Enginuity

The Green Edge
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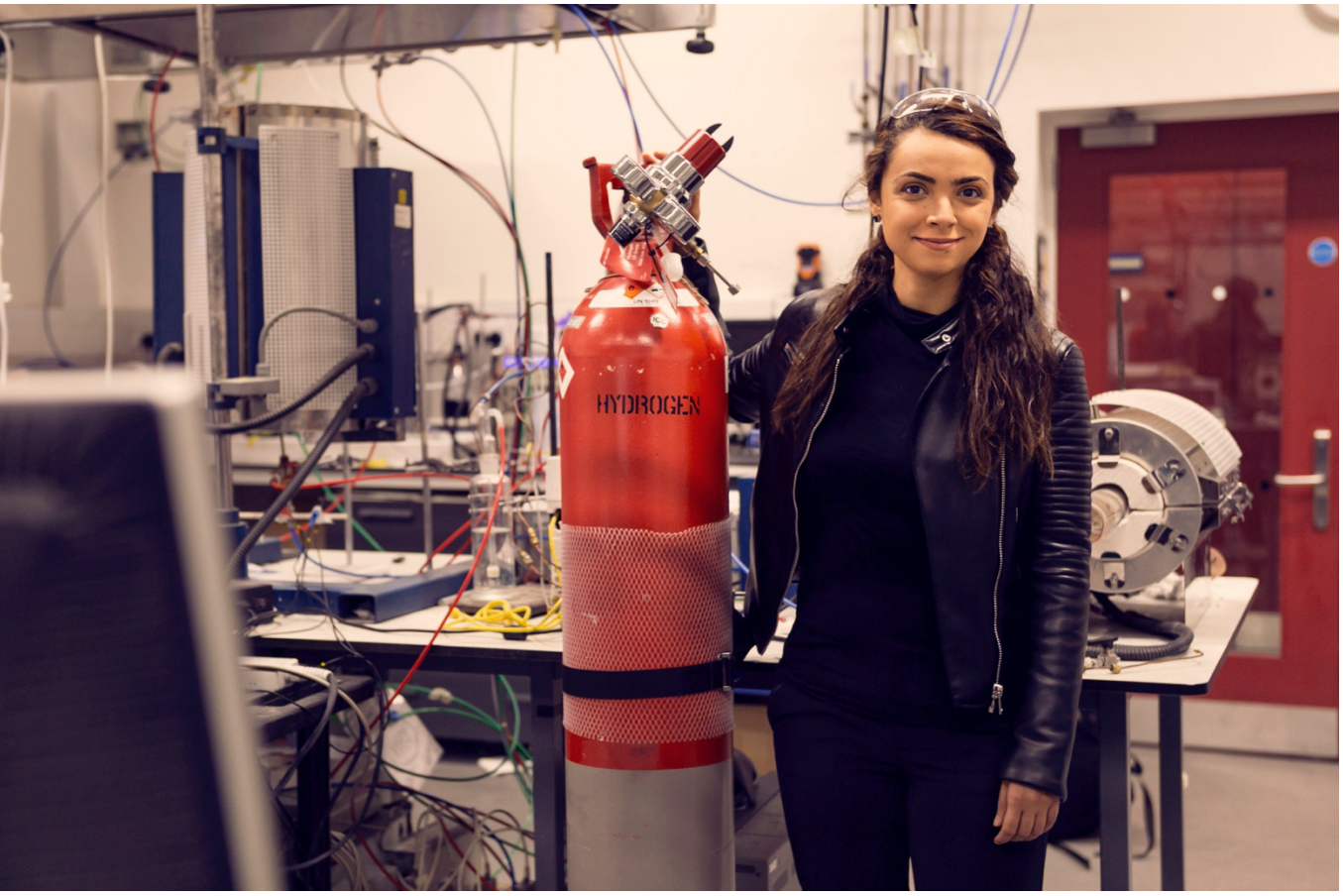
Human Capabilities for Sustainability



Introduction

The very nature of work and learning is undergoing a transformation. No longer is it sufficient to acquire a set of competences and rest on one's laurels. The capabilities of individuals to adapt, to be agile, and to continuously acquire new skills are becoming ever more crucial to keep up with the evolution of competences in today's world.

This paper, written in the style of a conversation between Enginuity and The Green Edge, explores these 'human capabilities'. We discuss the role of human capabilities in the context of one of today's biggest issues: the restoration of a sustainable world. By examining some of the human capabilities frameworks currently published, we investigate the cognitive, emotional and social qualities that are needed for people to think and act in a sustainable way. Most importantly, perhaps, we consider some of the major mindshifts needed to replace the current norms and practices – widely accepted to meet the needs of the present – with new ones that do not compromise the ability of future generations to meet their own needs.

To give our discussion a specific focus, we consider how sustainable mindshifts apply to a professional community generally acknowledged to be critical to actions for sustainability: Engineering and Manufacturing.

About the authors

Enginuity is a charity dedicated to finding new ways to close skills gaps in UK engineering and manufacturing. We have created a 'common language' for engineering and manufacturing occupation and skills data. We use this unique approach to sector data, alongside our deep understanding of the skills needs of UK engineering and manufacturing businesses, to help employers and employees have the right skills at the right time to adapt faster to change.

