

Establishing a Competencies Framework for Infrastructure Policy Professionals

Final Report to UKCRIC

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Executive Summary

This project sought to answer the question: *What specific competencies and types of expertise are required from infrastructure policy professionals as they address complex global challenges?*

The original motivation for this work came from the direct experience of the Principal Investigator(s), working across a range of infrastructure and policy topics in the contexts of academic research, practice and education. In recent years we have seen an increasing need to understand the essential competencies (skills, knowledges and behaviours) required by those working at the critical and complex interfaces of infrastructure and policy. We believe that this has proactive implications for the content and framing of degree programmes and continuing professional education to help professionals respond to the current challenges facing the sector. This report summarises the key research insights that that team believe have the capacity to inform research agendas across UKCRIC's missions, and directly inform education across higher education and workplace training.

This project takes a broad view of the infrastructure policy 'sector', encompassing traditional infrastructure areas (including water, waste, energy, green infrastructure, transport and digital) and professionals and organisations involved in decision-making across the public, private and third sector. Drawing upon two parallel threads of evidence, it combines (1) a review of existing competency frameworks, developed as guides for continuing professional development by bodies across the sectors of interest and (2) interviews with experienced professionals across public, private and third sector organisations and academic researchers. The insights have been used to explore and summarise the sector and how those within it are currently trained (Pg. 10-14), including drivers for change (Pg 11-12); to propose the key components of a 'Competencies Framework' for the sector (Pg. 15-25) and; to provide some conclusions and recommendations most relevant to the remit of UKCRIC (Pg. 26-27).

The infrastructure policy sector exhibits a number of features which shape the contemporary professional experiences of those within it. These include: the challenge of defining the right problem to solve, and developing sustainable solutions; the urgent imperative to make the sector more inclusive and diverse; the fact that the sector spans across professions and administrative boundaries, necessitating collaboration; and the fact that the sector is heavily project-based. Our research identifies two important external drivers (Climate Change and Digitisation and new technologies) and two important internal drivers (Imperative to advance diversity and inclusion agendas, and Lack of decision-making approaches to address risks and uncertainties) which are seen to be strongly motivating short and longer-term change in the sector.

The review of existing competency frameworks highlighted an existing focus on: communication and interpersonal skills; knowledge and practice and; processes and systems. The combined review and interview insights allowed the team to propose a more nuanced view of the key components of a competency framework for infrastructure policy professionals. This comprises sets of core skills (Communication and translation, Reflexivity and strategic thinking), knowledge (Generalist and specialist, Contextual knowledge and awareness) and behaviours (Working collaboratively across disciplines, Critical thinking and willingness to challenge the status quo, Initiative and emotional intelligence), as well as appreciating the cross-cutting importance of an enabling environment in which to develop professional competency (Paradigm change, Workplace culture, Leadership and mentoring, Suitable metrics for skills, knowledges and behaviours).

Considering the practical implications of this competency framework, professionals and institutions should be mindful of the need for undertaking continuous learning and an awareness of new innovations or policies affecting their work; improving flexibility, agility, creativity and ambition; pro-actively managing institutional knowledge, since projects and organisations often

outlast people working in specific roles; and adopting a mentality of embracing uncertainty and developing skills to manage it effectively.

Key takeaways from this report for UKCRIC, and other institutions active in this space, include:

- Emphasising the development of behaviours within professional competency—which have been underrepresented/undervalued in competencies frameworks to date in comparison to knowledges and skills
- Awareness of methods and tools to plan for an uncertain future—being able to understand and respond as best possible to short and long-term social and environmental changes
- Recognising the complementary value of generalist and specialist backgrounds—appreciation of the need for diverse, cohesive and highly competent teams, as well as talented individuals
- Evolving the recognition of professional accreditation as a license to operate—with a focus on understanding and developing professionals' environmental and social licenses to operate

This project shows that practitioners within the infrastructure policy sector have a large amount of tacit knowledge and expertise that has been gained through experience and ongoing reflection, which is a valuable source of insight and guidance for researchers and those seeking to make practical change in the sector.

Section 1: Introduction

The infrastructure sector currently faces multiple challenges: to respond to climate change and global environmental risks, support the short- and long-term recovery after the COVID-19 pandemic and to do so in an equitable way that improves livelihoods. One of the key mechanisms for achieving this is through policies set at the global, national and local levels. As such, developing the professional skills, knowledges, experience and behaviours of those in the sector to shape infrastructure policy- and decision-making to meet more sustainable and equitable outcomes is critical to achieving a transformation towards more sustainable, fair, resilient and efficient infrastructures and urban systems.

Those working at the interface of infrastructure and policy-making have a central role in setting policies and regulation, and approving projects. While most infrastructure policy professionals are highly qualified, we cannot take for granted that the content of degree programmes and continuing education from past decades is adequate to help professionals respond to the current challenges facing the infrastructure sector.

Training and education in this sector has tended to prioritise knowledge and specialised skills, with a distinct gap with respect to the required behaviours and ‘soft skills’ for practitioners. There is limited guidance on the specific competencies and types of expertise required from infrastructure policy professionals¹ as they address these complex challenges. While there has been significant research on transforming infrastructure systems in recent years (Deakin-Crick & Bentley, 2020; Dolan et al., 2016; Ortegon & Tyler, 2017), the wide range of learnings derived from these projects, as well as professional practitioners’ insights, have not yet been synthesised into a coherent and robust competencies framework.

Competence is defined by the Oxford Dictionary as ‘the ability to do something successfully or efficiently’. For this project, we break down competence(y) into three dimensions: skills, knowledges and behaviours². The project aims to gain a better understanding of the specific skills, knowledges and behaviours required by infrastructure policy professionals, in light of the current challenges faced by the broader infrastructure sector.

It is well-established that infrastructure is a major lever to enable change in how we live, travel and consume resources, as societies respond to climate change, sustainability challenges and growing inequality. However, the task of transitioning infrastructures to a net-zero future and deliver a just transition³ is challenging. The findings of this research provide guidance for infrastructure policy professionals, as well as senior managers and HR professionals responsible for education and training, explaining the critical skills, knowledges, and behaviours required to respond to current challenges.

Aims

To produce a ‘Competencies Framework’ for infrastructure policy professionals, drawing together the findings of recent years’ research (Liveable Cities; Deakin-Crick & Bentley, 2020) and the experiences of policy and industry professionals. This output will support UKCRIC’s portfolio of

¹ For the purposes of this report, an ‘infrastructure policy professional’ is someone who contributes to the development and implementation of infrastructure policy. These professionals do not just work in the civil service – they can also be found as practitioners or researchers in the private sector, third sector and academia.

² These dimensions are adapted from the British Standards Institute framework for Built Environment Professionals (BSI, 2021). This framework refers to four dimensions: skills, experiences, knowledge and behaviours. We chose to draw on three of these dimensions as they were most relevant to represent the data collected.

³ A just transition refers to an economic, social and environmental transition that is ‘as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind’ (ILO, 2022).

research as it transitions to an institute, augmenting the value of UKCRIC to facilitate engagement activities and impact-oriented research.

Project objectives

1. Generate a large dataset of evidence from academic researchers and industry professionals, on the required competencies and expertise for infrastructure professionals
2. Synthesise a 'Competencies Framework' from the evidence collected
3. Disseminate the results to academic, policy and industry audiences to directly inform ongoing research agendas, training policies and higher education curricula

This report explains how the competencies framework was developed and presents the key initial findings. This report integrates the two deliverables initially proposed for the project: (1) a findings report that presents the research results in a style and form that is accessible for a policy and industry audience and (2) the core considerations for establishing a Competencies Framework for infrastructure policy professionals. An accompanying journal article, which we plan to submit to a subject-relevant journal, is in production and we will supply a draft of this article to UKCRIC once submitted for review. Any academic publications drawing upon data and insights from this project will duly acknowledge the support of UKCRIC.

How do we define infrastructure policy?

This project takes a broad view of the infrastructure policy sector, encompassing areas including water, waste, energy, green infrastructure, transport and digital, because of the common challenges facing these types of infrastructure, and the many interconnections between them.

The infrastructure sector comprises professionals and organisations across the public, private and third sector. While the public sector holds formal responsibility for setting policies and legislation, private and third sector organisations and academic researchers have a strong role both in shaping public policy, as well as delivering on new policy agendas. Appendix 2 shows the range of organisations that took part in the research.

Does this project imply that we need specialist policymakers?

