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Historical Geographies of Engineering: Knowledges, Practices, Identities

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ABSTRACT

Drawing on established scholarship in the historical geography of science, the history of technology and science and technology studies, this paper argues for the significance of an historical geography of engineering. Large-scale and transformative infrastructure projects have been a common focus in historical geography, however comparatively little attention has been paid to the engineers responsible for designing and implementing them. This paper reviews recent work which has foregrounded engineers and their work across diverse times and places. It conceptualises engineering in three ways: as a form of knowledge about the world that is connected to, but distinct from, science; as a set of practices undertaken in specific locations; and as an identity that, since the profession's origin in the 18th century, has enabled individuals to claim expertise in relation to environmental management and therefore exert power over land, territory and people. The article reviews geographical inquiry that foregrounds these perspectives on engineering and suggests future directions for research in the field.

1 | Introduction

Geography is crucial in the history of science. Since the 1990s, geographers have argued that scientific knowledge is constructed through human action, and that this action always takes place in, and is shaped by, its social and spatial contexts (Shapin 1998; Naylor 2005; Powell 2007; Finnegan 2008). Numerous works have analysed diverse geographies of scientific production, interpretation, transmission, dissemination and reception (Withers 2001; Livingstone 2003; Livingstone and Withers 2011; O'Sullivan 2019; Naylor and Goodman 2020; Mayhew and Withers 2020). Like science, engineering can be understood as comprising a range of human actions carried out in particular places, ranging from the office to the lecture hall to the meeting room to the field, with the aim of generating particular kinds of transferable knowledge, power and authority. Given the similarities between science and engineering, it has been suggested by Maria Lane (2020, p. 700) that, 'historical geography should embrace engineering in the same way it does science'.

While there are many similarities and connections between the two, historians of technology have established that engineering should be considered a fundamentally distinct form of knowledge and practice from science. To consider engineering as merely the application of scientific knowledge to the material world is overly simplistic—there are practices, skills and forms of knowledge that are unique to engineering, each of which have their own geographies (Layton 1974; Hansson 2007; Meijers 2009; Boon 2011).

The primary goal of engineering is the creation of material things and the reshaping of physical spaces. While geographers have studied many engineering projects, considering their political or economic origins and their social and environmental implications, attention has only begun to be paid to engineering itself as a socially and geographically transformative process, to the technical questions involved, and to the engineering professionals whose work brought about material and environmental change. As Lane (2020, p. 713) points out, 'few historical geographers have explicitly addressed engineering in a science and technology studies framework—as a profession, practice, narrative, or mode of knowledge creation'.

Engineering is a notably diverse field, encompassing various career paths, specialisms and national traditions. Originating as a named profession in 18th century, many early engineers came from artisanal backgrounds such as stone mason, instrument maker or mill wright (Jones 2011). In the 19th century, routes into engineering narrowed, usually requiring formal training through pupillage in Britain or an engineering school in Europe (Hirose 2010). Subfields such as civil or mechanical engineering emerged, differing in status, personnel and methods of training and practice. Engineering also differed nationally: French engineers were state-controlled in their training and practice, while the most prestigious British engineers acted as independent 'consulting engineers' (Lundgreen 1990; Andersen 2011b). Some national engineering traditions, such as those of Russia and Spain, were heavily influenced by the French system, whiles others such as in Britain, Brazil and the United States differed substantially (Lundgreen 1990; Gouzévitch 2011; Martykánová 2014; Silva, Batholo, and Proença 2015).

Lane (2020, p. 698) suggests we might study 'engineering as transformation, engineering as connection and dislocation and engineering as displacement'. This approach links with geographical work analysing the social, political, economic and environmental implications of material and spatial transformation brought about by processes such as industrialisation, urbanisation and imperialism. Nineteenth-century engineering projects such as the telegraph and the railway have been recast as projects of national and continental reimagining, leading to the connection of some and the dislocation or displacement of other, communities (Rozwadowski 2001; White 2012; Lane 2020; Pereira 2024). The same technologies were used to extend colonial power and territorial control in Asia, Africa and the Americas (Marsden and Smith 2005; Adas 2006; Decker 2020; Cowen 2020). Work on 20th-century water engineering has analysed the social, political and technical construction of 'modern water' and its connections with processes of colonial, postcolonial and nationalist reimagining (Linton 2010). Water engineering projects, particularly large-scale dams, have been the focus of studies considering nation-building and the politics of development (Kaika 2006; Swyngedouw 1999; Shamir 2018). Engineers themselves, however, are often only included in such enquiries by implication, as the technical agents responsible for implementing projects decided on elsewhere and by others. This approach illuminates the relationship between infrastructure and society, but misses a detailed focus on engineering as a spatially specific technical practice and on engineers as agents of social and political change.