The Green Edge https://greenedge.substack.com/ is an online newsletter and podcaster, launched in 2021 to collate, review and synthesise the fast-expanding array of green workforce and skills reports emerging from across the UK economy and internationally. We have since become a comprehensive and up to date source for green jobs and skills-related publications in the UK. Through the lens of green jobs and skills, we are close watchers of all aspects of the green economy and the UK's progression towards Net Zero.

Intertwining Competences and Capabilities

As we look towards the horizon of the evolving job landscape, the intertwining roles of occupational competences and human capabilities become ever more pronounced, especially in the face of increasing AI and automation. The rapid pace of technological advancements means that certain tasks that rely purely on specific competences are becoming automated. This includes roles in data entry, basic analysis, and even some customer service operations.

Yet, as the age of automation unfolds, there's a burgeoning recognition of the irreplaceable essence of human capabilities. While machines can efficiently process data and execute tasks, they lack the innate human attributes like emotional intelligence, ethical reasoning, creativity, and the nuances of critical thinking. For instance, as we tackle complex future challenges ranging from climate change to societal inequalities, the capability for nuanced understanding and innovative problem-solving will be paramount.

This intertwining of occupational competences and human capabilities lies in the idea that people's cognitive abilities, emotional intelligence, social skills, and physical capabilities can influence or serve as foundations for acquiring and applying occupational competences. A willingness to learn plays a crucial role in acquiring new competences, while capabilities to adapt to changing circumstances, embrace new challenges and engage in continuous learning allows individuals to expand their skill sets and stay relevant in rapidly evolving work environments.

And, while competences are critical for job performance, capabilities can significantly impact how effectively those competences are applied. For instance, a highly skilled individual with strong communication and teamwork capabilities is likely to collaborate more effectively with colleagues, leading to enhanced productivity and outcomes.

Collaborations of this type also beckons a more interdisciplinary approach to work. Engineers, for instance, might find themselves collaborating closely with environmental scientists, requiring not just the competence in their specific field, but also the capability to communicate, understand, and appreciate diverse interdisciplinary perspectives.

Competencies and Capabilities in the Workforce

Before we go any further, we should make sure our terms are clear. For example, when we refer to **occupational competences**, we mean the specific skills, knowledge, abilities, and expertise that individuals possess and can apply in performing a particular job or task effectively. These competences are generally practical and job-specific, are often measurable, and are sometimes referred to as **professional competences** or **technical competences**.

It is also important to differentiate between **occupational competences** and **occupational capabilities**. While occupational competences ensure that jobs or tasks are done correctly and efficiently, occupational capabilities delve deeper into an individual's growth trajectory. It's not just about what they can do now but what they might be able to achieve in the future. This encapsulates an individual's potential to evolve, adapt, and enhance their skill set within a technical domain. The cultivation of technical capabilities embed a profound sense of confidence, making individuals not just competent but agile and innovative, capable of productivity at an amplified pace compared to competences alone.

At Enginuity, we focus on the dynamic evolution of competences and capabilities in the workforce. Our emphasis is not just on specialised proficiency in engineering and manufacturing, but also on unlocking the broader human potential within these sectors.

Unlocking broader human potential moves us into the realm of **human capabilities**. These refer to the overall capacities and potentialities of individuals. They encompass a range of human attributes, including cognitive, emotional, social, and physical abilities. Human capabilities are not limited to work-related skills but extend to various aspects of life, personal development, and well-being.

As we shall see, human capabilities can be described using a range of different **human capability frameworks**. Typically, these might include capabilities like critical thinking, emotional intelligence, adaptability, resilience, creativity, and the ability to learn and grow. In general, we might regard good human capabilities frameworks as being both applicable to today's world and, as far as possible, tomorrow's. They should describe mixtures of human qualities that are relevant – even needed – by everyone, and which may be either innate or acquired through experience. Some sources may describe these as 'transferable skills' or 'soft skills' but we are avoiding using these terms here, as we believe they are too limiting and too prone to be used in a loose way.

Our analysis has revealed a clear distinction between **technical competence frameworks** and **human capability frameworks**. The former emphasises job-specific proficiency, while the latter promotes the holistic development of individuals, equipping them with transferable skills that span various roles and sectors. This highlights the importance of overarching human potential within specialised job proficiency.

A first look at Human Capability Frameworks: Meta-skills

We have already mentioned a number of human capabilities like critical thinking, emotional intelligence, adaptability, resilience and creativity. Let us see how these capabilities appear in capabilities frameworks. We will start with meta-skills.

While the roots of meta-skills have been around since metacognitive research done during the 1970s, today they are increasingly being considered as essential for the 21st century and the need to prepare people to live and thrive in an ever-changing and complex world.

Meta-skills are described as innate, timeless, higher-order skills that create adaptive learners. They are used from birth to test and explore the world, and provide the keys to unlock the acquisition of other transferable and technical skills. They are visualised in various ways – one recent and thoughtful piece of work that we like, commissioned by Skills Development Scotland (SDS), lays them out as shown in *Fig. 1*.

At time of writing, SDS is still working on the process for implementing meta-skills into the Scottish educational and vocational training systems. But elsewhere, interpretations of the meta-skills framework provide some useful pointers of how these capabilities can – and should – be incorporated into a person's life and work.

