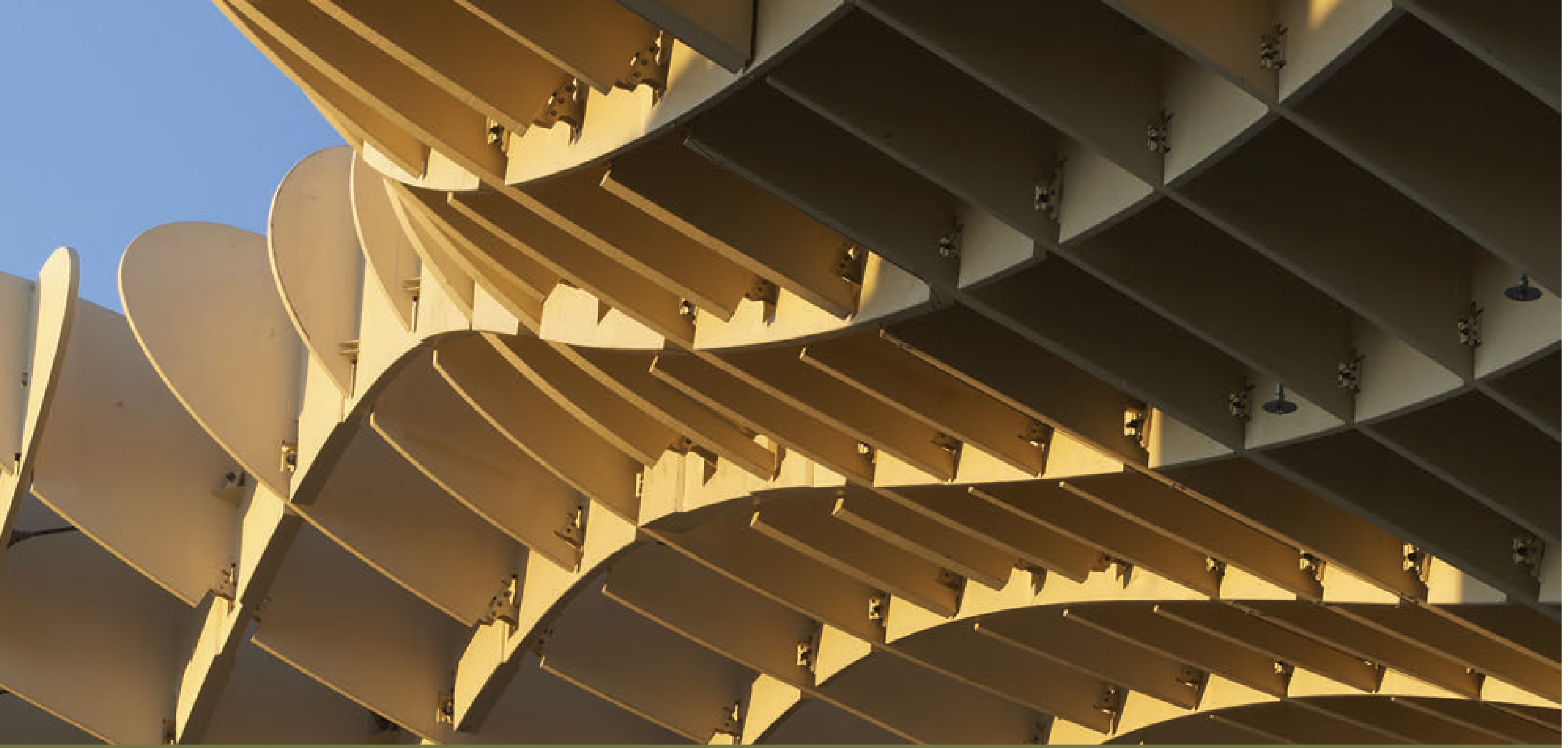

Shaping a better world: How this challenge differs across two modes of engineering practice

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> Engineering practice has evolved in response to changes in the wider economy and today's grand challenges. Only by understanding these evolutions can we best administer the benefits and responsibly manage the transition.

Introduction

A four-year research project sponsored by Arup in partnership with Univeristy College London (UCL) has been building on the understandings emerging out of philosophical and social studies of science, technology and society. This project investigates the ways in which engineers are active in shaping the social aims and values towards which the socio-technical infrastructures of modern life progresses. There is a growing sense that engineers must take an active role in the delivery of advances towards sustainability, a knowledge economy and a changing landscape of engineering opportunities. This research has sought to better understand the roles undertaken by engineering consultants and the challenges in taking an active role in shaping a better world.

Arup's strap line is 'We shape a better world'. The subject of this research was the engineering practices at Arup. An empirical approach was adopted which adds to the body of academic understanding and achieves an in-depth social study of contemporary engineering practices. Engineering firms seeking to impact positively on today's society whilst operating in ever more diversified and innovative ways will gain insight from this research.

Methodology

Investigations began with a study of the role of values in the firm's development, from its foundation by Sir Ove Arup, through to its involvement in high profile projects that contributed to the firm's growth. A theme from this was an ongoing diversification into interdisciplinary markets and modes of working whilst retaining the firms traditional, mono-disciplinary engineering design services.

The observed developments in modes of working were first related to trends observed in the wider economy. The transition to a knowledge economy no longer restricts knowledge creation roles to those with academic credentials. Industry actors are increasingly engaging in 'Mode 2 Knowledge Production': primary research in interdisciplinary teams producing innovations towards niche market needs (Nowotny et al., 2001).