This article extends Lane's call for historical geographers to turn to engineering, exploring a series of themes that arise from a focus on engineers, rather than engineering projects. These themes are engineering knowledge—the way in which engineers conceptualised space and their professional relationship with it; engineering practice—the place-specific practices carried out by engineers to develop, demonstrate, validate and deploy engineering knowledge; and engineering identity—how and where engineers came to think of themselves as engineers, and present themselves as such within society.

2 | Engineering Knowledge

Historians of technology have established that engineering required knowledge that was different to the knowledge required in science. As Mitcham and Schatzberg (2009, p. 40) note, 'scientific laws do not immediately function as engineering design principles,' but must be translated and combined with other kinds of knowledge to produce a material artefact or change to the environment. Engineering principles such as how to build structures and manufacture artefacts, or how to intervene in dynamic physical systems to produce specific effects, combined knowledge of science, personal experience and, as the profession grew, consideration of precedents, codes of practice and professional standards. Because of this, engineers occupied a liminal professional position that Jonathan Harwood (2006, p. 54) refers to as 'the Janus-faced nature of engineering as an activity—situated since the 19th century between the worlds of 'science' and of 'practice''.

It is also significant to understand how engineers framed the extent and purpose of the specialist knowledge they amassed about the environment. From its origins in the 18th century, Western engineering has been dominated by the ideal of controlling nature. In the Charter of the London-based Institution of Civil Engineers in 1828, Tredgold (1828, p. 9) famously explained engineering as 'the art of directing the great sources of Power in Nature for the use and convenience of man'. In this definition, he imagined the profession as defined by a shared goal and attitude to nature, regardless of the practices or people involved. The idea is echoed in some later accounts of engineering: Henry Petroski, a philosopher and civil engineer, for example, argued in 1985 that engineering aims 'to make something stand that has not stood before, to reassemble Nature into something new' (Petroski 1985, p. 9). Introducing the edited collection *Water, Engineering and Landscape* in 1990, geographer Denis Cosgrove reflected on 20th-century engineering as characterising 'a triumphalist age of apparent mastery over nature' (Cosgrove 1990, p. 1). Kaika (2005, p. 13) associated this perspective with the broader 'Promethean project' of modernity which aimed to tame nature for human purposes and thereby manifest human control over space in urban contexts. This way of imagining humanity's relationship to nature has been highlighted across multiple contexts by geographers and historians interested in urban and industrial development, territorial power and modernity (Oliver 2000; Mitchell 2002; Hommes and Boelens 2014).

Careful attention to the historical geographies of engineering knowledge, however, illustrates that this model of engineering as domination over nature is historically and geographically contingent, emerging from and perpetuated by 19th and early 20th century Western culture. In other times and places, engineers developed alternative ways of imagining the environment and their relationship with it, for example, seeking to accommodate or work with, rather than control, natural phenomena such as river flows, weather, atmospheric conditions, waves and tides. Acknowledgement of the limitations of the model of control has in recent years led engineers to replace traditional 'hard' engineering solutions with 'soft' engineering, 'building-with-nature' systems, or nature-based solutions (Qi et al. 2020). Rather than controlling nature for human ends, these interventions, informed by environmentalist perspectives, 'are geared at green, ecological, and biophysical infrastructure derived from elements within the landscape as a means to divert risk and (re-) direct urbanization' (Soens, de Block, and Jongepier 2019, p. 689). In some contexts, challenges to the ideas of engineering as control have engaged with indigenous epistemologies, technologies and practices (Forrest and Cicek 2021). Elsewhere, criticism of engineering projects has derived from aesthetic concerns around protecting natural beauty (Gruffudd 1990). A focus on engineering knowledge has enabled researchers to ask why and with what consequences particular models of human-environment relations became dominant or even hegemonic in particular times and places, and to consider the role of engineers in shaping societal attitudes to nature.