Fig. 1: Meta-skills wheel. Image: SDS

In the context of the workplace, meta-skills are overarching skills that underpin and enhance the application of the more ‘traditional’ skills. They're more about the ‘how’ rather than the ‘what’. For example, while traditional skills might teach someone the mechanics of writing a report or coding a program, meta-skills guide how one approaches the task, solves problems when they arise, or collaborates with others in the process. Let us consider some of the key distinctions between the two:

- **Tangibility vs. Intangibility**: Traditional skills are often tangible and specific. For example, a certificate in digital marketing or a degree in civil engineering testifies to certain traditional skills. Meta-skills, such as adaptability or critical thinking, are intangible and more challenging to quantify, but their effects permeate various aspects of work and life.

- **Short-term vs. Long-term Relevance**: Traditional skills, while essential, might have a shelf-life due to technological advancements or industry shifts. For instance, knowledge of a particular software might become obsolete in a few years. Meta-skills, being timeless, equip individuals to navigate changes, learn new traditional skills as needed, and remain relevant.

- **Job-specific vs. Universal Application**: Traditional skills are often job-specific. A skill relevant for a data scientist might not be directly applicable for a graphic designer. Meta-skills, however, are universally applicable. Whether one is an artist, engineer, teacher, or entrepreneur, capabilities like effective communication, empathy, and problem-solving are invaluable.

- **Acquisition and Training**: Traditional skills are often acquired through formal education, training programs, or on-the-job experience. Meta-skills, while they can be nurtured and developed in educational settings, are also deeply influenced by life experiences, personal reflections, and broader interactions with the world.

- **Assessment**: Traditional skills can often be assessed through tests, certifications, or direct observation. Evaluating meta-skills is more complex, requiring holistic assessment methods that might include feedback from peers, self-reflection exercises, or situational judgment tests.

In the context of the modern workplace, the distinction between meta-skills and traditional skills is not about their relative importance but about their interplay. While traditional skills provide the foundation for executing specific tasks, meta-skills enhance the quality, adaptability, and depth of that execution. In a rapidly changing world, the synergy between these two types of skills ensures that individuals are both competent in their roles and adaptable to evolving challenges.

Comparing other frameworks

There are many other human capability frameworks to choose from and, to be honest, the law of diminishing returns probably comes into play as we look at more and more of them. But it's probably worth taking a look at one or two of the more general frameworks to see what we may be missing before we move on to take a closer look at the ones that are targeted towards sustainability and engineering.

The Human Capability Standards Reference Model (*Fig.2*) from the Institute of Working Futures in Australia is a comprehensive framework that reviewed others from the likes of OECD and the World Economic Forum during its development. Now in its third version (2022), it defines four 'domains' into which it fits sets of capabilities. Not surprisingly, quite a few of them – critical thinking, creativity, adaptivity, communicating, and collaborating, for example – are also present on the meta-skills map, although they may not appear at the same levels.

For example, the Working Futures framework allocates an entire domain to leadership, with its own subset of capabilities, whereas it appears as a single item as part of social intelligence on our meta-skills framework.

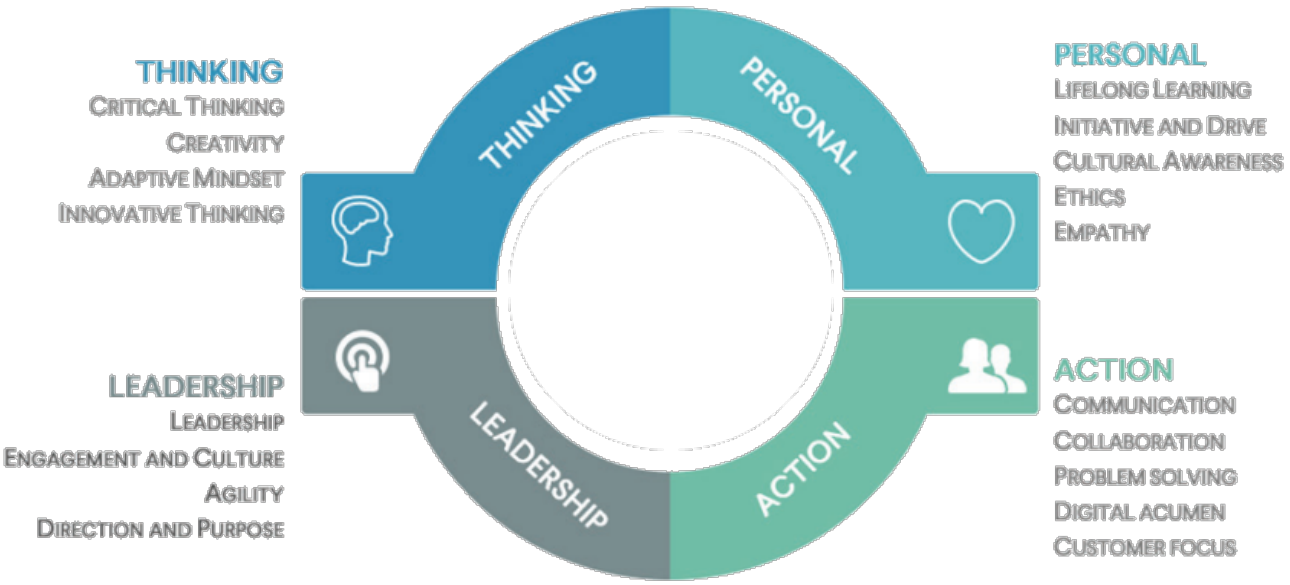


Fig. 2: Human Capability Standards Reference Model. Image: Working Futures.

