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What do we actually mean by ‘sociotechnical’? On values, boundaries and the problems of language

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ABSTRACT

The term ‘sociotechnical’ was first coined in the context of industrial democracy. In comparing two projects on shipping in Esso to help define the concept, the essential categories were found to be where systems boundaries were set, and what factors were considered to be relevant ‘human’ characteristics. This is often discussed in terms of values.

During the nineteen-sixties and seventies sociotechnical theory related to the shop-floor work system, and contingency theory to the organisation as a whole, the two levels being distinct. With the coming of information technology, this distinction became blurred; the term ’socio-structural’ is proposed to describe the whole system.

IT sometimes is the operating technology, it sometimes supports the operating technology, or it may sometimes be mistaken for the operating technology. This is discussed with reference to recent air accidents.

1. Introduction

In the course of a ridiculously long working life I have known and worked with Ken Eason, sporadically and with intervals, across forty-four years. Having written down that sentence, I find it hard to believe. We have collaborated on projects and in the Bayswater Institute, agreed on many things, argued on some, and now share the management of the Bayswater Institute.

We first met in 1969, when Ken was in the EMI Ergonomics Laboratory headed by Brian Shackel and I was Social Sciences Adviser in Esso Petroleum. Esso had contracted a number of activities to EMI and this time it was Ken who came, to carry out a study of salesmen. He devised a scale which stays in my failing memory: respondents were ranged from the technical salesman at one end of the scale, who sells on the basis of the technical characteristics of the product, to the social salesman at the other end, who takes the customer to a nightclub and drinks him under the table.

Around 1970 Ken moved with Brian Shackel and Leela Damodaran to the new HUSAT Research Centre at Loughborough, where the basic frame of reference was ergonomics as in EMI, and I joined the Tavistock Institute of Human Relations. In 1973 I entered into what became a seven-year consulting relationship with one of the UK’s clearing banks. This began with a major study of branch banking. A team of five people, partly from the Tavi and partly from HUSAT, did a week’s fieldwork in each of four branches around the country, and then produced a massive report. By that time Ken was developing his special interest in information systems. The bank’s Organisation and Methods Department latched on to this and went on to develop a distinct stream of work with him. At one point they arranged to meet him over lunch. When I asked how it had gone, he said, “As far as I can remember, it went: sherry, hock, claret, port, brandy...” Ah, those were the days.

Our next collaboration was in collecting case studies in the use and application of the social sciences. The project was difficult to fund and took a long time to do and then to write up; the book did not come out until 1991, after I had left the Tavi and started the Bayswater Institute. Its title, “Putting social science to work” (Klein and Eason, 1991), is really what the Institute is about. Twelve years later, when I circulated friends and colleagues to ask if they could suggest candidates for a new Director, it was therefore not surprising that Ken said “I might be interested in that myself”. So in 2002 he became Director and we have been working together, much more closely than before, ever since. When he in turn stepped down as Director, a whole new phase of creativity sent him into becoming a leading expert on information systems in the National Health Service, particularly the now notorious NPfIT (see, for example, Eason, 2005, 2007).

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I am delighted and honoured to have this opportunity to celebrate Ken and his work. I will use it to make a brief attempt at disentangling some problems of ambiguity around the term sociotechnical – a hostage to fortune if ever there was one.

2. So, what do we mean when we say 'sociotechnical'?

Historically, what seems to have happened is that first engineering, then production engineering, and later systems design have aimed at optimising the technical system as if it was self-contained. In the process some other things were neglected, and that gave rise to a number of reactions. One popular reaction, from the ranks of a particular kind of behavioural science – the "Human Relations Movement" – has been to try to optimise the social system as if this, in turn, was self-contained. So there are programmes and activities to do with communications, relationships and behaviour, styles of management, participative leadership, etc, which in their turn take no account of technology or task. 'Splitting' became institutionalised. Sociotechnical theory makes explicit the fact that the technology and the people in a work system are interdependent. Each affects the other. Technology affects the behaviour of people, and the behaviour of people affects the working of the technology. It is inevitable, it is a real part of the situation, and one therefore needs to take account of *how* they affect each other.