No, not necessarily. Policymakers in the United Kingdom tend to be generalists, and transitioning between a range of different sectors is seen as desirable for career progression⁴. This research recognises the distinct skills, knowledges and behaviours that are advantageous for policy professionals in the fields of transport, water, waste, energy, green infrastructures, digital and telecommunications. Many of the research participants identify as generalists, explaining how a varied background and generalist skillset helped them play a valuable role in the infrastructure sector. While the report identifies and emphasises a specific set of priority skills, knowledges and behaviours for the infrastructure sector, it does not imply that a wholesale change in the training of policymakers is required.

How do we define skills, knowledges and behaviours?

Table 1 defines skill, knowledge and behaviour, with relevant examples for this report. While in practice these terms are often used interchangeably, in attempting to build a more nuanced

⁴ Page & Jenkins (2005). *Policy Bureaucracy: Government With a Cast of Thousands*. Oxford: Oxford University Press.

picture of competency it is useful to distinguish between them to illustrate how the work of infrastructure policy professionals spans what they know, the specific skills they can perform, and the behaviours that are demonstrated in practice.

In conjunction with the skills, knowledges and behaviours, this report also recommends desirable characteristics for the 'enabling environment' or wider work environment for infrastructure policy professionals. This reflects the finding that individual efforts are not sufficient to address the challenges facing the sector.

Table 1 - Defining skill, knowledge and behaviour

	<i>Definition</i>	<i>Example</i>
<i>Skill</i>	A skill refers to the ability to perform an activity or task consistently with a specific intended outcome	The ability to translate complex technical information to a non-expert audience
<i>Knowledge</i>	Knowledge is defined as the assimilation of facts, theories, frameworks and practices related to a specific role, activity or task. It can take different forms, including disciplinary, technical, tacit, indigenous and local knowledge	Knowledge of the sources of embedded carbon in highway projects
<i>Behaviour</i>	Behaviours are defined as observable things that an individual does or does not do. Given the strong interpersonal dimension of professional work, and the requirement for professionals to address complex problems, behaviours are important to work effectively	Demonstrating emotional intelligence to resolve a team conflict

Source: Adapted from BSI (2021)

Background: What is currently known about this subject?

An initial literature review on this subject found little published work on the distinct skillsets required by policy professionals working in the infrastructure sector. Page and Jenkins' *Policy Bureaucracy: Government With a Cast of Thousands* (Page & Jenkins, 2005) examines the everyday work of policymakers in the British Civil Service, showing the importance of 'improvised expertise' since most civil servants are trained as generalists and transfer their skills across different policy areas.

Ethnographic research on health policymakers, and the types of knowledge they draw on, emphasised that policymakers held responsibility for turning proposals from ministers into 'workable policies' by producing policy documents and securing the support and potentially resources of powerful individuals within the organisations (Maybin, 2014). This shows the strong communicative dimension of policy work, in terms of making sense of complex policy issues, and communicating this to politicians and other stakeholders in a way that helps to gain their support for certain policies. However, it does not go into detail to explain the skills that policy professionals need to do this work effectively.

Another perspective on infrastructure policy comes from the field of political ecology, which is the study of the political, economic and social factors shaping the way we understand and respond to environmental change or environmental issues. This field takes a particular interest in infrastructures, insofar as they represent a man-made attempt to control the effects of nature, or

harness natural resources. This is useful to understand the link between expert knowledge and infrastructure development, emphasising the social processes by which trained experts and professionals understand, analyse and seek to address environmental challenges through infrastructure development. This also relates strongly to the ‘value’ we place on different kinds of infrastructure interventions, and has been a useful perspective through which to highlight the narrow range of values—dominated by economic/financial—that the viability and success of infrastructure projects have been historically judged by.

For example, Finewood (2016) shows that there are distinct epistemologies (ways of knowing and analysing infrastructure issues or systems) embedded within the professional experiences and know-how of those responsible for planning and delivering infrastructure projects (Finewood, 2016). The embedded understandings of what infrastructure could and should be are evident, for example, in the contrast between ‘green’ and ‘grey’ infrastructures: grey infrastructures seek to manage stormwater by capturing and treating stormwater as quickly and efficiently as possible using engineered interventions like sewers and pipes, while green infrastructures aim to manage stormwater at source and across landscape scale with systems that mimic natural ecological processes, using rain gardens and bioswales, which also produce wider social and environmental benefits (ibid.). This contrast shows how green infrastructure seeks to mimic natural processes while grey infrastructures try to control natural processes by collecting and removing stormwater.

The social processes and mobilisation of expert technical knowledge shaping infrastructure development are also influenced by gender, race and class. Siemiatycki et al. (2019)’s research on the ‘front-end’ production of infrastructures is relevant to this research, showing how organisational structures, power relations and symbolic narratives are unequal along the lines of gender, race and class and prioritise individualised narratives. For example, histories of infrastructure feature ‘master builders’ such as Baron Haussmann, Isambard Kingdom Brunel and Robert Moses, and although these have been replaced by networks of engineers, politicians and financiers, the sector has maintained a strong masculine bias (ibid.).

While researchers have examined the ways that infrastructure professionals deploy their expertise and participate in delivering infrastructure projects or solutions, the body of research about the distinct skills, knowledges, experiences and behaviours of professionals is limited. Crick & Bentley (2020) emphasise the need for systems thinking capabilities for professionals that develop and manage infrastructure systems, using a case study from an Australian water utility to show that strategies to improve water resilience relied on individual employees’ openness to innovation and learning. Crick et al. (2018) show that infrastructure organisations require learning ‘infrastructures’ that escape the tendency to separate learning from planning and implementing, because this separation creates gaps in knowledge and undermines learning feedback loops.

Leach & Rogers (2020) set four principles for encouraging transdisciplinarity⁵ in the engineering of infrastructure systems: multidimensional problem framing, talented and diverse human resource, collaboration instead of competition, and supportive governance, structures and processes. These points usefully inform our thinking about competencies, highlighting specific capabilities (e.g., systems thinking), and the need to span different disciplines to address complex societal issues related to infrastructure development.

⁵ Transdisciplinarity refers to the integration of knowledge or theories from multiple disciplines with knowledge from practitioners or people outside academic. This approach is desirable in the field of infrastructure development because it can account for local contextual knowledge that better shapes infrastructures around the local environmental context and human needs.

Methodology

Given the lack of conceptual frameworks identified within the literature review above, the methodology for this project used an exploratory approach—we sought to find out what skills, knowledges and behaviours are important rather than testing an existing theory or conceptual framework. To do this, we used thematic analysis to identify emergent topics from two key sources: existing competency frameworks for continuing professional development and semi-structured interviews with those working in the sector. By drawing on these two complementary sources (expression of desired competencies within the workforce, and the lived experience of practitioners), the study aimed to describe the sector and the current challenges it faces, and to capture the skills, knowledges and behaviours that are most relevant for professionals at the present time. Analysing existing frameworks showed how competencies are being codified and assessed across a range of professional bodies. Collecting data through semi-structured interviews prioritised professionals' personal reflections and explanations of their professional activities⁶.

Table 2 summarises the data sources, collection methods and how data was analysed.

Table 2 - Data sources, collection methods and modes of analysis

Data source	Collection method	Mode of analysis
Published professional competency frameworks <i>66 frameworks, see Appendix 1 for list and explanation</i>	Desktop research	Thematic analysis
Interviews with experienced infrastructure professionals <i>42 interviews, anonymised. See Appendix 2 for list of participating organisations</i>	Semi-structured interviews, conducted online. Snowball sampling used to recruit participants	Thematic analysis of qualitative data

Limitations to the study

The study data drew upon the experiences of individuals and institutions based in the United Kingdom. While many of the interviewees have experience outside the UK, the data collected and resulting findings should not be generalised outside the UK context without careful consideration of local political, social and environmental factors.

A key challenge for the methodology was to accurately discern which skills, knowledges and behaviours were important across the infrastructure sector, without reinforcing the systemic inequalities identified by Siemiatycki et al. (2019). Seemingly-objective preferences for certain styles of communication, organisation or problem-solving in workplace settings can result in bias against colleagues. Managing this risk required careful analysis and interpretation of the interview data to identify and scrutinise whether participants' views reflected unequal organisational structures or working practices. Incorporating questions about inequalities within the sector encouraged participants' to reflect on these challenges, and many offered insights into the challenges that helped discern the connections between systemic inequalities and the requirements for specific skills, knowledges and behaviours.

⁶ While alternative approaches to data collection, such as direct participant observation, shadowing or journaling of daily activities could have obtained more granular data, we opted for this approach to collect data from a broader range of practitioners and build from their own reflections instead of direct observation of their work.

Section 2: Defining the infrastructure policy sector

This section draws on our interview data to describe the defining features of the infrastructure policy sector, followed by a summary of the current drivers for change that infrastructure policy professionals are facing.