The Human Capability Standards Reference Model highlights five core competencies – **Communication, Collaboration, Critical Thinking, Adaptive Mindset**, and **Problem Solving** – that we believe are fundamental for the workforce of the future. From our perspective, the remaining capabilities may shift depending on the nature of the job and the organisational landscape. These capabilities, essential for holistic employability, may not be uniformly mandatory like the foundational five. For instance, healthcare roles might underscore the value of empathy, whereas positions in technology demand a pronounced digital expertise.

Fig. 3: DigComp – digital competence framework for citizens. Image: EU Science Hub.

The subject of digital acumen as a human capability rather than purely an occupational competence leads us to the European Commission's (EC) DigComp framework (*Fig. 3*). DigComp addresses the EU Council's recommendation in 2018 to support 'the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society'.

Staying with the EC, we also have LifeComp *(Fig.4)*, which regards personal, social and learning-to-learn as a set of capabilities applying to all spheres of life that can be acquired through formal, informal and non-formal education, and which can 'help citizens to thrive in the 21st Century'. Again, we see much overlap with the previous frameworks, with the possible addition of wellbeing, which LifeComp possibly draws from other frameworks we find from bodies like OECD.

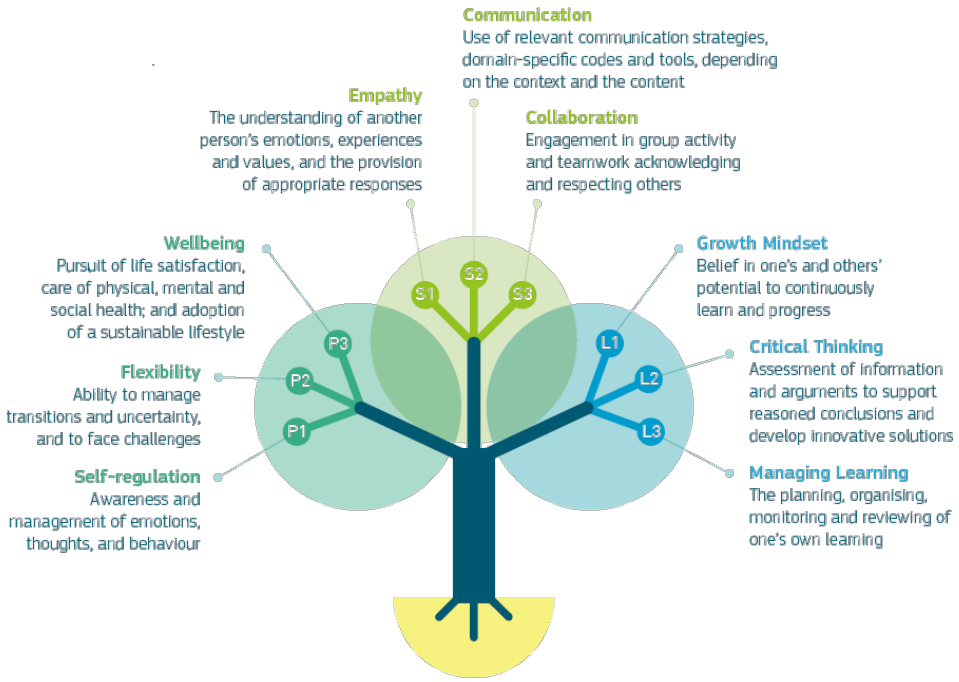


Fig. 4: LifeComp – key personal, social and learning-to-learn capabilities. Image: EU Science Hub.

There are others we may look at, like the International Labour Organization's Global framework on core skills for life and work in the 21st century. But since many of these tend to play mix up with our definitions of occupational competences and human capabilities, we'll leave these for now as what we consider to be a good representative selection.

Collective Capabilities

The rise of the type of Human Capability Frameworks we see above has undeniably shed light on individual capabilities, enhancing professional development. However, at Enginuity, we've noticed that these frameworks often focus solely on individual human capabilities. This limitation raises concerns, particularly when considering the application of Human Capability Frameworks in organisations of all sizes.

Collective capabilities, shaped by institutional structures, play a vital role in determining organisational success. An organisation's strength lies not just in the skills of individual members but in the collective synergy achieved through teamwork, cooperation, and shared vision.

Work occupies a significant portion of our lives. Beyond individual capabilities, executing diverse technological and organisational functions within a company requires a cohesive set of 'appropriate' and 'collective' productive capabilities. Productivity results from the interplay of collective outcomes rather than isolated individual contributions.

While individual expertise in specialised areas is crucial, the collective capability within and across teams in engineering and manufacturing sectors significantly impacts project and product success. This interdependence and collaboration underscore the importance of enhancing collective capabilities, which can lead to better outcomes, innovative solutions, and sustainable practices.

Enhancing collective capabilities goes beyond improving individual skill sets. It also involves fostering better coordination within organisational units and building effective collaborations with external stakeholders, such as suppliers, buying firms, or consultants.