In addition, while there is much research documenting this interdependence once technology is implemented, it also exists at the stages when technology is being designed and developed. Factors that affect individuals and organisations at the output end, that is as a consequence of technology, apply with equal relevance at the input end, that is among design teams and the organisations that contain them. In other words, technology is not only an independent variable, having consequences for skills, tasks, roles, values, relationships, careers, group functioning, departments, and the organisation in which it is implemented. It is also a dependent variable (Klein, 1994). I would suggest that the result looks like this (Fig. 1):

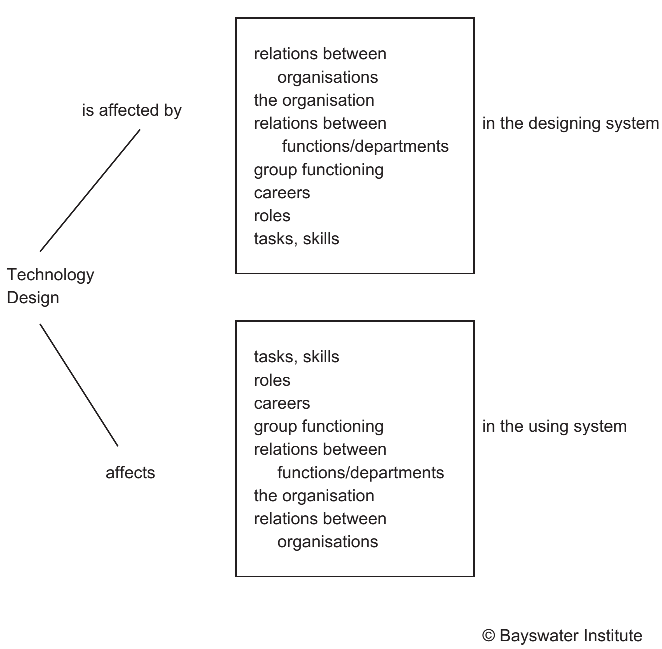

Fig. 1. Factors affecting and affected by technology design.

The term 'sociotechnical' is inevitably imprecise, almost as imprecise as the term 'system'. If you google it, you get more than three million responses. The important concept to hang on to is that of interdependence. That is unlikely to cause dispute; it is when one tries to work out interdependence between what and what that the trouble starts.

3. Work systems and values

The interdependence was first conceptualised by researchers from the Tavistock Institute studying technical change in coal mining (Trist and Bamforth, 1951; Trist et al., 1963). At the same time, they took it in a particular direction. From the very beginning, the interdependence between the social and the technical implied by the phrase was associated with democracy on the shop floor – Eric Trist conveys the excitement with which they discovered how miners at the Haighmoor coal seam in South Yorkshire organised themselves on the basis of their knowledge and experience of the task: "Cooperation between task groups was everywhere in evidence, personal commitment obvious, absenteeism low, accidents infrequent, productivity high…" (Trist and Murray, 1993). Attempts to reproduce this natural experiment were first taken up in Norway. They were accompanied by defining and making explicit what constitutes satisfactory work experiences; continuing learning and development featured strongly in this, and there was a strong assumption that these were well served by autonomous group working (Thorsrud and Emery, 1969). (Later researchers pointed to some other, less beneficial aspects of group working and to the fact that it did not necessarily apply in all situations - see for example Euler, 1977).

In the late nineteen-sixties and early seventies the approach was taken up by the Norwegian shipping industry. Javier Lezaun, a historian of the social sciences, has published an account of the ship *Balao*, which was set up in 1972 as a deliberate demonstration experiment, in which new and more democratic forms of work organisation would not only be studied but be encouraged by changes in design. It was the culmination of the programme. Lezaun calls his paper "Off-shore democracy: launch and landfall of a sociotechnical experiment", which is characteristic of the identification of sociotechnical with democratic at the time (Lezaun, 2011).

At the beginning of the Norwegian shipping programme the Tavistock people had wanted to put a researcher on board the ships taking part, but the Norwegian trade unions insisted that such researchers should be Norwegian. So they had a researcher available with maritime experience but without an assignment. Fred Emery contacted me in Esso to ask whether Esso's Marine Department, with its fleet of oil tankers, might be interested in some shipboard research.

A project evolved with the title "Life and Work at Sea", and was carried out by two Tavistock researchers, Simon Baddeley and Alan Trist. It fitted in with Esso's exploration of the possibilities of 'integrated crewing', i.e. the merging of the two main sub-divisions of the total task, engine room and deck. But it was not explicitly concerned with work-place democracy. The researchers were anthropologists with a grounded approach, and studied what they found. This is how they described their frame of reference: "…the effectiveness of the ship as a total system is seen as being the result of the interplay of the characteristics of the ship as a place of work and a living community on the one hand, and the characteristics of seafarers on the other."

By chance, we had a broad programme in an ergonomics frame of reference going on in the Marine Department at the same time. This was defined more tightly than the Tavistock project: "…to examine and analyse the functions of a ship's navigating bridge and the tasks and workload of the associated personnel, and to establish design principles, based on the methods of systems analysis and ergonomics research, leading to recommendations for improved bridge and control-centre layout".