The main features of the infrastructure policy sector

The challenge of defining the right problem to solve, and developing sustainable solutions

This means going beyond the narrower scope of delivering pre-defined outputs such as new roads or upgrades to utility networks, to think more rigorously and creatively about the framing of the policy problem, and the potential solutions ranging from policy and regulation to technology upgrades or capacity expansion. The fragmentation of responsibilities and expertise across the domains of public policy, planning and engineering can undermine a more holistic and integrated approach to defining problems and solutions.

The urgent imperative to make the sector more inclusive and diverse

Despite the introduction of equality, diversity and inclusion initiatives in recent years, there is still significant work needed to make the infrastructure sector a more inclusive and diverse place to work for people of different genders, ethnicities and classes⁷. Participants in this project emphasised that this is an issue of fairness and justice, which also had practical implications for the quality of decision-making and the sector's ability to cater for the needs of everyone in society.

The sector spans across professions and administrative boundaries, necessitating collaboration

There is rarely a single department or organisation with authority and responsibility for infrastructure; it is typically fragmented across different professions and organisational boundaries. Thus, working in a collaborative way across organisations or professions, and communicating with other stakeholders or actors, is a critical part of the job for most infrastructure professionals.

The sector is heavily project-based

Since construction and engineering projects are frequently required to upgrade, retrofit or expand infrastructure networks, much of the work undertaken by infrastructure professionals is done in project teams that are interdisciplinary and only exist for the timespan of the project. This implies that although professionals learn from projects, project-based teams may not always capture and retain institutional knowledge due to their temporary nature.

⁷ While this report does not re-iterate the range of challenges and opportunities related to diversity and inclusion, we refer to reports by the National Audit Office (NAO, 2015) the Department for Transport (DfT, 2021) and the Greater London Authority (GLA, 2020).

Drivers for change in the infrastructure policy sector

At present, the infrastructure policy sector faces a range of challenges that place specific demands on professionals. Tables 3 and 4 outlines the main drivers for change, based on our interview data. These are separated into external drivers from sources or challenges outside the sector (Table 3), as well as internal drivers that result directly from issues within the sector (Table 4).

Table 3 – External drivers for change for professionals working in the infrastructure sector

External drivers		Implications for workforce
Climate change	Uncertainty over how to deliver on net-zero commitments	Climate commitments important to maintain credibility and demonstrate social responsibility
	Narrow focus on carbon reduction targets	Skills gap for evaluating and managing carbon, lack of technical expertise
Digitalisation and new technologies	Lack of foresight regarding emerging or future technologies Impact of new technologies on societal needs	Workforce development not integrated with technological innovation

Table 4 – Internal drivers for change for professionals working in the infrastructure sector

Internal drivers		Implications for workforce
Imperative to advance diversity and inclusion agendas	Lack of progress in shifting attitudes and industry norms	Opportunities for access, learning and advancement are limited for minority groups within the sector
Lack of decision-making approaches to address risks and uncertainties	Poorly-specified outcomes for infrastructure investment Risk of lock-in effects from current decisions that are difficult to reverse Siloed working Limited evaluation and learning processes	New approaches to decision-making and managing uncertainty More collaboration across disciplines

A notable feature of these challenges is the *pace of change*: those interviewed noted that while issues like climate change have been recognised for some time, its importance has grown rapidly. Over a period of just a few years the demands placed on the infrastructure moved from needing to provide reporting and disclosure on climate impacts, to the imperative to halve greenhouse gas emissions by 2030 and reach net-zero by 2050. Similarly, the combined impacts of new technologies and shifting societal needs can change quickly: the COVID-19 lockdown measures in the UK and beyond spurred a sudden shift towards digitalisation and remote work using existing technologies. Even after lockdown measures were removed, the behaviour changes and new ways of working have persisted for many office workers who continue to work on a fully- or partially- remote basis.

How are infrastructure policy professionals currently trained?

This section draws on research interviews and existing competency frameworks across a range of professions. It summarises insights into current training approaches and benchmarks and standards for competency.

The evidence shows that both specialists and generalists have important roles in infrastructure policy, planning and delivery. Specialists are typically developed as experts in a discipline, such as ecology, civil, geotechnical or mechanical engineering, or economics. Generalists can come from a range of backgrounds, and those we spoke to typically attributed their skills as a generalist to a wide variety of work experiences.

We identify the following career trajectories in the research participants:

- Generalists who originally trained in disciplines traditionally linked to infrastructure (e.g., engineers, planners). They have built upon a base of subject-specific expertise to take on broader managerial or leadership roles within the sector
- Specialists in disciplines traditionally associated to infrastructure that were nurtured by experience, being exposed to multiple projects, working with different stakeholders and organisations (the Army, industry, government, academia)
- Professionals with background in disciplines not traditionally linked to infrastructure (e.g., education, ecology). They bring an outsider perspective and can connect the technical component of the infrastructure sector to societal grand challenges (e.g., social value, environmental sustainability)

Alongside formal university education and training, participants emphasise that learning through apprenticeships and informal learning on the job, and iterating from these experiences, are major components of their learning pathways. Since a large proportion of learning takes place after formal education is complete, this highlights that the right structures for on-the-job learning must be in place, including good leadership, effective mentoring, and initiatives for equality, diversity and inclusion so that learning opportunities are available to all. This last point on inclusion arose from a gender perspective in particular, since women reported that they did not always receive equal opportunity to the mentoring and professional networks that support them to learn and gain experience from their professional work.

On-the-job learning is supported by talks, webinars/seminars, and workshops hosted in-house or by industry bodies. Roundtables and informal ‘brown-bag’ sessions⁸ are helpful to learn about new ideas or review the different roles and responsibilities within a given project. Project-based learning is also dominant—where a project could be a large-scale construction or engineering project, but equally could take the form of developing a new policy or regulation—because it involves interdisciplinary teams working in temporary project teams, and individuals accrue knowledge across a series of projects during their career.

Industry bodies and learned societies⁹ have a large influence on professionals’ learning through the formal chartership or accreditation processes they oversee, as well as their advocacy and thought-leadership work in advocating for stronger policy action on issues such as climate change, biodiversity and the circular economy.

⁸ A ‘brown-bag’ lunch is an informal training session held during lunch breaks to facilitate sharing and learning between colleagues

⁹ Learned societies are typically not-for-profit organisations that promote a specific discipline, some of which also act as industry bodies representing one or a group of related professions.

Benchmarks and standards for competency

Existing competency frameworks were analysed to better understand the current expectations and benchmarks for professional skills, knowledges and behaviours. Through thematic analysis the content of these frameworks was grouped into the following themes: communication and interpersonal skills; knowledge and practice; process and systems; responsibility, leadership and management; and professional commitment.

Existing competency frameworks take different forms: continuous prose, diagrammatic, a list of bullet points on a page, or a combination of all three. Some frameworks are standalone documents and others derive from a more general industry standard. Some are comprehensive in their expectations of members, including both a description of skills, knowledges and behaviours but also providing examples of how those behaviours can be demonstrated. Not all organisations have their own framework: for example, 15 refer to the competency framework produced by the UK Engineering Council¹⁰ according to their websites and as such, they were not included in the analysis. In many cases, frameworks use similar language, which suggests a convergence of priorities or a common source, even where not directly cited. This provides a level of consistency in the expectations of members of different sectors within infrastructure.

The analysis of existing competency frameworks alongside interview data with a wide range of experienced professionals showed that there were many overlaps between the frameworks and practitioners' accounts. These are organised into themes that were drawn inductively from the frameworks.

Communication and interpersonal skills

Existing competency frameworks and interviews both show the importance of communication, translation across disciplines, and interpersonal skills. These skills are essential in order to effectively communicate with stakeholders, alongside presenting findings in presentations at conferences. Some frameworks also emphasise the need for members to be able to be reflective and communicative with colleagues to create positive and open work environments. They also provide guidance on how working relationships should be conducted within their roles.

Knowledge and practice

Interviews focus more on knowledge about the social and environmental impacts of infrastructures, policy processes, governance systems and commercial aspects. In contrast, competency frameworks focus more on specialised technical knowledge. Drawing on different approaches to apply technology to their specific industries is a recurring theme across the frameworks analysed, alongside knowledge of how to apply technical standards, codes, and regulation. Some frameworks also specify that members should have a reflective knowledge of their own personal limitations alongside critical understanding of the limits of their own knowledge. Interviews focus more on leadership and mentoring, as ways to create the 'space' for exploring new types of solutions, challenging the status quo, learning and developing personally and professionally. The frameworks also advise members to undertake additional training. This can be academic qualifications such as an MBA, Diploma in Engineering Management or being able to demonstrate on-the-job learning. Commitment was also described as adhering to industry specific codes of conduct (e.g., Chartered Association of Building Engineers), and continuing professional development.