As the global landscape increasingly pivots towards sustainable practices and technologies, the emphasis on Collective Capability within organisations becomes paramount. For businesses and institutions, fortifying collective capabilities doesn't just enable the efficient execution of tasks; it paves the way for the deeper integration of sustainable methodologies into everyday operations. It's about blending individual expertise with collaborative synergy to foster innovation and adaptation. This holistic strategy doesn't merely optimise processes – it equips organisations with the resilience and foresight necessary to navigate the challenges of an evolving sustainable era. In essence, nurturing both individual proficiency and collective strength could be the keystone to ensuring a resilient, sustainable organisational future.

We believe there's a need for talent development to adopt this type of multi-dimensional approach. For sustainability and elsewhere, the future workforce should possess a harmonious blend of both occupational competences and human capabilities. An example of this approach is the new Engineering Modern apprenticeship in Scotland, which emphasises environmental best practices and sustainability, aligning with Enginuity's vision of fostering an environmentally conscious and sustainability-driven mindset among professionals.

Capabilities for Sustainability: Mindsets and Mindshifts

As argued by Enginuity above, the concept of collective capabilities is particularly relevant in the context of sustainability. So, how does a capabilities framework designed specifically for sustainability vary from the general frameworks we've seen previously?

GreenComp (*Fig.5*) is a new (2022) capabilities framework from the EU and, as such, sits in the family of frameworks that include DigComp and LifeComp. It tells us it 'provides a common ground to learners and guidance to educators [and] responds to the growing need for people to improve and develop the knowledge, skills and attitudes to live, work and act in a sustainable manner'.

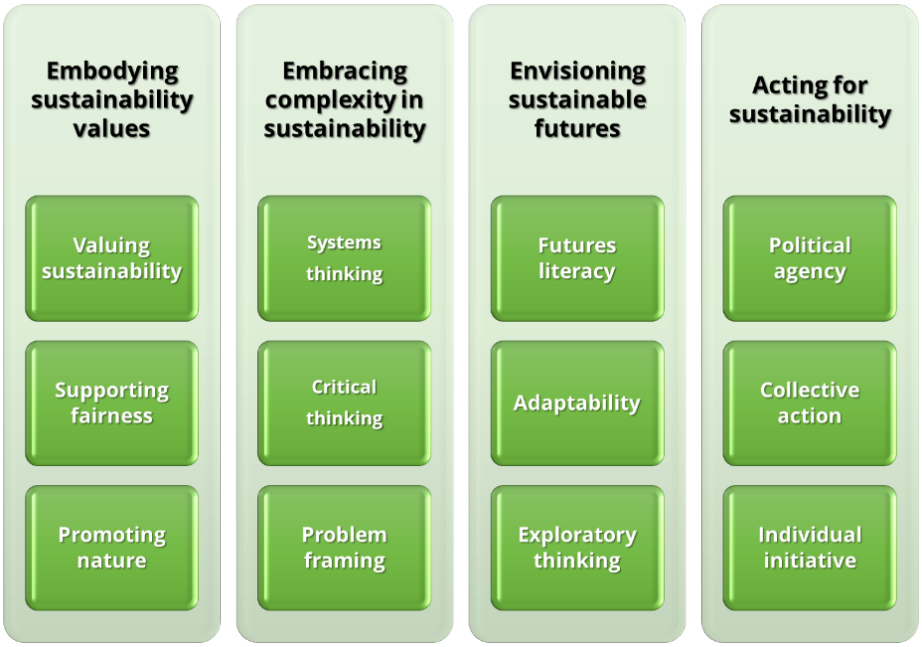


Fig. 5: GreenComp – European sustainability capabilities framework. Image: TGE adapted from EU Science Hub.

Immediately, we can see some commonalities with the general frameworks – critical thinking, adaptability, initiative; and collective action, for instance. But a key difference is that GreenComp is targeted towards the specific goal of establishing populations with sustainability mindsets, in which people are 'big picture' thinkers and agents for sustainability, working from knowledge bases that understand and care about our planet's present and future state.

Considering this further, it becomes clear there is a strong argument that these mindsets can not be established without some major mindshifts being made throughout populations. Mindshifts are likely to include:

- **From Short-term to Long-term thinking**: One of the most critical mindshifts required for sustainability is shifting from a short-term focus on immediate gains to long-term thinking that considers the consequences of actions and decisions on future generations. This change in perspective is vital for making sustainable choices that may not yield immediate benefits but are crucial for the well-being of the planet and its inhabitants in the long run.

- **From Linear to Circular Economy**: A shift from a linear 'take, make, dispose' economy to a circular economy that promotes recycling, reuse, repair, and regeneration is necessary. Emphasising resource efficiency and reducing waste can lead to a more sustainable and less resource- intensive model of economic development.

- **From Individualism to Collective Action**: Sustainability challenges are global in nature and require collective action. Moving away from individualistic mindsets to fostering a sense of shared responsibility and collaboration is essential for implementing large-scale sustainable solutions.

- **From Consumerism to Conscious Consumption**: Encouraging a shift from consumerism and overconsumption to conscious and responsible consumption is crucial. This involves valuing quality over quantity, considering the environmental and social impact of products and services, and supporting sustainable businesses.