Even where discourses of engineering as control were close to hegemonic, material conditions presented challenges, as has been shown in work analysing disasters, accidents and failures (Pritchard 2012; Dishington 2020). One example is work on the short and long term social, cultural, economic and environmental impacts of flooding brought about as the unintended consequence of engineering works, or by the failure of flood defences (McEwen and Werritty 2007; Ewen 2014b; Mizelle 2014; L. J. Hill 2015). Engineers associated with failed projects had to answer to clients, the government, the public and their peers and could face professional and personal censure if they were unable to adequately defend their methods, judgement and professional reputation (Hunt 1996; Dishington 2020). Engineering failures could also cause significant environmental challenges, lead to new collaborations, regulations and ways of working and spark debates over the wisdom of pursing the interventions in the first place (Wellock 2013; Gill 2016; Dishington 2020). By focusing on how, despite their rhetoric of dominance, engineers in practice struggled to control environments, theorists from a range of disciplines have developed models of engineering which emphasise hybridity, negotiation and compromise. Such approaches include environmental historian White's (1995) 'organic machine'; urban historian Ewen's (2014a) 'socio-technological disasters'; environmental STS scholar Pritchard's (2011) 'envirotechnical systems'; and geographer Swyngedouw's (2015) 'hybridized landscape'.

Despite its complicated position in practice, the idea that engineering meant control was connected in important ways with other geographical concepts, particularly territorial and colonial expansion. Control over land and its physical features has been identified as a means of demonstrating political power over territory and its inhabitants. Chandra Mukerji argued that the 16th century Canal du Midi in France served as a, 'as a silent demonstration of disciplinary power over the earth' and 'demonstrated the efficacy of a new kind of power, engineering the land as a form of government...a model of impersonal rule' (Mukerji 2009, p. 2, 5). Through engineering landscapes, modern states materially manifested claims to power. Within Britain, studies have analysed how engineers became embedded in political struggles over control and management of natural resources ranging from London's water supply to Derbyshire's lead mines to fisheries on the River Tay (J. Hillier 2014; Endfield and van Lieshout 2020; Dishington 2024). This concept has been adopted to explain how engineering infrastructure facilitated the physical and conceptual extension of territorial control within empires, for example, by the British Empire in the construction of railway systems in India and Australia; the Aswan Dam in Egypt; and the Owen Falls Dam in Uganda (Marsden and Smith 2005; Andersen 2011a; Shamir 2018).

In postcolonial contexts, engineering projects similarly took on wider political significance in connection with discourses of development, modernity and nationalism. Large-scale infrastructure projects such as dams have been recognised as 'set-pieces of nation-building' (Bromber, de la Croix, and Lange 2014, p. 290) and 'a way to build not just irrigation and power systems, but nation-states themselves' (Mitchell 2002, p. 44). Such projects functioned as powerful national symbols (Kaika 2006; Suyarkulova 2014; Miescher 2014; Cowen 2020). Beyond this symbolic significance, the systems required to implement significant engineering projects were themselves important in constituting nation-states. As Swayamprakash (2014, p. 155) suggests 'arguments by engineers were preformative as much as representative acts': the discursive construction of engineering projects simultaneously solidified the contours of the nation, while the bureaucracies and managerial systems required for major engineering work went hand in hand with the growing legitimacy and power of the postcolonial nation state. The social and political position of technical specialists such as engineers was accordingly reframed: in postcolonial Africa, Craggs and Neate (2024) demonstrate that academic expertise was explicitly imagined as supporting large-scale national infrastructure, discourses of development and nation-building, while in Brazil, Silva, Batholo, and Proença (2015) identify a shift in the identities and roles imagined for engineers in response to shifting political geographies.

From railways to lighthouses, mines to canals, steamships to hydroelectric dams, large-scale infrastructure projects supported the conceptual assertion of authority over space by colonial and national authorities. At the same time, they brought about substantial economic, bureaucratic and physical changes, including the often-violent dispossession of indigenous communities and the remaking of environments to destroy or significantly alter their ways of life (Marsden and Smith 2005; Adas 2006; Andersen 2011a; Cowen 2020). Such infrastructures became powerful symbols, underpinning narratives of imperial and national identity, civilisation, progress and modernity. Every stage in the development, construction and maintenance of these infrastructures drew upon engineering knowledge which was filtered through engineering perspectives on the appropriate relationship between humanity and the environment.

