labelled as wrong rather than countered with new evidence (Chan et al, 2017).

Some see technology has a role in developing algorithmic fact checkers that detect misinformation and raise alerts when information is returned through search engines. However others have argued that many individuals lack evaluation skills and so can't distinguish dated, biased or exploitative sources (Scheuele & Krause, 2019) . The use of fact checkers needs also to be coupled with strategies that tackle an individual's motivation to actively seek out information that prizes accuracy over other merely reinforcing their pre-existing beliefs.

Refuting misinformation involves dealing with complex cognitive processes. The Debunking Handbook (http://sks.to/debunk) proposes that to be effective refutation must focus on core facts rather than the myth to avoid reinforcing misinformation by making it more familiar. Any mention of the myth should be preceded by explicit warnings stating the upcoming information is false, and an alternative explanation should be provided that accounts for why the original misinformation was disseminated in the first place. The strategies are expanded in Table 2:

The Familiarity Effect	**The Overkill Effect**	**The Worldview effect**	**Alternative explanation**
Problem Familiarity increases the chances of accepting information as true (so debunking a myth might actually reinforce it in people's minds)	**Problem** A simple myth is more cognitively attractive than an over complicated correction.	**Problem** For those who are strongly fixed in their views, encountering counter-arguments can cause them to strengthen their views	**Problem** When a myth is corrected a gap is created in a person's mind. To be effective that gap must be filled.
Solution First, focus on the facts that need to be communicated, in the following order: • Core fact emphasised in headline • Core facts reinforced in initial text • Myth • Explaining how the myth misleads	**Solution** Less can be more Generating 3arguments can be more successful in reducing misperceptions than generating 12 arguments which can end up reinforcing the initial misperception • Use simple language, short sentences, clear subheadings • Avoid derogatory comments that alienate people • End on a strong and simple message	**Solution** Outreach should be directed towards the undecided majority rather than the unswayable minority • Couple worldview threatening messages with self affirmation (e.g. by asking people about a time when they felt good as they acted on a value that was important to them) • Frame the information in a less threatening way (e.g. "carbon offset" rather than "climate tax")	**Solution** Provide an alternative explanation for the events covered by the misinformation Explain why the myth was wrong • Expose denial techniques of selective use of information, conspiracy theories and misleading testimony of fake experts • Arouse suspicions by suggesting motives why the myth was promoted • Use an explicit warning ("watch out, you might be misled") • Graphics present evidence better than text

Table 2: Strategies for correcting mis-information (Adapted from the Debunking Handbook 2012)

4. Understanding persuasion

Relying exclusively on an evidence based approach reflects the logos aspects prevalent in traditional engineering discourse, appealing to the rationality and logical integrity of an argument. To be effective in leading change the other aspects of Aristotolean rhetoric, ethos and pathos, need also to be embraced and can add powerful tools in developing the skills of persuasion (Table 3).

Ethos **Focus on the author** **(credibility, trust)**	**Logos** **Focus on the argument** **(consistency, logic, reason)**	**Pathos** **Focus on the audience** **(emotions)**
ETHIcal Integrity Track record Background and Qualifications Peer esteem Morality	*LOGical* Reporting and metrics Statistics and Modelling Theoretical reasoning Impact assessment Supporting references	*EmPATHy* Vivid descriptions Story Telling Legacy
Common pitfalls		
The Entertainers stance: *Too much about me, myself and my style (ethos)*	**The Pedant:** *Ignoring relationships with the audience and depending entirely about statement on the subject*	**The Advertisers stance:** *Undervaluing the subject and overvaluing pure effect*

Table 3: Three aspects of Aristotelian rhetoric

Equally these methods of persuasion can influence perceptions of credibility, the spread of viral stories, and belief in factual unsound statements (Haythorn, 2019). Together they can be used to go beyond conveying detail, but to create meaning. So engineers also need to convince and persuade which may require challenging commonly held viewpoints, asking the listener to accept new ways of thinking about a problem, and convincing the audience that others may be wrong.

4.1 Pathos

Pathos is an appeal for an emotional response in the audience, (typically pleasure or fear). For some this is uncomfortable and may be shunned as unscientific or misleading. But when faced with the need for a quick decision, arguments which elicit emotion such as fear are frequently adopted to drive choice. In responding to a new transport initiative, an individual may initially respond positively because it could relieve some daily stress they experience in their own travel arrangements, but after more consideration they may come to see it as negative because of fears over the destruction of some valued pat of their environment. A problem arises if decisions are based on this response alone, i.e. in the absence of logos and pathos. This can be seen in the anti-vaccination movement (refereed to earlier) which has no proven rational basis but which is becoming responsible for the re-emergence of preventable diseases. Such a response is based solely on an irrational fear of creating autism in children.