- **From Competition to Cooperation**: Traditional models of competition may not always align with sustainability goals. Emphasising cooperation and partnerships between businesses, governments, and civil society can foster more comprehensive and integrated sustainability efforts.

- **From Anthropocentrism to Ecocentrism**: A significant mindshift involves recognising that humans are part of a larger ecosystem and that nature has intrinsic value beyond its utility to humans. Embracing an ecocentric perspective can lead to more respectful and sustainable interactions with the natural world.

- **From Denial to Climate Action**: Acknowledging the reality of climate change and its impacts is essential. Encouraging climate action at all levels, from individuals to governments, is necessary to mitigate its effects and adapt to the changes already occurring.

- **From Inequality to Social Equity**: As we have already said, sustainability does not only address environmental concerns but also strives for social equity and justice. Mindshifts are required to address disparities in access to resources, opportunities, and decision-making power.

- **From Technocentrism to Nature-based Solutions**: While technology can play a crucial role, there should be a shift towards recognising the value of nature-based solutions and ecosystem services in promoting sustainability.

These mindshifts will not be not easy to achieve. They challenge existing norms, practices, and belief systems. They will involve education from the earliest years and throughout people's lives, along with policy, legislation, awareness-raising, inclusive dialogue and many other levers. Far beyond simply adopting a few eco-friendly practices, this will require a fundamental transformation in the way individuals, societies and institutions think, behave, and operate.

Why Engineering and Manufacturing are critical

The intersection of engineering, manufacturing, and sustainability is undeniably one of the most crucial junctures of our time. As we stand at the precipice of significant global challenges – from climate change to resource scarcity – the role of engineers and manufacturers becomes more pivotal than ever. Their choices, innovations, and practices will lay the foundation for the world's sustainable future.

As with the general population case described by The Green Edge above, the engineering and manufacturing journey is more than just integrating eco-friendly materials or adopting renewable energy sources. It's about a paradigm shift in thinking. It necessitates viewing engineering and manufacturing not just as processes to create products, but as holistic systems interconnected with our environment, economy, and society.

Many sustainable practices and methodologies are already well established in the field of engineering and manufacturing: design for sustainability; collaborative innovation; development and use of sustainable materials; Life Cycle Assessment (LCA); resource efficiency and Circular Economy; and Lean Manufacturing, to mention just a few. Many of these also incorporate some of the sustainability mindshifts we saw previously. Short- to long-term thinking, for example, embraces design for sustainability, sustainable materials and LCA, while a shift from linear to circular economy thinking should be common to all. Some mindshifts, though, may be a little harder for engineers to grasp. From technocentrism to nature-based solutions, for instance, may prove hard for some engineers, many of whom live techno-centric - or at least technophilic – existences.

But, if we consider the GreenComp framework, we could argue that engineers are well placed to make valuable, perhaps even unique, contributions to each of the domains we saw earlier. Being trained as problem solvers (if not problem framers) and, for the most part, being good at things like STEM and other technical stuff, engineers are likely to be towards the front of the pack when it comes to **embracing complexity in sustainability**. They may not all be systems thinkers (yet) but they to tend to be systematic thinkers, able to take on the holistic view, frame the problems and think critically about what needs to be done. Many of them already do that each and every day in their professional lives.

Also, as children many future engineers drew or built futuristic models and envisioned how cars might look, planes may fly or people may live when they – the future engineers – grew up and made new things for them. A short jump, perhaps, to **envisioning sustainable futures**.

Then, within the right operating environments, engineers are generally good on individual initiative, while collectively they can – and did – put men on the moon. Add political agency to that mix and we can see how engineers could become top-notch at **acting for sustainability**.

Where we feel engineers may need a little more help is in getting them to a position where they are **embodying sustainability values**. While the principles of sustainable engineering and manufacturing might include labour conditions, human rights, community and other social impacts, some of the capabilities required of the engineers involved – support for equity and social justice, reflection on personal values, acknowledgement that humans are part of nature, and so on – may well be ingrained in each individual's world view but are not necessarily supported by the engineering education they received.

Overall, some work may be needed to build a world army of fully-rounded, sustainability-ready engineers. But we are optimistic. Most of the engineers we meet are already well along the road to being sustainability-capable. At the very least, they are generally able to quickly take on board sustainability mindsets like holistic problem-solving, prevention rather than mitigation, pushing the boundaries of what is currently possible, designing for resilience and adaptability, and exploring how natural processes can be integrated into solutions. By adopting these mindshifts, engineers can play a transformative role in promoting sustainability, contributing to a cleaner, more equitable, and resilient future for society and the planet.

A Sustainability Framework for Engineers

Our recommendation is for authoritative bodies, such as the Engineering Council, to incorporate frameworks like the Global Responsibility Competency Compass from Engineers Without Borders (EWB) (*Fig. 6*) into their standards and educational frameworks. We believe that integrating technical competency with human capability frameworks can cultivate professionals who excel in their specialisations while remaining versatile in communication, critical thinking, and problem-solving across various domains.