I recognise that it is immodest to cite oneself, but the simultaneous existence of these two major projects did offer then and still does now a rare opportunity to discuss boundaries and values. What follows is drawn from the original account:

> ... here were two teams, of the highest calibre and reputation in their fields, doing good and exciting work. Both used systems concepts and terminology, the one being concerned with the man-machine system and the other with the sociotechnical system... Both were oriented towards adapting technology to human characteristics rather than the other way about. Both were working on Esso's oil tankers, so that technical and organizational variables were constant.
>
> And yet, there seemed to be no connection. The work they did was quite different, the only aspect discussed by both in somewhat similar terms being the relationship between the lookout and the officer on watch. Intellectally they drew on different sources: their work was carried on in different institutions, published in different journals, discussed in different societies. It was so different that they did not even appear to be in competition. It seemed to me that, if systems theory meant anything, there had to be a conceptual link, but I did not know what it was....
>
> I invited the two teams to a seminar. It was a failure. They came out of courtesy to me, but they seemed to have little to say to each other. Afterwards they were each inclined to be rather disparaging about the other's work. They said they would exchange field notes and research reports, but did not do so.
>
> I then left them alone for 18 months, as I did not want to interfere with them. After that I tried again, and arranged a second meeting, which turned out to be much more fruitful.
>
> (Klein, 1976, chap. 6).

We found two things to compare: the first was where the teams set systems boundaries, that is what they considered to be part of the system being considered and therefore susceptible to change, and what was outside the system and to be accepted. Interestingly, they discussed these differences not in terms of system boundaries but in terms of values: the more there was included within the boundaries of the system being considered, the more radical the values; the more there was outside the system being considered, and therefore not susceptible to change, the more conservative the values. The Tavistock team set the boundaries very wide - they questioned everything, up to the need to transport oil. The ergonomics team accepted the need to transport oil, the ship, the ship's bridge. Within that, they were then able to do work on such things as the perceptual problems in tanker berthing and how these changed as tonnage and size increased, the adjustment needed when moving between a lighted operations room and the dark outside, and much more.

The second difference lay in what they considered to be the relevant human characteristics for their work to focus on:

> It is the enormous range of parameters involved in even a limited part – the human part – of the system that is relevant here. Between them these teams tackled a very large number, but even then they could not possibly be comprehensive. It is never a question of 'human factors', but always of 'some human factors'. For instance, at one point in their discussions the first group of research workers talked about their interest in career patterns among seamen, the reasons why there was now diminishing motivation to go to sea at all, and therefore the possibility that a man would see a short spell at sea as an episode in his life rather than taking it up as a career. The other group talked about their interest in navigational errors and stranding.
>
> Now there is no point at all in arguing the intrinsic merits of tackling career patterns as against the intrinsic merits of tackling navigational errors. Chalk has a function and cheese has a function...
>
> (Klein, 1976, chap. 13).

In combination, the two factors, of where boundaries of the system being considered are put and what parameters to investigate within them, tend to lead to the difference between usability and personal development as design objectives.

4. Work systems and the organisation

The Tavistock people were of course strongly aware of organisations in broader terms than work systems on the shop floor. They dealt with this by referring to the whole organisation as an "open sociotechnical system", but that is where one begins to have problems with the terminology. The value of the phrase lay in drawing attention to wider issues of the various environments of organisations, and their interdependence with others. But in practical terms, what did it actually mean? "Open" yes; but "sociotechnical"? The phrase seems to have gradually fallen into disuse.

During the nineteen-sixties and seventies it was congruent with the operating technologies of the time to see the functioning of the industrial organisation as a whole as distinct from that of the shop-floor work system. For the functioning of the organisation as a whole in its environment, contingency theory came for me to be the most useful way of looking at the relationships between structural and behavioural factors.

Contingency theory proposes that there is not one best way to organise, which for generations had been the holy grail. At the time, it was thought that the ideal way to organise could be found in army experience and encompassed 'general' truths like that there was an optimum span of control, i.e. that one manager could not manage more that about seven people, since he (it was usually he) had to manage not only their relationships with him but also their relationships with each other; or that there were optimum levels in a hierarchy. Rather, the revolutionary concept was that you should organise according to your particular circumstances. This was difficult to accept; it meant that you had to make serious diagnosis of your circumstances.