4.2 Logos

Logos appeals to logic, as represented in numerical analysis, rational solutions and statistical significance.

But this can be open to mis-interpretation, for example when we confuse correlation between variables as explanatory causation of a problem. This is illustrated when concluding that because of high frequency of firefighters observed at building fires, they are responsible for the event. Again used in isolation (without pathos) seemingly logical solutions may be seen as immoral. Decisions reached in isolation of emotional responses, coldly through rational objectivity, should be avoided without reference to ethics and moral conduct. Therefore choices guided entirely by logos can be as bad as those driven by pathos.

4.3. Ethos

Ethos can be defined as the disposition, character, or fundamental values peculiar to a specific person, people, corporation, culture, or movement. It is perhaps a more complex concept than logos or pathos, and Aristotle split the idea into three parts:

- *phronesis*– useful skills, experience & wisdom (good sense)
- *arete* – virtue, goodwill, (good character)
- *eunoia*– convincing the audience of one's knowledge and intentions (goodwill)

Ethos is vital to a sound argument with only 3 reasons for unsound arguments to exist:

i) the speaker is wrong due to a lack of good sense
ii) the speaker is lying due to lack of moral character
iii) the speaker is silent because they don't care if the audience hears good advice

It is important to understand that unlike pathos and logos, the root of ethos comes from outside the argument itself. That is the audience must know the speaker's experience (good sense) and moral character to avoid falling for unsound advice. Establishing credibility and trust is central to the concept, but this is often hard to judge over the internet and through social media, and the *appearance* of credibility alone isn't enough to judge a speaker as credible.

In seeking to persuade, credibility can be bolstered by using *similitude* (creating a sense of mutual identification using pronouns such as "we" and "us") and deference (signalling respect for others through personal humility

So where can an engineering student turn if emotions cloud our judgment and logic is uncertain? Haythorn (2019) and Varpio (2018) suggest some simple tests which can be applied. After hearing an argument or statement, (whether on-line or in person) consider your own position to the piece, and ask:

"How did it make you feel?"
"Does it confirm what you *want* to be true"
"Do you have any stake in the events at play"

Then consider the logic of the piece and ask:

"Does everything make sense?"
"Do the numbers add up?"
"Do the findings logically connect to support the conclusions being draw?"
"Are there errors in the author's reasoning"
"Does it align with a wider context, or does it seem out of place?

Finally consider the position of the speaker

"Do they have experience with the topic being discussed?"
"Do they have a history of honesty?"
"Do they benefit from your support of the argument?"
"Who crafted the message and to what end?

As an entertaining distraction, Grant (2019) analyses Donald Trump's use of Twitter feeds and campaign speeches to create and sustain fake news, leaning heavily on ethos and pathos, almost to the exclusion of logos. Effective communicators avoid overemphasis on a single appeal, anchoring a presentation in all three (ethos, logos and pathos). Common traps have been identified by Booth (1963) who identified three common imbalances if only one persuasive device was used (see Table 2).

4.4 The use of metaphor

The use of metaphors can be an effective way of communicating with a sceptical public, which use the familiar to explain the unfamiliar. Standard metaphors create explanations that obtain common currency and become universally understood. They provide the hook on which empathy with the issues can be gained. Karlsson (2015) believes finding appropriate metaphors for sustainability, and critically reflecting on their social and economic implications, is crucial to avoid reinforcing values that are inconsistent with sustainability outcomes. He proposes three metaphors that can inform what sustainability actually means and what is at stake in debates which require action from the local to the national and global. These include the familiar ecological footprint; a rocket moving from a sustainable state on the launchpad to a different sustainable state in orbit through the importance of a sustainable trajectory, and a runway (of unknown length) where the occupants of an aircraft can take off into a post scarcity civilisation, decelerate back to frugality and competing tensions or overrun the runway altogether in a devastating and irreversible crash. Similarly Larson (2011) writes: "the metaphors we adopt today have significant repercussions for our current and future approaches to environmental sustainability". Perhaps the most powerful metaphor of all was the invocation of Spaceship Earth popularised by Buckminster Fuller and evoking the imperative of dependence on resources with finite limits.