Processes and systems

The frameworks provide guidance as to the processes by which members should conduct their work. This includes preparing and controlling budgets/costs connected to their projects,

¹⁰ The Engineering Council is the UK regulatory body for the engineering profession.

alongside representing the needs of clients. Some frameworks also include the recruitment process within their guidance. This begins with the writing of prescriptive job descriptions, shortlisting candidates according to good practice. Frameworks also specify how members should have good working knowledge of Health and Safety regulations alongside other key regulations. For example, Construction Law Competencies specifies that members should 'Understand the provisions of the Housing Grants (Construction and Regeneration) Act 1999. As amended by the Local Democracy and Economic Development and Construction Act 2009'. Interviews also focus more on behaviours such as collaboration, critical thinking, agility, initiative and emotional intelligence, and emphasise the importance of an enabling environment to complement individual skills, knowledges and behaviours. Overall, the frameworks provide expectations about how members should be aiming to operate within a team and how line management should be conducted as a support mechanism.

Notably, there is limited mention of climate change, greenhouse gases emissions, or carbon management within the frameworks analysed, consistent with the interviews which reported that this is a major gap in terms of professionals' knowledge. While climate change is now taking a more prominent place in higher education across a range of degree programmes, for those trained in previous years it remains a significant gap.

Section 3: Establishing a competencies framework for infrastructure policy professionals

Our research explores the question of what skills, knowledges and behaviours are desirable for infrastructure policy professionals to work effectively. This section integrates the frameworks review and interview data to present a competencies framework for infrastructure policy professionals, with interview quotes and an in-depth discussion of the framework. It also provides detailed insights on the behaviours and enabling conditions that best support infrastructure policy professionals to work effectively, which are a major feature within the interviews but are only articulated to a limited extent in existing frameworks.

The urgent imperative to make the infrastructure sector more inclusive and diverse cuts across the different skills, knowledges and behaviours, as well as the enabling environment. This issue is integrated into the framework instead of treated as a stand-alone concern or a specific aspect of the framework.

The numerous discussions about skills, knowledges and behaviours with experienced professionals show that ‘ideal’ professionals, also referred to as ‘unicorn talents’ with perfectly-matched skills and experiences to the demands of a role, rarely exist. As such, the aim of this competencies framework is not to define an ideal-type infrastructure professional — to do so would risk exacerbating issues in recruitment and undermining the efforts of diversity and inclusion agendas to break down stereotypes and make the sector more inclusive. Instead, the competencies framework examines the range of skills, knowledges and behaviours that are identified in research interviews, using quotes to show how they are important for the specific tasks and responsibilities of infrastructure policy professionals. We stress that these skills, knowledges and behaviours won’t necessarily look or sound the same in practice, and the framework intends to open new discussions over working practices and behaviours, instead of limiting the focus or imposing narrow norms on what is desirable.

Which skills, knowledges and behaviours are desirable?

This section elaborates on the desirable skills, knowledges and behaviours for infrastructure policy professionals based on the research interviews. Many of these headings are not surprising; general competencies in data analysis, team-work and problem-solving are ubiquitous across many professions. However, this section provides an in-depth summary of *how* and *why* these skills, knowledges and behaviours are important for the infrastructure policy sector, using interview quotes, as noted, to illustrate these points.

Table 4 outlines the key skills, knowledges and behaviours that will be elaborated in this section.

Table 4 - Overview of key skills, knowledges and behaviours for infrastructure professionals

1. Skills	2. Knowledges	3. Behaviours
Communication and translation	Generalist and specialist knowledge	Working collaboratively across disciplines
Reflexivity and strategic thinking	Contextual knowledge and awareness	Critical thinking and willingness to challenge the status quo Initiative and emotional intelligence
4. Enabling environment		
Paradigm change Workplace culture Leadership and mentoring Suitable metrics for skills, knowledges and behaviours		

Skills

Research participants identify a general skillset spanning decision-making, communication, data analysis and interpersonal skills, summarised in Table 5. These are skills that professionals should be familiar with at the very least, and aim to develop proficiencies in accordance with their specific role and related responsibilities.

Table 5 - Desirable skills for infrastructure professionals

- | | | |
|--|--|---|
| <ul style="list-style-type: none"> • Goal-setting, prioritising and structured decision-making • Ability to infer causality and trends | <ul style="list-style-type: none"> • Quantitative and qualitative data management and analysis • Theories of change • Systems thinking or systems mapping | <ul style="list-style-type: none"> • Interviewing, focus groups and round tables • Use of visualisation tools |
|--|--|---|

Beyond the list of specific skills in Table 5, the following skills are highlighted as priorities for infrastructure professionals: Communication and translation; Reflexivity and strategic thinking; Leadership and mentoring.

Communication and translation

Effective communication is essential to provide relevant information in suitable and accessible language and formats, adapting to the needs of a specific audience and context. As the infrastructure policy sector deals with complex policy processes and outcomes, professionals need to communicate effectively by understanding other's objectives, motivations, and agendas. Effective communication is also an essential precursor to build relationships, trust, and confidence.

The multidisciplinary nature of infrastructure projects and collaboration across different organisations implies that communication also involves elements of translation—whether to a

different profession, a different authority or organisation, or to speak to the interests of a different population or context. For example, one participant notes:

*“It has happened so many times that we were spending an hour discussing. **You had an engineer, you had someone like me working in social science, urban development, environmental politics and then you have a lawyer and then you had a health specialist.** We would have the conversation around one sentence and then **in the end you realise that everyone was understanding something very different.**”*

In light of these situations with high potential for misinterpretation or miscommunication, it is desirable to have people who can span the different disciplines, translating and mediating between different stakeholders and experts:

*“I think you really need **someone who will be able to be the interdisciplinary person, meaning the person who knows exactly the different uses of the word ... and can be able to translate into very simple ways, which ensure that everyone is on the same page all the time.**”*

Beyond this translational role, participants also note the ability to know how to communicate their needs clearly to another specialist from a different discipline, and how this is often learnt entirely on the job:

*“There is a gap there, where people are going to go into consultancy as an ecologist. Nine times out of ten **they will have to speak to an engineer or be able to understand where an engineer is coming from, and that, I've learnt on the job. No one's taught me that. I haven't been taught at university, or at any other level.**”*

Reflexivity and strategic thinking

The concept of reflective practice appears repeatedly throughout the interviews. Drawing from the work of Schön (1983, p. 54), reflective practice refers to ‘the ability to reflect on one's actions so as to engage in a process of continuous learning. It involves paying critical attention to the practical values and theories which inform everyday actions, by examining practice reflectively’. This includes reviewing whether one's initial assumptions are holding true, or whether the chosen strategies or approaches for collaboration and communication are effective. This approach is powerful as a way to inform strategic thinking for infrastructure policy professionals, since the pace of work or projects can shift the focus to completing tasks, at the expense of learning:

*“... my last point, maybe it's a characteristic, is the **need to be reflective.** The need to actually **think about and learn from things that you did well but you could have even done better, or things that didn't go well but actually there's great lessons that can be learnt from that, so that next time you can do a good job. I just don't think we spend enough time doing that, because we're on this escalator that is just forcing us to go from one thing to the next, and because of the pace of that escalator, we never get time to get off, stop and look back at the journey that we've gone on.**”*

A greater focus on strategic thinking is also needed to scrutinise the kinds of infrastructural solutions that are deployed to respond to policy problems:

*“My fear is that **we are getting quite good at learning how to deliver stuff better, but not to deliver the right stuff.** [...] The trouble is, most of these people who are doing this are learning about **delivering more effectively and efficiently, what they've always done.** So they think they're getting better at building a railway. They think they're getting better at building an airport. They think they're getting better at building cars. **Not thinking**”*

about what they need to do differently. To some extent, it's only when big exogenous things or threats to their business become clear, do they actually bother doing stuff."