Such an integrated approach offers numerous benefits, from nurturing a comprehensive set of required skills to enabling continuous learning, promoting cross-disciplinary collaboration, and aligning technical efforts with sustainability goals. A crucial part of this integrated approach involves identifying and recognising transferable skills. Transferable skills, such as problem-solving, leadership, and team collaboration, are essential as they enable individuals to apply their knowledge and abilities in a variety of work settings. Recognising these skills can further facilitate cross-disciplinary collaboration, as individuals with a diverse range of transferable skills can easily adapt to and contribute in different technical and non-technical environments.

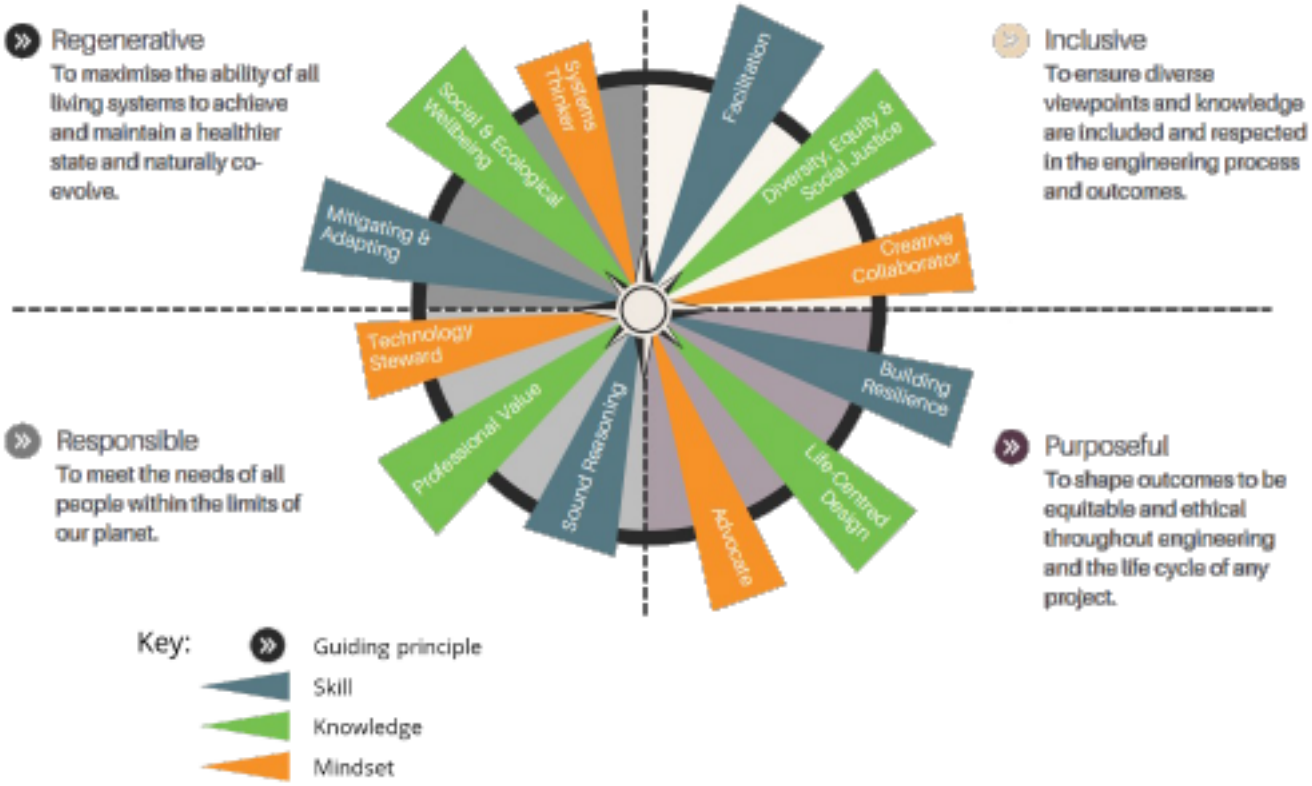


Fig. 6: Global Responsibility Competency Compass. Image: EWB

We support and agree with Enginuity's recommendation. In this paper, we've considered meta-skills, general and sustainability-focused capabilities frameworks, and discussed how they might apply to the engineering profession. In our opinion, EWB's Global Responsibility Competency Compass fits the bill well.

In it, we see core capabilities from the meta-skills and general frameworks alongside systems thinking and advocacy/agency as per GreenComp. Significantly, perhaps, we see that the Compass attempts to address some of potential gaps we identified around engineers embodying sustainability values. We particularly like the links between the compass' guiding principles and the mindsets that each one requires. So much so, that we repeat them here for emphasis (*Fig.7*).