5. Classroom exercises to communicate Sustainable Development needs

The above discussion has focussed on the twin imperatives of engineers being able to identify and counter mis-information and face up to deniers who use fake news to support inaction or dismiss urgent realities, and to develop skills of persuasion themselves that engage beyond merely evidence based rational arguments their discipline encourages. Irish (2016) points to three important aspects: persuasion is an ability that can be learned; persuasion depends on an understanding of the audience; and an audience's persuadability changes depending on contextual situations .

These issues are beginning to be explored at Cambridge University with a series of classroom exercises and challenges developed for use on the MPhil in Engineering for Sustainable Development.

5.1 Exploring Worldviews

This activity is based on an exercise proposed by Irish (2016) at the University of Toronto designed to encourage students to develop a foundational understanding of their own world views. It is a highly personal activity which require sensitive handling but with students drawn each year from over 20 countries this can be a rich resource to explore how individuals have constructed their internal belief systems. Understanding this can help clarify their own motivations and be more empathetic towards the motivations of others. Irish captures the importance of this, stating "It is the subjective foundation that allows us objectivity; it is the objective basis of our being which enable our individual and collective subjectivity. It is our lens through which the world is seen. Yet for most of us, its basis and origins lie entirely unexamined"

The MPhil programme has always asked volunteers to present to the group their own **personal stories**, relating to what they had done prior to coming to Cambridge. This is now nuanced by asking them to think about and share (if they are willing) their responses to three questions (Irish (2016) :

1. Where do I come from – what are the experiences factors, influences that make me who I am?
2. How do I see the world as a result of these influences (or in resistance to them?)
3. How does my world view impact my interaction with the world?

This is still in the early stages and needs further refinement but the process of encouraged shared self reflection provides a rich educational experience, both for the individual and the group as a whole. Having students who can critically assess their own world view and understand the power this can give them is an important step in how they can operate within rhetorical situations. Formality is kept to a minimum and anyone not feeling willing to participate is excused, whilst listening to what emerges from their colleagues

5.2 The power of structured debate

Another activity regularly featured on the ESD MPhil programme is an annual class debate, usually around a motion proposed by the student such as " This house believes de-growth is the only way of achieving sustainable development" or " Nuclear power is the solution to all energy created problems in the 21st century". A refinement to this is asking each proponent/opponent and seconder to craft their arguments based entirely on either logos, pathos or ethos. (This is similar to other activities elsewhere in the programme which require students to advocate for a piece of infrastructure based on teleological, utilitarian, or deontological ethical positions).

5.3 Pitching for Sustainability

The third activity arose directly out of our of student feedback, when training was requested on how to provide a 1-2 minute pitch for sustainability to convince a sceptic. Again this existing activity has been modified to incorporate all three aspects of Aristotolean rhetoric incorporating elements of logos, ethos and pathos and to be even more challenging, students are asked to develop a metaphor to initially engage the listener. Working in small groups students make their pitches to the whole class, and their approach is collectively unpacked through subsequent discussion and its effectiveness analysed.

5.4 Open and closed minds

A final activity is to critique the approach of two presenters of a BBC documentary ("The Great American Oil Spill") who explore the aftermath of the Deepwater Horizon oil spill disaster in 2010. Originally used to contrast the differences between an open minded approach and one driven by preconceived conceptions seeking blame, the discussion is now extended to identify how each presenter balances the use of pathos, logs and ethos in their commentary

All these activities are informal and not assessed and delivered through a supplementary programme of games, change challenges, simulations and role plays as a means of placing students in a situation where they must empathise with other perspectives. For them to work the skill lies in the quality of debrief and reflection afterwards, for which sufficient time must be set aside. Student feedback has usually pointed to this being an enriching experience and a good counterpoint to more formal studies and assignments.

6. Conclusion

Ahern (2000) argued that if engineering is to be discerned in its full complexity, an engineering voice needs to be developed. We argue here that engineers need to develop a voice both as honest brokers for sustainable development, and for spotting and responding to fake news and mis-information. This will be uncomfortable for many, but is a vital skill given the urgency of actions that need to be taken, where successful persuasion becomes critical.

What is clear is the fundamental pre-requirement to achieve this kind of discourse is imagination and creativity and a willingness to play an active role in the increasingly urgent debate.

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