*"...what that means for the way you design cities, transportation systems and **everything, needs to be very different, looking ahead, to what we would have been thinking about 20 years ago.**"*

Foresight and strategic thinking around potential future technological change is a key issue for infrastructure policy. Without a coherent vision for what future societal needs infrastructure will be catering for, there is a risk of building future infrastructures for past needs, creating lock-in and assets that are not fit-for-purpose:

*"My big fear is that a lot of people out there are still stuck in thinking around stuff that was right 20 years ago, and I'm not certain it is any more, to tell you the truth... Again, it's this whole decision making and thinking around the longevity of your infrastructure, the repurposing of it, its adaptability. What I worry is [...] classic transportation planning is being **you do more of what you've already done, because it's always worked in the past.** So you bang in more roads and then get surprised when they become full of traffic."*

*"I think the **people who think about infrastructure for the future, and plan for it, need to take a much better, more rounded view of life and society in the future, in the world we live in, rather than coming out with weird, classical bits of transportation analysis.**"*

Knowledges

A broad variety of knowledges are identified as important for infrastructure professionals, spanning from disciplinary and technical knowledge to tacit, indigenous or local knowledge. Research participants identify specific topics that all professionals should be familiar with (summarised in Table 6), showing that knowledge of the environmental and social impacts of infrastructures, alongside the policy processes and governance systems shaping infrastructure development, are a priority alongside an understanding of the commercial aspects and ways of thinking to grapple with uncertainty and complexity.

Table 6 - Desirable knowledges for infrastructure professionals

- | | | |
|--|--|---|
| <ul style="list-style-type: none"> • Environmental sustainability and carbon literacy • Systems principles • Principles for managing uncertainty and complexity | <ul style="list-style-type: none"> • Foresight, forecasting and backcasting • Governance principles and systems • Policies and the policymaking process | <ul style="list-style-type: none"> • The social value and ethical dimensions of infrastructure projects • Commercial aspects of infrastructure delivery |
|--|--|---|

Generalist and specialist knowledge

Beyond the list in Table 6, interviewees also identify that expectations for professionals to have specific knowledge depended on their profile as either a generalist (T-shaped) or specialist (I-shaped) professional. The contrast between these types of professionals is explained below:

*"You have an **I-shaped person, someone who is deeply, deeply technical, very strong in their field, and then you have T-shaped people, who've got this... They're not***

technical experts, but they can put their arms around the broad church of infrastructure and engineering, and understand how to help integrate, help communicate, and help choreograph the overall approach—and be able to talk to clients and with other professionals, architects, urban designers, planners, and so on, in a language that allows the interfaces to be understandable, manageable.”

However, even where practitioners are generalists, they frequently need in-depth knowledge of the technical aspects of infrastructure systems to work effectively. Another interviewee illustrates this clearly:

*“I would describe myself more as an environmental project manager. So I am that generalist who's linked to the client. I just had a meeting earlier where they asked me about five different aspects, and I had to be able to not blag, and **have a general understanding of what you would do** on noise, what you would do on waste, and what you would do on carbon **but without being a technical specialist in all of them.**”*

Participants recognise the important contributions of specialists who can engage in highly detailed and rigorous analysis or design, alongside those with the ‘bigger picture’ and curiosity to take a broader perspective to complement the detailed work:

*“You need technical people who are really willing to get into massive datasets that understand the analytics and can do it rigorously, but **we also need people who have the creativity, flair, empathy, actually for the citizens to which we are delivering,** and can bring that to bear in the early stages of solution development.”*

*“It's much more about **willingness and curiosity to understand what patterns of change that are happening around the world.** So it's almost breadth rather than depth of knowledge that is more important to start with, and then from there, training quite carefully through the fact that we're a very small team and we do a lot of work together and we give responsibility to people. Then we send them around the world to talk to people of all kinds and to practice interviews. **It's actually just normal career professional development, through which the people who come through our system go out into the world and make a difference.** Obviously there's only a few people that have ever done this.”*

Contextual knowledge and awareness

Contextual knowledge also emerges as a major consideration for any policy or project, since all infrastructure projects are situated in a local geographic, environmental, social and economic context. For any projects or policies, it is critical that infrastructure regulation or development is responsive to local needs, and it is possible that a given project is effective in one local context, but has a high risk of failure in another if local knowledge is not taken into account. As participants recount, the different needs of stakeholders and the public creates a challenging context to understand the varied impacts of new policies or regulations, and negotiate the different demands to develop solutions that are the best possible fit:

*“... **being able to respond to the asks that come from these different communities,** as well as to the users and the general public, and **being able to manoeuvre within this extremely complicated space.** And the fact that **it's not easy to learn that,** and those people who, through whichever means have been able to acquire that expertise, are seen as extremely scarce and unique.”*

Since most professionals do not have easy access to local knowledge about a policy or project, collaboration is critical to gather this information and develop a sound understanding of the context:

*“I think first of all it's all about the collaborative efforts. So **you really need to engage a wide range of stakeholders**. Identify the ones that are important and also try to speak to others who understand views that you might not be aware of to **bring everyone on that journey together**. Understand people's objectives and agendas and what are they - almost like triggers and blockers for action, so you can account for that. Also the different timelines to which they work.”*

Behaviours

The behaviours identified by the interviewees are summarised into three themes: Working collaboratively across disciplines; Critical thinking and willingness to challenge the status quo; and Agility, initiative, and emotional intelligence.

Working collaboratively across disciplines

Building on the skills of communication and translation discussed earlier in this section, pro-active collaboration across disciplines was highlighted as a key behaviour to effectively solve problems in the infrastructure policy sector. Since policy design involves a lot of specialised or tacit knowledge, professionals had to reach out and build their own networks of experts and stakeholders who could help them to understand the nuance of any given situation:

*“I don't think that you can know everything, but **for me the key is to know who to ask when I don't know**. That's something that I had to learn really, really fast, that it's okay not to know everything, but know immediately who are you going to ask for specific and different tasks.”*

*“I guess it's people who can, again, **think a little bit outside of their sole area of expertise**. If you're working on a project that does have to do with providing energy access you would hope... I think **the most successful people I've seen are those that are able to identify synergies, but at the same time are able to think of what works for me as a business or as an entity** who are providing access? What works for the user? What does the user need? What are our constraints? What are our opportunities?”*

A practice defined as ‘dot-joining’ is discussed as a way to counter fragmentation and siloed ways of working, by making people or organisations aware of the wider context and avoid the unnecessary duplication and inefficiency of duplicated work across different organisations or workstreams:

*“[It's] just to engage with as many of these pots and organisations as possible, and **be a dot joiner**. That's an expression that I hear quite a lot—'dot joiner'. There's one lady [...] She puts on a business club - chief dot-joiner - because that's her mission, is basically to join dots, just **to end this fragmentation and make people aware of each other; make organisations aware of each other**, that they're doing so. Although it's a very difficult thing to organise and do—it's a high level—but at a personal level, I think it's just engage, engage, and engage more; but this does take a lot of time out of your day job.”*

Policies and projects in urban settings also create a strong need for multidisciplinary working, by virtue of the different infrastructure assets, and their related risks and complementarities, occupying the same or overlapping spaces in urban areas:

*“Just going back then to the multidisciplinary, and hopefully interdisciplinary, nature of the projects [I] have worked on, so it's always been through this engineering lens, but the idea with them all is to **understand the interface between how the various services in an urban environment are delivered and to understand that it's not solely a technical question. It's a human question**, are the trams going to the places where people need them to go at the times they need them to get there? Are they affordable? As well as, do they have the capacity? How are they actually dealing with the timing and the interface with the other traffic and all of those things? All these questions. If you only have some of them, you're not able to fully answer, is it a sustainable, say, intervention or setup? Is it resilient? Is it liveable? Does it make people's lives better or easier in some way? That's where the multiple perspectives come in.”*

Critical thinking and willingness to challenge the status quo

Critical thinkers are described as not being afraid of challenging and changing the status quo, coming up with different ideas and solutions rooted in a critical openness to experimentation, embracing uncertainty and uncertain outcomes, innovation, and exploration. While this can potentially slow or disrupt the progress of policies or projects, a number of participants emphasise the need for this type of thinking to avoid mistakes and scrutinise the presumed effectiveness or feasibility of a given policy or project:

*“I think **[what we need is] a willingness to ask questions**. A self-belief that **if something that should be intuitive doesn't feel intuitive then it might be slightly wrong**.”*

Participants also emphasise non-linear thinking and the idea that infrastructure development should be linked with a clear vision of what kind of nation or society we want to have in the coming decades, instead of relying solely on what worked in the past:

*“If you think I'm going to spend £100 billion doing High Speed 2, forget it. If you think I'm going to spend £100 billion doing High Speed 3, forget it. I want that £200 billion and I want it [...] to massively boost onshore, offshore wind, PV, bits of blue hydrogen, so we want to really make a step change, very rapidly, to decarbonisation. Which will ultimately be much cheaper for society, much more equitable [...] So **you think about things differently. [...] and I think it's that change from linear thinking to non-linear thinking**. It's thinking what step changes are likely to happen and will this strategy be good enough. [...] It may not be perfect, but it's good enough. **The one thing that's certain is if you keep doing what you're doing, you're always going to get what you've got**.”*

A number of interviewees reflect on where these behaviours come from, noting that they are largely social—learnt from deliberation between colleagues and debates in the media and politics. But they can be encouraged through fostering curiosity and the willingness to ask questions and give people permission to explore different visions of the future that could be created through infrastructure policy:

*“I see these skills as, to a large degree, inherent. The **curiosity, the desire to ask questions, the willingness to link across things, make connections, be creative, weave stories, I see them as inherent**. I see them as skills that we teach out, only to try and teach back in at university level.”*

*“Then we have the creative ideation. So the skillsets and competencies around **being able to go beyond what is familiar to us, but be more inclusive in ourselves, be able to think laterally and creatively**.”*

Initiative and emotional intelligence

Lastly, participants told us that initiative and emotional intelligence are important for individuals to work well in teams and respond to the fast-paced nature of infrastructure policies or projects. Initiative is when professionals can independently assess a situation, form and introduce new interventions or solutions. Due to the collaborative and team-based nature of this work, initiative does not necessarily imply that individuals resist collaboration or seek only to work independently, but rather that they demonstrate willingness to share responsibility over an issue and take on responsibilities to form and/or implement solutions.