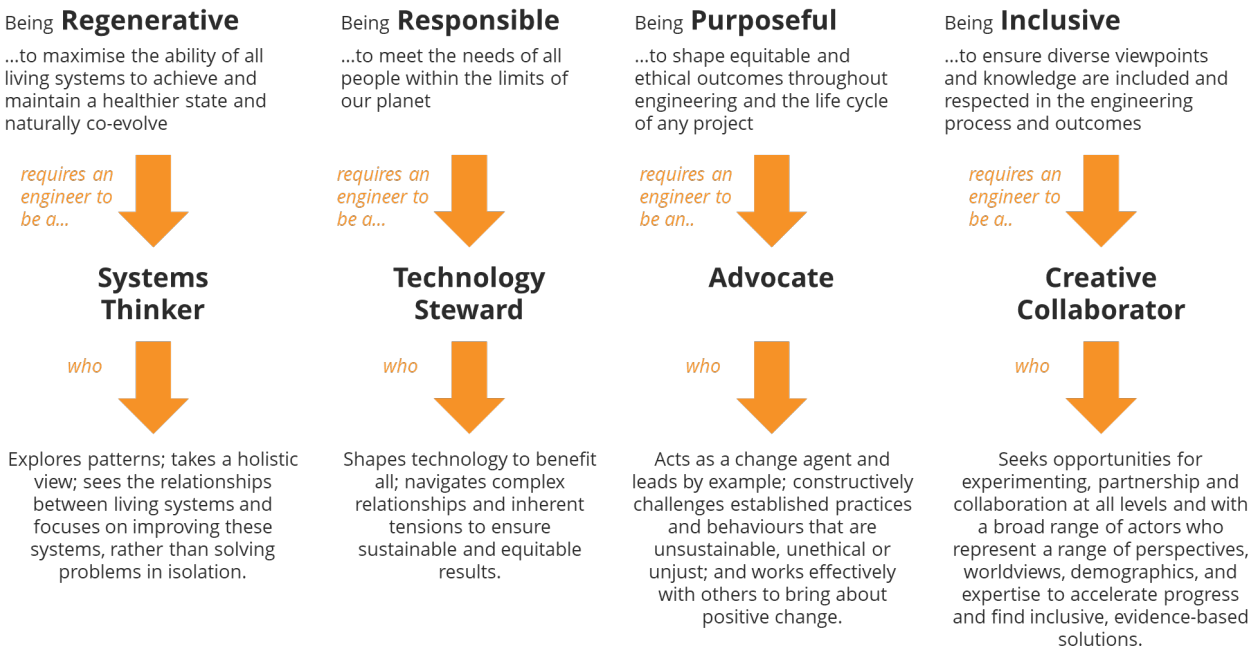


Fig. 7: Guiding principles and mindsets for sustainability-capable engineers

Achieving the types of engineering mindshifts we see here, though, requires a thoughtful and comprehensive approach. Certainly, incorporating sustainability teaching into engineering curricula from foundational level through to advanced courses will expose students to sustainability challenges and solutions from early in their education.

An example of this ideology in action is the collaborative work between the Royal Academy of Engineering and the University of Manchester on the initiative 'Progressing to be an Engineer'. This initiative, aimed at enriching the learning experience of primary school children in engineering, embodies a strategic approach to inculcate engineering mindshifts right from the foundational level. It provides a framework for teachers and STEM educators to integrate engineering teachings within the mainstream curriculum for children aged 5 to 11 (Key Stage 1 and 2 in England), aligning with National Curriculum requirements, showcasing the practicality of early exposure to engineering and sustainability education, setting a precedent for future initiatives aiming to nurture socially responsible engineers.

Initiatives like this will encourage collaboration between engineering and other disciplines like environmental science, social sciences, and economics, fostering systems thinking and exposing students to diverse perspectives on sustainability. Experiential learning will provide opportunities for students to engage in real-world projects and internships related to sustainability. Use case studies of successful sustainable engineering projects and showcasing of prominent engineers who have made significant contributions to sustainability can inspire and motivate students to embrace sustainability in their careers. And sustainability- focused research will inform curricula, inspire innovation, and provide evidence for the importance of sustainability. There are other methods too: guest lectures and workshops; sustainability competitions; online resources and open courseware; discussions on ethics, values, and social responsibility in engineering education; industry partnerships: peer-to-peer learning; and continuous professional development.

By implementing these strategies, educational institutions can create a conducive environment for fostering the necessary mindshifts we've seen here. Graduates who are well-versed in sustainability principles will be better equipped to contribute to the development of innovative, responsible, and sustainable solutions for the challenges of the future.

In the UK, we believe it is significant that the Engineering Council has expressed its support for EWB's Global Responsibility Competency Compass. As the regulatory body for the UK engineering profession, the Engineering Council sets and maintains internationally recognised standards of professional competence and commitment. It holds the national register of over 228,000 engineers and technicians who have been assessed against its standards and awarded one of its professional titles.

However, realising this or any of the other frameworks we've examined here requires a collaborative effort involving educators, regulators, professionals, employers, and policymakers.

There needs to be a shift in focus from enhancing competences to building capacity. Enginuity aligns with this transition, emphasising a comprehensive approach that integrates environmental best practices and sustainability. Given the rapid global transformations, it's imperative to ensure our workforce remains environmentally and sustainability-driven.

By melding foundational pillars like critical thinking, communication and adaptability with technical competences and capabilities, we witness the emergence of a robust, multi-dimensional professional framework. The identification and recognition of transferable skills are pivotal within this framework, augmenting the capability of professionals to transition smoothly across diverse roles and projects. Professionals fortified with this trifecta not only assimilate swiftly within their work environments but are also strategically positioned to offer impactful, meaningful contributions. This synergy underscores the core proposition: organisations and educational institutions must recognise, differentiate, and invest in these distinct but harmoniously intertwined facets.

The result? A workforce that's not just skilled but resilient, adaptive, and poised to confront and navigate the dynamic contours of the contemporary workplace.