3 | Engineering Practice

Drawing on insights from phenomenology, sociology, anthropology and gender studies, the shift to focus on practice, known as the practical or pragmatic turn, significantly reoriented the history of science from the 1980s (Golinski 1998). Knowledge began to be understood as being 'made and sustained through situated practical activity' (Shapin 1994, p. xix). Science, therefore, was analysed as 'a practical activity, located in the routines of everyday life' (Secord 2004, p. 657). Latour (1987), for example, drew attention to the significance of the material in constructing scientific knowledge in his observations of the everyday work activities of scientists. Scholars who focused on practice challenged earlier approaches that understood science as theoretical and idea-based, comprised primarily of written outputs and interested solely in the search for universal laws and the testing of hypotheses. The turn to practice was a crucial element in the growth of the historical geography of science: if science was understood as a series of practices carried out by people, it followed that those practices were carried out in specific places.

Engineering theorists have also adopted this focus on practice, using methods such as ethnography to ask questions about the routine processes carried out by engineers (Buch 2015). How did carrying out specific actions enable them to make authoritative knowledge about sites, materials and processes? Within what spaces and places did these actions occur and why? To what extent, and for what reasons, were specific practices recognised as part of 'engineering'?

By focusing on engineering practice—on what engineers do on a day-to-day basis—it has been shown that, in addition to specialist theoretical knowledge, successful engineering requires tacit skill. Developed by anthropologist Michael Polyani, the idea of tacit skill challenges positivist conceptions of knowledge as 'abstract, mechanical, deterministic and therefore possible to centrally plan' (Nightingale 2009, p. 353). Some knowledge or skill, Polyani argued, cannot be fully articulated, codified or formalised, but is nevertheless fundamental to the ability of an individual to successfully complete a task: tasks like drawing or playing the piano cannot be learnt purely through theoretical study but require tacit skill that can only be acquired by practice. This concept has been used to argue that scientific expertise is not simply recalling facts or understanding theories, but also includes knowing how to perform actions such as calculating, observing or measuring (Collins and Evans 2002). In the same way, engineering has been shown to include both knowledge of theory and tacit skills such as drawing, measuring, visualising, imagining, evaluating, negotiating and managing (Robertson 2013; Dishington 2024). Historical geographies of engineering consider how different forms of engineering knowledge and skill were made, and made authoritative; what people or groups were associated with them; what hierarchies structured the relationship between different practitioners and forms of knowledge; and what places were significant in these processes.

One important activity that has been analysed is the practice of measurement. Drawing on an extensive body of work in the historical geography of science considering the nature, use and authority of scientific instruments, historical geographies of engineering have similarly begun to consider measuring practice and instruments (Warner 1990; Withers 2013; Taub 2019; J. Wess 2023). In a scientific context, this work has considered how practitioners established the credibility of knowledge derived through field research, for example, through the construction of a specific field site as a 'truth-spot' (Gieryn 2006), and has explored the differences between the principles used to legitimate knowledge claims made through field research in comparison with other spaces such as the laboratory (Kuklick and Kohler 1996; Kohler 2002). Similarly, research in geography has demonstrated the significance of instruments and practices of measurement in the creation of knowledge in exploration and surveying (Driver 1998; Macdonald and Withers 2015; Naylor and Schaffer 2019; J. A. Wess and Withers 2019). Researchers have analysed the challenges of maintaining credible results in light of the difficulties of transporting fragile instruments over significant distances and operating them in remote and inhospitable field locations (Schaffer 2011; Fleetwood 2017; Withers 2019).

Measuring and quantification in engineering have been theorised as working to transform natural forces such as rivers into abstract, calculable and predictable forms which could then, in theory, be easily controlled (Dishington 2024). Further avenues for consideration of the role of instruments and measuring in engineering remain. As has been shown in work on exploration and citizen science, the time-consuming and labour-intensive nature of large-scale measurement required substantial administrative and bureaucratic management, as well as collaboration between a diverse range of people, many of whom have been omitted from mainstream historical narratives (Achbari 2015; Naylor 2019). Future work in the historical geography of engineering could consider how measuring practice intersected with global engineering networks and involved previously understudied actors, particularly local contractors and apprentices. Porter (1995) has shown that the role of measurement in engineering differed geographically in relation to national engineering customs and cultures. Further work could use a geographically sensitive focus on measurement to develop more nuanced analysis of particular engineering customs and cultures, and the ways in which they were extended, modified or abandoned in particular environmental conditions.