Emotional intelligence is the capacity to be aware of our own emotions, and work with people in a way that carefully and empathetically manages professional relationships. In practice, emotionally intelligent people demonstrate self-awareness of their own emotions and consider carefully how emotions may affect working relationships or decision-making processes. This does not imply that emotions should be absent from the workplace, but rather that a degree of self-awareness and empathy can help improve working relationships and collaboration.

While initiative is demonstrated as a behaviour, participants noted that it arose from a mindset of being curious and attentive to the changing circumstances:

*“I think a lot of it is a mindset thing, a curiosity and interest. Then, also, just that **awareness of how things work and how things fit together in the broader sense.**”*

Empathy is identified as a particularly important aspect of understanding the societal impacts of infrastructure policies or projects, whereby they impact on the environment or people’s everyday lives or livelihoods in concrete ways:

*“Actually, thinking about the equity aspect... **It's empathy but you have to experience it first-hand almost to really understand what it is like to be more affected by pollution or more affected by climate elements.** So just go there, if you're a policymaker, go to the places, **see it first-hand, instead of just seeing it through your screen and your computer, to really generate this empathy and really understand deeply what it means not to have equity.**”*

An enabling environment for the infrastructure policy sector

Improving the effectiveness of infrastructure policy professionals does not, and should not, rely solely on individual efforts. Organisations must also create the right *enabling conditions* to allow people to learn and develop. Individual efforts can only ever go so far to compensate for a lack of adequate leadership and support, and a well-functioning work environment.

The research interviews identify four key enabling conditions: workplace culture, leadership, paradigm change and metrics for performance. These conditions act as enablers for infrastructure policy professionals to put into practice the skills, knowledges and behaviours discussed in the previous section.

Workplace culture

Workplace culture appears a number of times in interviews, as participants stress that the informal norms around communication, problem-solving and collaboration are important to allow individuals to question assumptions, scrutinise alternative policy solutions and build trust with other colleagues. Since there is a common theme around the importance of challenging the status quo, whether that takes the form of fixed assumptions about societal infrastructure needs, or siloed working between different disciplines, a degree of openness in the workplace is important so that professionals are not disincentivised to raise challenges.

Participants mention that to change the culture at work they focused on challenging the linear, hierarchical mode of career development that is based around the progression of individuals as they gain more experience. Instead, they focus on building competencies in multidisciplinary teams:

*“Yes, **we do need to change the culture**... but it's things like the **traditional hierarchies of the professions**, it's just not going to be how it is, the way that I'll go back to engineers because that's where I came from. You start off being a mini-me and then you move on to a medium-me, and then, one day, you might become a big-me if you're lucky. It's just not how skills and value are going to be delivered. We're going to be delivering in those multidisciplinary teams. Actually, **people with relatively little experience may well bring an enormous amount of value and ways of thinking into projects**. It's not all about the years. The key is that you've been working. **It's about the way that you think and the way that you can bring, maybe convene people and bring ideas together.**”*

The emphasis on team-based or collaborative working comes from the recognition that it is unrealistic and unhelpful to push all individuals to have a complete skillset, like the ‘unicorn talents’ mentioned earlier:

*“There's no way that you can have all of these skills as strengths. So part of it is **you need to build the team around you that complements your strengths with their strengths.**”*

Culture change also implies a stronger recognition and professional commitment to the social and environmental aspects of infrastructure development, and some organisations note a trend towards more environmental consciousness in younger cohorts—although this trait is also very evident in some more experienced professionals as well:

*“It's noticeable, **the younger cohorts, the new graduates, are very mindful of the need to be much more careful and protective about the environment and ecology and deliver much improved sustainable credentials**. So definitely ambition, and definitely an appetite to do that.”*

Leadership

Hand-in-hand with workplace culture, leadership is another important enabler to set direction and show organisational commitment to improving infrastructure policy and development. Leadership

refers to the capacity of creating an environment for people to thrive, where they feel motivated, have space for exploration, for speaking up, for coming up with new ideas, and for growing, learning, and developing personally and professionally.

Existing competency frameworks set expectations for how members should provide leadership and mentoring. Members are expected to lead or influence their teams understanding the limits of their skills and knowledge. They should help to develop and assist others to meet changing technical and managerial needs. To motivate and influence others to agree and deliver objectives, to identify the individual needs of their team, plan for their development, assess their individual performance and provide constructive feedback. Members are also expected to provide expert leadership for multi-disciplinary teams (internal and/or external) to enable them to deal effectively with complex and contentious issues and tasks.

An interviewee identifies four dimensions of leadership: “leadership of self, leadership of others, commercial leadership, and technical leadership”. Following this taxonomy, the interview data fits mostly into the *leadership of others*. Some interviewees describe their working environments as spaces where learning is encouraged, mistakes are allowed as learning mechanism, and overseen by a supportive leadership, where feedback plays a very important role.

*“The leadership sets a tone for the way work is done and like how people feel about bringing in new ideas, because you might actually have a super diverse team but are you actually leveraging their talents, is another question. You might be really good at getting folks in the door, but actually can they articulate or are they inspired to articulate their views? Are they excited to share something that's new and might not actually work? All of that is really important for how the work gets done, but you really have to cultivate an environment. I think **the groups that do it well, they have those leaders with that experience.** I think the leaders who have that experience, that's a million-dollar question because I don't think in those traditional spaces that you're even rewarded for that early on. **I think it's something, the leaders really have to love that themselves and prioritise that as part of their brand.** I don't even know if promotions and all that stuff even takes that into account.”*

*“I've had quite a bit of the remit to create the **vision and the values and the culture.** We've on-boarded all of these people during a pandemic and **tried to create the environment that people are able to feel motivated to feel that they can bring their best ideas, that it's safe to challenge.** All of that stuff around, how do you create a high performing culture is something that you might not worry about if you're just in the strategy and the technical side. **The people is 90 per cent of it, right? So it's about people. It's a very different set of skills.**”*

One of the most relevant dimensions of leadership is mentoring, to provide professionals with ongoing support to improve their practice and learn from experience. Participants note that mentoring and coaching is not a one-way process whereby more experienced staff passed down their knowledge to junior staff. Rather, it should focus on building greater understanding between different staff and leveraging the diversity of perspectives and experiences to solve problems more creatively:

“Those who are experienced in a discipline need to be willing to enter into both mentoring and coaching roles as well as reflective roles in which they share their experience and try to match it to the skills, the perspectives, the priorities that we need for infrastructure policy and climate change policy going forward. It's definitely a multipolar type of thing. It's not a, 'These people are in control; therefore they have the knowledge. Therefore, they need to pass it down.' It's more, 'This is the dominant group who probably

*shouldn't be going forward, and **we all need to work together to make sure that's the case and the best of what that group knows is passed down.** That it's built on from multiple, diverse perspectives so that we're not just fixing problems in the same ways as we've done them, but we are understanding the root causes of problems that need to be fixed."*

Paradigm shifts

A common thread running through many interviews is the paradigm change that is underway as the infrastructure sector seeks to move past the legacy of siloed working, narrow conceptions of the value of infrastructure, and the reality that past infrastructure policy has been culpable for locking in high-carbon, environmentally-unsustainable modes of production and consumption. The interviews show the progress that has been made to think about infrastructure in a more holistic and integrated way, and point to the specific enabling factors to maintain this progress.