Preliminary observations showed that Arup engineers now engage in at least two distinct modes of practice. One is based on traditional technical design within established engineering disciplines and one is based on combinations of disciplinary expertise. Two archetypal case studies representing each mode of practice were sought from within Arup to gain in-depth answers for each on:

- What is the engineer's role and responsibility in defining and delivering outcomes?
- What are the implications for the engineer's ability to actively engage in the positive shaping of these outcomes? This included implications for requisite cognitive skills, expertise or sensitivities; management systems and approaches; levels of ethical reflection; and the adequacy of existing quality assurance systems.

The methodology was based on participant observation, semi-structured interviews, project documentation and discourse analysis.

Results and discussion

A summary of the key features for each mode of practice studied is given in Table 1. The case studies displayed profoundly different engineering practices with very different implications for the engineer who seeks to provide leadership.

Traditional Technical Design Practice

Engineers provide design services to achieve predetermined client or stakeholder aims. There is, however, still scope for design objectives to conflict with organisational objectives. For example, aspirations for progressing design contributions towards higher levels of environmental sustainability can be challenged.

Whilst monodisciplinary work is underpinned by bodies of experience in the form of design codes and guidance, the design engineer is always exercising degrees of judgement in its application. With codes often prescribing only minimum criteria for public safety and comfort, the engineer is often active in introducing social valuations and has scope to introduce additional or more stringent performance criteria.

In the example studied this manifested as trade-offs between design effort and material efficiency. Managerial contingencies such as schedule and budgetary pressures and the division of design responsibilities were found to be exerting an influence. Judgements were also framed by the wider economic and policy context in which the engineer was working; in this case, the economic value placed on labour in relation to that placed on materials.

In seeking to impact positively on social values in this mode of practice the engineer is required to focus on fostering earlier and closer working relationships with clients. This is used to bring design knowledge to bear on conceptual design stages and communicate benefits to clients. Where benefits are not valued within the wider economic and market context, the engineer is also faced with the challenge of providing industry leadership. This starts with the commitment of extra design resources to overstep the basic design brief or codes, and dissemination of design experiences into the relevant policy areas. For example, in the case study performed, design engineers faced tradeoff's between labour and material costs within design budgeting, hence an appropriate policy domain to engage would be the 'Ecological Modernisation' debates (e.g. see Bell et al., 2011).

	Traditional Technical Design Practice	Mode 2 Practice
Project Scoping:	Passively received by engineer from client/ stakeholder group.	Actively shaped with client/stakeholder group.
Project Team:	Mono-disciplinary, typically in-house and stable/permanent with time.	Interdisciplinary, inter-sectoral/organisational and bespoke/one-off.
Engineer's Role:	The application of known scientific principles to the design of feasible and economically efficient technical solutions.	Primarily: 1) Problem identifier, solutions broker; and 2) Problem solver through enlistment of heterogeneous knowledge workers into knowledge production and systems design.
Method:	Fixed, utilising significant bodies of historic knowledge, repeated often and codified.	Bespoke, developed in conjunction with aims and one-off. Based on knowledge production and appropriation by design.

Table 1 Summary of descriptors

Mode 2 Practice

A key attribute of this work is knowledge creation in a specific social and technical context towards an outcome that is transdisciplinary, in that it is not reducible to any one of the contributing disciplines (Gibbons et al., 1994). This is achieved by a constant expansion and reconfiguration of expertise to respond to dynamic market needs.

Unlike traditional practices, engineers face the challenge of needs-definition, entailing active engagement with the relevant social setting. Stakeholder workshops are an example of this in practice. In particular, understanding where gaps exist in three areas has emerged as key to the successful application of Mode 2 practice:

- Knowledge, skills or expertise
- Capabilities or technological provisions
- Empowerments present/absent in the current division of roles and responsibilities

In understanding the first of these, the engineer confronts fundamental questions regarding the suitability of different forms of knowledge. They must critically examine and manage the constraints of current understandings in the development of the project methodology.

Given the novel, transdisciplinary nature of the products, the central challenge of this mode of practice is the development of appropriate quality assurance frameworks. Knowledge and expertise requirements in Mode 2 practice are directly related to highly variable project contexts. A long-term challenge is how to manage organisational learning, apply appropriate expertise gained to new opportunities, and tie it into the management of professional identity within the marketplace. The development of management systems to enable the required density of interdisciplinary interfaces both internally and with external partners is also of key importance.

Conclusion and next steps

In offering traditional design services engineers need to make an active choice to diverge from protocols that deliver little advance towards modern societal challenges such as sustainability. In newer modes of operation engineers are required to engage in new areas with little established knowledge management or quality assurance infrastructure. A proactive approach to critical reflection and learning is required in both modes of practice. This can be informed by studies of practices that utilise methods and insights developed by the social sciences.

Through studies such as this one we can further develop the body of knowledge necessary to foster 'moral imagination', 'reflexive awareness' and 'techno-social sensitivity' in engineering practice. We can also improve the organisational and policy infrastructure necessary to support engineers in shaping a better world.

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References

Bell, S. J., Chilvers, A. J., Hillier, J. O. (2011). The socio-technology of engineering sustainability. Proceedings of the Institution of Civil Engineers. Engineering Sustainability, 164, (3): 177-184

Busby, J. S. and Coeckelbergh, M. 2003. The Social Ascription of Obligations to Engineers, Science and Engineering Ethics, 9, (3): 363 - 376

Fisher, E., Mahajan, R. L. and Mitcham, C. 2006. Midstream Modulation of Technology: Governance from Within, Bulletin of Science, Technology and Society, 26, (6): 485 - 496

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. 1994. The new production of knowledge. London: Sage Publications

Harris, C. E. 2008. The Good Engineer: Giving Virtue its Due in Engineering Ethics, Science and Engineering Ethics, 14: 153-164

Nowotny, H., Scott, P. and Gibbons, M. 2001. Re-thinking Science: Knowledge and the Public in an Age of Uncertainty. Cambridge: Polity Press