Visualisation through technical drawing has been highlighted as another important, and geographically specific, engineering practice. Geographers have long drawn attention to the power of maps and practices of map-making to instil certain ways of seeing the world with authority and power (Harley 1988). In engineering, drawings served a slightly different, but no less critical, function. In the 1970s, engineer and historian Ferguson (1977, p. 828) drew attention to the significance of the visual in engineering design, arguing that an engineer 'thinks with pictures'. Subsequent work further developed analysis of visualisation in engineering. Where geographers have shown that maps drew their power from being accepted as an accurate representation of reality, engineering drawings have instead been considered 'fantasy visualisations' which explicitly imagined a future reality (Robertson 2013, p. 128). They functioned as what Dobraszczyk (2008) calls 'mediating representations,' communicating a design to contractors, politicians and the public, thus playing a role in bringing the imagined futures they represented into being. Beyond this communicative role, Robertson (2013, p. 132) has argued that 'knowledge was made and defended by visual means in engineering'. Engineering visualisations were used to validate the authority and status of engineers over other specialists, as Nystrom (2014) has demonstrated in the context of mining engineers in the United States. Practices of representation and the functions served by engineering diagrams were multiple, complex and provide important avenues for inquiry for geographers interested in the nature and power of visual representation.

A focus on what engineers do draws attention to ongoing processes of maintenance and repair, challenging the traditional prioritisation of design in studies of engineering (Jackson 2013; Denis, Mongili, and Pontille 2015; Russell and Vinsel 2018). Examining the work done to maintain and repair artefacts and infrastructures draws attention to new geographies of engineering outside of traditional sites associated with innovation. Edgerton (2006), for example, directs attention to the reuse and remaking of technology by mechanics in the Global South and examines the particular, locally embedded, knowledge and skills that such work required. A focus on repair can also highlight overlooked contributions to knowledge production in otherwise well studied contexts by those who may not traditionally be considered scientists or engineers, for example, those who were responsible for building, calibrating and maintaining equipment in 17th century laboratories (Shapin 1989). Finally, it facilitates alternative ways of understanding relationships between humans and technology, for example, through frameworks highlighting a logic of care in technical work (Denis, Mongili, and Pontille 2015).

These three examples demonstrate the potential of geographical study of engineering as a spatially situated practice. Future research drawing on such approaches could consider the geographies of other common engineering practices such as research and theorising; teaching and learning; evaluation, testing and expert witnessing; financial management; the presentation of ideas through speech or writing; and interpersonal interactions with clients, employees and the public.

4 | Engineering Identity

Finally, historical geographers have considered what it means to be an engineer, how this might intersect with other identities and how engineering as a professional identity was built by specific kinds of disciplinary and professional boundary work, much as science was demarcated from non-science (Gieryn 1983). Engineering identities were formed, negotiated and performed within a wide range of spaces including the family home, engineering office, meeting room, classroom, field site, or learned society, and intersected with other identities such as gender, race, class and disability.

Early studies of engineering as an identity placed it within the history of professionalisation (Morrell 1990). In 1990, historian Morrell (1990, p. 982) analysed engineering through the 1930s Carr-Saunders/Wilson model of professionalisation as 'a process involving the pursuit of various forms of power'. Using a functionalist approach, Morrell attempted to identify key mechanisms of profession formation such as institutions, behavioural expectations, difficulty of entry and growth in numbers, that enabled a group to obtain and exercise profession-related power. Early examples of these mechanisms can be identified in engineering from the 18th century, including first adoption of the title 'Civil Engineer' by John Smeaton and the formation of the Society of Civil Engineers (later the Smeatonian Society of Engineers) in 1771 (Buchanan 1983).

As the number of engineers grew, the status and social power of engineering increased, and engineers began to evidence a self-conscious professional identity and to think about what it meant to be an engineer in both technical and social terms (Buchanan 1989). This is significant as sociologists Collins and Evans (2002) have conceptualised expertise as both substantive and attributed: it is the ontological characteristic of having specialist knowledge or experience, but also a social construct that confers special status and power to the person considered an expert. Applying this analytical perspective to engineering highlights what engineers needed to know or do, but also how engineers came to be recognised and wield power within society.