Ensuring that new projects or policies are led by professionals with a range of backgrounds is found to be an important factor in encouraging the paradigm shift:

*"The problem with projects at the moment is they're often project-managed, but **the project manager is an engineer by training, and so often, all they do is think about: how do we engineer this? How do we design this from an engineering, grey infrastructure, hard infrastructure, point of view?** What would be great is the project manager is an ecologist or a climate expert, or has an understanding of how nature allows—regarding climate adaptation and climate resilience, because I think climate adaptation, climate resilience are the two key things that are not talked about enough. Particularly the fact that it's very unlikely we're going to achieve that one-and-a-half degrees. So climate adaptation and resilience is going to be hugely important. So if they were project-managing it, and then had some engineers in that were involved in the design, then I think that would just work so much better."*

Another important aspect is interdisciplinary working and building competencies as a team, instead of isolated individual experts:

*"I'm leading a major project but I don't have a civil engineering background. So I need people around me that can provide that civil engineering challenge to the supplier that I'm going to be less able to do. Conversely, perhaps I'm a bit more experienced on the data, the analysis, the economics. I'm pretty good at the commercial and I'm pretty good at the stakeholder stuff and the strategy stuff. So **I've got some stuff, but my team have also got some others.** The important thing is, **between us we've got the skills that we need to deliver this.** So **the competency framework, interesting; should it be for the individual or should it be for the team? You think about whether the team as a whole has this covered.**"*

Metrics for performance

The final aspect of the enabling environment is the selection and use of suitable performance metrics to monitor and encourage professional development and team performance. Participants note that existing competency frameworks are used for promotion applications, but not necessarily on an ongoing basis to guide continuing professional development. This suggests that there is an opportunity for additional resources—not necessarily in the form of a standard competency framework—to support infrastructure policy professionals with skills development. While this report does not specify a set of performance metrics, these could be created at the organisational level, based on relevant topics covered within this section.

Section 4: Discussion and recommendations

This project aims to gain a better understanding of the skills, knowledges and behaviours required for infrastructure policy professionals to tackle complex societal challenges. We find that climate change, the biodiversity crisis, societal inequalities and digitalisation are major external drivers for change across the sector. Internally, organisations and professional bodies are actively working on improving equity, diversity and inclusion, and the lack of robust decision-making tools to grapple with complex infrastructure issues. The 2050 target to reach net-zero is particularly effective in catalysing action on decarbonising infrastructure systems, although at times the sole focus on greenhouse gas emissions comes at the cost of more holistic approaches to managing emissions alongside wider environmental and social outcomes. The fast pace of change in technologies and working practices sometimes causes strain in long-term projects with limited flexibility for change. On the part of infrastructure professionals, this demands:

- Undertaking continuous learning and an awareness of new innovations or policies affecting their work
- Improving flexibility, agility, creativity and ambition
- Pro-actively managing institutional knowledge, since projects and organisations often outlast people working in specific roles
- Adopting a mentality of embracing uncertainty and developing skills to manage it effectively

What were the key findings of this research?

Emphasising the development of behaviours within professional competency

Traditionally, training and education have focused on creating and acquiring knowledge. In the last couple of decades, there has been a push towards developing skills, with an emphasis in soft skills in the recent years. Our research shows that the infrastructure sector requires further emphasis of behaviours that can integrate these knowledge and skills into a broader, systemic, complex, interconnected, more diverse, awareness.

Awareness of methods and tools to plan for an uncertain future

Interviews raise critical questions about the overarching strategic premise of infrastructure in society, reflected in the quote “my fear is that we are getting quite good at learning how to deliver stuff better, but not to deliver the right stuff”. Deciding what the ‘right’ policies are is a process that involves politics and deep consideration of how infrastructures support society, and the degree to which they make it possible for people to have an improved quality of life without locking in dependency on finite resources or damage to the environment.

Recognising the complementary value of generalist and specialist backgrounds

While the idea of a competencies lends itself to individual development, the interviews conducted for this project show a strong appreciation of the need for cohesive and highly competent teams, as well as talented individuals, and a recognition of diverse skillsets within teams. There are positive feedbacks between an appreciation of diverse and cohesive teams and ongoing efforts to make the infrastructure sector more inclusive and diverse, since both initiatives seek to move away from narrow, exclusive cultures and notions of effectiveness and success within the sector. However, the interview data shows clearly that inclusivity concerns are distinct from broader cultures of teamwork and collaboration, and positive improvements would require persistent effort and championing from across the sector.

Evolving the recognition of professional accreditation as a license to operate

Historically, technical competency has been one of the primary considerations to gain professional accreditation. Interviews conducted for this project show that accreditation is still a major influence over which types of learning are prioritised, and in turn, the expectations for professionals. However, as noted in the ‘challenges’ section, there is an increasing need for professionals to focus on the environmental and social license to operate. Both the interviews and the review of existing competency frameworks show a notable gap in knowledge on the environmental impacts of infrastructure (notably related to climate change and biodiversity loss) as well as the social benefits of infrastructure policies or schemes. This suggests that integrating this knowledge to put it on an equal footing with other technical knowledge would improve the effectiveness of infrastructure policy professionals to grapple with current challenges facing the sector.

How can organisations or professional bodies use this report?

The competencies framework outlined in this report can be used to inform and assess areas for improvement in current training programmes (under and postgraduate programmes, CPDs and short courses, chartership or fellowship processes, internal organisational training programmes). This research is based on interviews with a range of practitioners to understand challenges across the sector, however, it may be beneficial for organisations to identify a subset of the skills and competencies that are most relevant for their staff, or engage with staff to better understand the detailed implications of these skills, knowledges and behaviours, for their everyday work.

Opportunities for further research

This project shows that practitioners within the infrastructure policy sector have a large amount of tacit knowledge and expertise that has been gained through experience and ongoing reflection, which is a valuable source of insight and guidance for researchers. Further research could be conducted to continue the line of inquiry of Crick & Bentley (2020) and this report, by engaging with specific organisations to co-produce research projects that support organisational goals for improving support for practitioners to develop specific skills, knowledges, behaviours and expertise. Another potential line of inquiry could examine the role of specific types of resources—such as competency frameworks—and how they are or are not used in practice to support continuing development.

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Appendices Appendix 1 – Analysis of existing CPD frameworks

Sixty-six (66) frameworks were included in the analysis, sourced from organisation websites. They were sourced using desk-based research focusing on taking a cross-section of professional organisations, employers, and public sector organisations across the different sectors which the team deemed to be relevant to infrastructure policy. These included engineering, wildlife, water, transport, the armed forces, and the civil service among others.

List of existing CPD frameworks analysed

(many of the institutions listed below have multiple frameworks for different thematic areas and stages of professional development. These links, wherever practicable, direct to the root page for these frameworks).

- Become a member | BCS - The Chartered Institute for IT.* (n.d.). Retrieved 16 September 2021, from <https://www.bcs.org/media/8826/fellow-applicant-guidance.pdf>
- Chartered Association of Building Engineers—Routes to Chartered Membership.* (n.d.). Retrieved 16 September 2021, from https://cbuide.com/page/routes_to_chartered_membership
- The Chartered Institution of Building Services Engineers (CIBSE)—Find your Grade.* (n.d.). Retrieved 16 September 2021, from <https://www.cibse.org/getattachment/Membership/Find-your-Grade/Fellow-Grade/FCIBSE-Application-Guidance-2021.pdf.aspx?lang=en-GB>
- Chartered Institution of Civil Engineering Surveyors—Competencies.* (n.d.). Retrieved 16 September 2021, from <https://www.cices.org/membership/about/competencies/>
- Engineering Council—Assessment Standards.* (n.d.). Retrieved 16 September 2021, from <https://www.engc.org.uk/standards-guidance/standards/>
- Engineering Council—Prof Bodies UK.* (n.d.). Retrieved 16 September 2021, from <https://www.engc.org.uk/about-us/our-partners/professional-engineering-institutions/>
- Engineering Council Information and Communications Technology Technicians (ICTTech).* <https://www.engc.org.uk/standards-guidance/standards/icttech-standard/>
- ICE Attributes for professionally qualified membership.* (2021, March 3). Institution of Civil Engineers (ICE). <https://www.ice.org.uk/my-ice/membership-documents/member-attributes>
- Institution of Engineering Designers—Apply for Membership.* (n.d.). Retrieved 16 September 2021, from <https://www.ied.org.uk/wp-content/uploads/2022/02/Product-Design-and-CAD-Standard-Edition-2-December-2021.pdf>
- Institution of Lighting Professionals.* (n.d.). Institution of Lighting Professionals. Retrieved 16 September 2021, from <https://theilp.org.uk/membership/>
- IMechE - Meeting the UK-SPEC - competence profiles and case studies.* (n.d.). Retrieved 16 September 2021, from <https://www.imeche.org/membership-registration/professional-development-and-cpd/working-towards-professional-registration/competence-framework-uk-spec>
- Institutions | EngineeringUK.* (n.d.). Retrieved 16 September 2021, from <https://www.engineeringuk.com/institutions/>
- Institute of Water.* (n.d.). Retrieved 16 September 2021, from [IWater Fellow-Application-Guidance.docx](#)
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- Science Council - Chartered Scientist – competency matrix* <https://sciencecouncil.org/web/wp-content/uploads/2021/01/Matrix-grid-of-competencies.pdf>
- Society for the Environment – Chartered Environmentalist Registration | CEnv - CEnv* <https://socenv.org.uk/chartered-environmentalist/>
- Stoker, D. (n.d.). The Institute of Marine Engineering, Science and Technology—Apply For/Upgrade Your Membership.* Retrieved 16 September 2021, from

<https://www.imarest.org/membership/membership-registration/upgrade-your-membership>

The Institution of Structural Engineers—Initial Professional Development (IPD). (2019, May 20).