Work on expertise as substantive has considered what an individual should know, learn, or be able to do in order to be considered an engineer. One theme highlighted by such work is the ongoing relevance of personal experience and engineering judgement, despite the growing significance of unattainable ideals of 'mechanical objectivity' within contemporaneous scientific work (Daston and Galison 2007). Engineering decision-making explicitly and self-consciously combined scientific or theoretical knowledge with judgement based on personal experience. As engineer McLaughlin (2021, p. 215) put it 'to the engineer, scientific truth has always been suspect. Probably one of the oldest engineering comments was "That works in the lab, but out here in the real world it does not work that way."' Conceptual framings and language which explicitly combined theory or abstraction with experience and expert judgement have been traced in many cases. Macfarlane (2019), for example, has demonstrated that place-based knowledge and local expertise, as well as acknowledgement of uncertainty, were deployed in works carried out on the St. Lawrence River and Niagara Falls in the 20th century. A focus on engineering, therefore, has introduced important nuance to common stories of increasing precision and reliance on impersonal abstraction and quantification in the modern period (Parrinello, Benson, and Graf von Hardenberg 2020).

In social terms, engineering since the 18th century has developed significant power and prestige. Scholars have studied this process, asking how and in what places engineering acquired this elevated status. In particular, 19th-century European colonialism was intimately connected with engineering. Headrick (1981) influentially argued in 1981 that technologies functioned to materialise power in imperial contexts and could therefore be considered 'tools of empire'. Others have subsequently traced the relationship between British imperial systems and the growing power and influence of engineers in Britain, and particularly London. Andersen (2011b), for example, identified imperial projects as an important means of elevating an influential cohort of consulting engineers based in and around Great George Street, Westminster in the 19th century. The status, reputation and metropolitan location of this group enabled them to control technical aspects of imperial infrastructure, but also to work as intermediaries connecting imperial administrators with London-based financiers and contractors, and placed them in a privileged position to secure work directly from the Colonial Office (Andersen 2011b). Individual-scale stories have explored how particular engineers demonstrated expertise and secured status, crossed national and imperial boundaries, and developed transnational networks, reputations and sensibilities (Pursell 2010).

Engineering was connected in important ways with ideas of social class. Engineering, and particularly colonial engineering, represented a path to gentlemanly status in the late 18th and early 19th century (Buchanan 1983). Sites of professional status such as learned societies and engineering institutions, particularly the Institution of Civil Engineers, could function as gentlemen's clubs for those who would otherwise have no access to such facilities (Buchanan 1983). From the 1850s onwards, particularly impressive or large-scale infrastructural works could even result in knighthoods for their engineers (Andersen 2011b): Sir Daniel Gooch, for example, was made a baronet in 1866 for his work in laying the first trans-Atlantic telegraph cable (Buchanan 1983).

As professional spaces increased in power and prestige, the boundaries drawn around institutional membership came to play an increasingly important role in defining the engineering profession. Women were excluded from early engineering establishments and societies, and therefore, by extension, from being recognised as members of the profession. Before the 20th century, women involved in engineering work often framed their involvement in other ways than through claiming the professional identity of being an 'engineer'. Some, for example, used family relationships as the 'devoted daughter,' wife or sister of an engineer to position themselves within the profession without challenging contemporary gender norms, even when the work they were presenting or defending was their own (Edwards and Harcourt 2018; Rees Koerner 2021). The first British women to call themselves engineers in the early 20th century had to negotiate spaces such as the learned society or academic conference carefully, considering how to dress, act and present themselves to secure respect as a 'lady engineer' within these masculine-dominated and masculine-coded spaces (Pursell 1993). Similarly in the United States, female engineers faced challenges presenting themselves as engineers in college settings and had to negotiate gendered expectations in order to demonstrate their competence as 'good engineers' (Bix 2004).

Social constructions of engineering expertise in the 19th century were also connected with contemporary racial politics. While white British engineers working to support imperial expansion and control were in the majority, Broich (2016, p. 200) has shown that Asian and African engineers developed their own engineering identities, adopting elements of the 'engineering profession's self-image as the vanguard of modern civilisation' but challenging implicit racial hierarchies that positioned whiteness as a critical part of being an engineer. Broich's analysis draws attention to the engineering colleges and organisations training and employing non-British engineers within the British Empire, including in India, Egypt, Ceylon (Sri Lanka), Sudan, Hong Kong, Ghana, Malaysia, Malta and Nigeria. Decker (2020) has analysed how indigenous railway workers made choices within German imperial systems to construct railroads in Namibia, while Silva, Batholo, and Proença (2015, p. 96) have traced the development of a self-consciously Brazilian engineering associated with nation-building initiatives in contrast to 'engineering *in Brazil*' [original emphasis] carried out by foreign experts, primarily with the goal of exploiting resources. Such work challenges the tendency to imagine engineering as enacted by white colonial agents of empire on a passive local population, instead highlighting engineering knowledge and techniques developed and practised outside of Europe. As environmental historian Hasenhörl (2021, p. 124) pointed out in 2021, it remains 'very rare that the tables are turned, with transfer processes towards Europe—or ones that bypass the Western world entirely—as the centre of attention' in histories of technology.

Finally, some work has begun to consider how engineering was constructed in relation to ideas of bodily capacity and disability. Through processes of professional and disciplinary identity formation, ideas that linked intellectual ability, precision and accuracy, and the capacity for expert judgement with some bodies and not others became engrained in many engineering contexts (Slaton 2013). Despite these powerful and often invisible assumptions, disabled people have practised engineering since the profession began—for example, 18th century visually impaired road surveyor, John Metcalf, known as Blind Jack of Knaresborough (Smiles 1904), or 19th century lighthouse engineer Alan Stevenson who experienced chronic pain and intermittent paralysis while working for Scotland's Northern Lighthouse Board (Mair 1978). Slaton (2013, p. 1) highlights that ideas about disability and engineering are constructed and performed in particular spaces such as 'classrooms, laboratories, factories, and construction sites; at engineering industry trade shows and academic meetings; in the halls of funding agencies and engineering-firm HR departments'. She refers to this as the 'politics of engineering epistemologies around issues of disability' (Slaton 2013, p. 2). In other words, her work investigates how disabled individuals have been excluded from engineering through the taken-for-granted and often unspoken ways in which engineering knowledge and practice are imagined and performed within particular spaces. Future research could extend this work to other times, places and institutions, or could consider the ways in which disabled engineers, like female engineers, were able to negotiate engineering spaces not designed to include them, and to perform engineering identities despite discriminatory assumptions.

5 | Conclusion

Drawing on approaches from the historical geography of science and science and technology studies, this article argues for an historical geography of engineering. In addition to considering the influence of infrastructures, historical geographers have begun to consider the work done to create and maintain them, and the people involved in that work. Researchers have considered the places where engineering happened, the types of knowledge that engineers generated about spaces, the locally specific practices they carried out, and how their public reputation and personal identities were developed in particular geographical contexts. In other words, historical geographers have demonstrated that engineering, like science, is fundamentally shaped by its geographies, and have begun to develop a historical geography of engineering which considers the spatially situated knowledge, practices and identities of engineers.

Recognising that relevant contexts of study 'are produced by how practitioners in the past worked and configured their work' (Mayhew and Withers 2020, p. 13), broader analysis may begin to explore the geographical frameworks and sites that were meaningful to engineers themselves, bearing in mind, as Edgerton (2006) has shown, that this may lead beyond traditional metropolitan centres and engineering institutions, and include activities that may not be traditionally considered 'engineering'. Such an approach may highlight spaces and practices that were crucial to the everyday work of engineers that have so far been neglected in histories of the profession, or lead to individuals that have not so far been considered significant.

Geography must continue to play a role in future research in the history of engineering. Beyond work to expand on the range of local examples and case studies available, further work should consider how engineering as a specific form of knowledge about space was implicated in the spatial politics of power. Engineering acted as a means of exerting power over physical environments, and therefore over the people who inhabited them. This professional power intersected in complex and geographically contingent ways with gender, race, class and disability as people worked to define what it meant to be an engineer, and to situate themselves within a rapidly growing and constantly changing profession. The stakes were high: to be an engineer entitled one to significant power and authority within society and over the environment. As the depth and diversity of the historical geography of science has demonstrated, the possibilities presented by beginning from the understanding that knowledge has a geography are numerous, and historical geographies of engineering have thus far only begun to scratch the surface.

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