<https://www.istructe.org/training-and-development/ipd/>

UK Civil Service Success Profiles (Current). (n.d.). GOV.UK. Retrieved 16 September 2021, from

<https://www.gov.uk/government/publications/success-profiles>

Appendix 2 – Interview data

Forty-two (42) interviews were conducted between October 2021 and February 2022. We sought to get an even gender balance: participants were 52% female and 48% male. 22% worked in the public sector, 29% in academia, 37% in the private sector and 12% in third sector organisations (Table 7).

Table 7: Organisations interviewed for the project

<i>Public sector</i>	<i>Third sector / academia</i>
Department for Digital, Culture, Media & Sport	Building Research Establishment
Department for Transport	Campaign for Better Transport
Highways England	Chartered Institute of Highways & Transport
Infrastructure & Projects Authority	Edinburgh Napier University
Kirklees Council	Northumbria University
London Underground	Royal Academy of Engineering
National Infrastructure Commission	Royal Town Planning Institute
	Sustrans
<i>Private sector</i>	Transport Planning Society
Aecom	University College London
Arcadis	University of Birmingham
Arup	University of Manchester
Atkins Global	We Own It
Buro Happold	Women in Transport
The Business of Cities	
Urban Foresight	

The interview protocols, provided below, were used to structure a discussion about each participant's career trajectory, the current challenges facing their profession or organisation, and their reflections on the most important skills, knowledges, experience and behaviours for professionals in their field. Interviews were recorded, transcribed and analysed for emergent themes using NVIVO.

Thematic analysis involved developing a set of codes to isolate different topics covered in the interviews. We opted to use pre-defined codes instead of a purely inductive analysis because it was necessary to target specific topics to respond to the project's aim, such as discussions about knowledge, skills and competencies, and existing modes or learning and professional development. However, a semi-inductive approach was introduced by validating samples of the data against these pre-defined codes and revising the codes to ensure they captured the full breadth of relevant interview content. The resulting list of Parent Codes and Descriptions is provided in Table 8.

Table 8 - Parent Codes and descriptions

Parent Code	Description
Change	Drivers for / attitudes to change & challenging the status quo
CPD Frameworks & Learning	Statements about formal frameworks for professional development, formal and informal learning
Disciplines	Statements about significance of disciplines, individually or collectively

Ethics, Fairness and Justice	Statements about ethics, fairness or justice
Finance / Resources	Statements about financial and non-financial resources
Governance	Ranging from community involvement and interactions with / between sectors and actors
Infrastructure Definitions	Definitions / scope of infrastructure inc. specific sectors
Knowledge, Skills, Competencies	Statements about knowledge, skills and competencies
New Thinking	Statements that interviewee did not frequently think about or answer the questions that we posed
Policy Processes and Politics	Relational space, communication with stakeholders and activities throughout policy process
Scales	Statements about scale inc. spatial, temporal
Stakeholders	Statements about individuals, groups and institutions

Using these Parent Codes, we divided the data for further analysis, structured around the plan for this report. Table 9 shows which codes corresponded to the different aspects of this report. Primary themes were derived inductively from coded data to respond to the question that characterised each aspect of the analysis.

Table 9 – Use of codes to develop analysis

Aspect of the analysis	Parent Codes used
How are infrastructure policy professionals trained?	<i>CPD Frameworks and Learning; Disciplines; Policy Processes and Politics; Stakeholders; Governance; Ethics, Fairness and Justice</i>
What are the current challenges faced by the sector?	<i>Change; CPD Frameworks and Learning; Disciplines; Infrastructure Definitions</i>
What are the key knowledges, skills and competencies required by policy professionals?	<i>Knowledge, Skills, Competencies; CPD Frameworks and Learning; Disciplines</i>
What enabling conditions are important for professionals to be more effective in this sector?	<i>Change; CPD Frameworks and Learning; Disciplines; Infrastructure Definitions; Governance; Ethics, Fairness and Justice</i>

Interview protocols

Describing the sector

Could you briefly describe the sector you work on / in?

- What are the most important challenges you see in your sector today?
- Would you also include in this list [the recovery from COVID-19, climate change, global environmental risks such as flooding and hurricanes, resilient and sustainable development]?

How does your sector contribute to, overall, improving wellbeing and livelihoods?

- What do you see is the connection between your sector and the concepts of justice and fairness?

In terms of disciplines, how diverse is your team and organization?

- What are the advantages/value and disadvantages of this diversity (address inter and multidisciplinary)?
- Do you see a predominance of a specific discipline or backgrounds in the sector?
- What do you look for when recruiting someone to work in your team? OR
- And with someone to collaborate or partner with?

Relevant competencies

What do you think are the most important skills, knowledge, or qualities for you to be competent in your role?

- Why are these things important?
- How did you learn them?
- How do you see the balance between technical knowledge (“hard”) and skills associated to communication and management (“soft”)?
- How were these skills, knowledge, and qualities affected after the experience of COVID-19 and how might they change(?) going forward?

Are you aware of any competencies frameworks, accreditation systems or continuing professional development pathways in your sector?

- What do you think about it?
- What is the importance of defining competencies for professionals/a competencies framework for your sector?
- How are these defined and who oversees their application?
- Are these updated over time?
- Do you see these competencies as unique to your sector, or see them elsewhere? *[if necessary, provide examples across infrastructure—transport, water, green infrastructure, energy, or telecommunications]*

Formal vs informal learning

What is your field’s/organization’s perspective about continuing professional education and postgraduate degrees? *[is this valued, encouraged, expected, funded...?]*

What does informal learning contribute to the development of skills and competencies?

[informal education/learning referred to as more unplanned, self-oriented, including conversations with peers, mentorships at work...]

Do you see any professional ownership of ethical principles within your sector? *(is it institutional, individual, or collective)*

What are the main challenges for the sector, regarding these issues?

Learning journeys

How does your institution/organisation adapt to change?

- How innovative is your sector? / What is the process to innovate in your sector?
- During your career, have you identified skills that were useful before which are not necessarily relevant anymore and vice versa skills that you consider are relevant now?
- How do competency frameworks within your map on to the reality of your work?
- How does learning happen within your organization? Are there mechanisms that allow individually acquired knowledge to turn into collective/ institutional know-how? (e.g., formalising experience so it is not lost through time: monitors and evaluates, implements new technologies, trainings, iterative and collaborative processes, collaborates with academia, collaborates with industry, pushed by public sector and/or regulation)

How does your organization/sector deal with risks and uncertainties? (e.g., climate change scenarios, political will, economic shocks)

- Are there methods or considerations for more flexible, responsive approaches?
- How have you adapted to the challenges you have previously identified for your sector? (e.g., managing complexity, big data - converting data into meaningful information- working across disciplines to address inequalities, climate change, economic recovery, integrated infrastructure)

Policymaking stages

From those skills you have identified previously, could you give examples of when you had to use them (in a policy context)?

- How did you recognise them as useful/fundamental?
- What is the rationale used in your sector to select/ prioritise projects, designs, technologies, etc.? (e.g., the criteria used for options appraisals)
- At what stage of a project or your career have you had to use these specific skills?

How does your sector deal with the tension between technical expertise and politics (i.e., the different languages used, use of evidence, interests)? *How do technical and political dimensions of policymaking interact in your sector?*

What would be the role of your sector in addressing social inequalities and injustices?

- Are people you work with aware of this?
- Is this an explicit mandate or is person-dependent?