There are different versions of the history, and this is not the place to elaborate them. For me, starting with research on the relationship between organisation and different production technologies (Woodward, 1958, 1965), different market characteristics (Burns and Stalker, 1961), different levels of differentiation and integration (Lawrence and Lorsch, 1967), and different kinds of control system (Woodward, 1970), the contingency concept came to refer to the behavioural and social impact of any 'hard' or structural aspects, that is any factors which were given, of which technology was only one.

So the relevant frame of reference for the interdependencies at the level of the workplace was sociotechnical theory – literally the interdependencies between social and technical aspects of the system (*not* between the social system and the technical system as it is sometimes described. That would imply two systems and would be a contradiction in terms). At the level of the organisation, one needed to look at the relations between any hard or structural factors and behavioural ones.

From the point of view of diagnosis rather than formal research, this essential concept cannot be applied mechanically. It first needs to be internalised, and what that then leads to in practice can vary a great deal (Klein, 2005, chapter 3). Here is an example:

> A company manufacturing gas cylinders was experiencing severe conflict between R and D, Production and Sales departments, centred on problems in the production of the biggest sizes. The technology for producing the latter was not fully understood and therefore required a lot of expert intervention, whereas that for smaller sizes was fairly routine. Thus, different [kinds of] people were required for the two different types of product, for which there were also significantly different criteria of quality. However, like many SMEs, the company used one physical plant to produce both types of product with the same organisation structure.
>
> After analysis of the characteristics of the tasks and technologies in relation to skills and structures, the researchers suggested rescheduling activity in the factory to simulate having two separate plants, each with different employees and organised differently to recognise the much greater judgement exercised by those making the large sizes. Initially, this clashed with a prevailing culture which valued uniformity, so that the idea of having two separate organisation structures was resisted. However, when the suggestions were tried, they reduced the conflict and allowed each team to concentrate on their different tasks, so that the technical problems with the large products could be gradually solved without disrupting production of the small ones (personal communication from Alan Dale).

The essential 'hard' or structural factors in this case lay in the characteristics of the product, and the differences between large and small sizes of cylinder.

5. Computers and the organisation

With the pervasive spread of computing, the distinction and boundary between the work system and the organisation system became less meaningful. Computers not only became part of operating technologies, but in the process generated information that fed into management systems. (In fact, they generated so much information that people often didn't know what to do with it. I have twice come across situations in the course of research where nobody could be found who used a regular management report that was produced about operations).

The links between operations and many aspects of management became automatic, often making the two indistinguishable. This did not only apply to manufacturing systems. The Bayswater Institute's first major programme of work was in Greenwich District Hospital, around a Hospital Information Support System or HISS that was being installed. This was not so much because they wanted a contribution to the HISS, but because it would be pervasive, reaching into all aspects and departments of the hospital, an entry route to hospital organisation.

As the distinction between the work system and the organisation system became less meaningful, it seemed to me so did the distinction between sociotechnical theory and contingency theory, opening up a need for re-definition.

Sometimes IT supports the operating technology; sometimes it *is* the operating technology; and sometimes it may be mistaken for the operating technology. It is often again a matter of how system boundaries are perceived; the fact that there are choices available may not be recognised:

In the nineteen-seventies I had an assignment to contribute to the design of jobs in a new vegetable canning plant which was being planned. An early part of the work was to hold some seminars on sociotechnical analysis and design for the company's project staff. The project engineer very quickly caught on to the basic ideas and became enthusiastic about them. From that point on he was of course in a much better position to apply them than any external social scientist could be.

The operation was canning peas and the raw material was dried peas, delivered in bulk. High up at one end of the proposed canning plant was to be a gallery housing tanks in which the dried peas would be soaked until they were soft enough for the next stage of the process, when the tank would be opened and the product released. The time required depended on the condition of the peas and weather conditions, and could vary. At one end of the gallery was to be a control room, manned by an operator who would control this process as well as others. The project engineer had the idea of designing this role so that the operator would not release the product by pushing a button at the console in the control room. He would walk out to the particular tank and pull a lever. In this way he would retain some physical connection with the task and the product, would experience the consequences of his own action, and would also from the gallery see, and experience his connection with, the whole production area below him (Klein and Eason, 1991; Klein, 2008).

It could have been done differently; doing it this way was, as suggested earlier, a matter of values. The design had two functions for the operator: it enabled him to stay in touch - literally - with what he was doing and experience its consequences, and it enabled him to identify more easily with the whole of the production task, not a sub-set. For the engineer this way of thinking was not directly the result of the sociotechnical teaching; it could not, for instance, have been derived from Cherns's Principles of Sociotechnical Design (Cherns, 1976, 1987). The teaching provided the framework and created a mindset within which he then exercised his judgement, imagination and experience.

6. A detour into unfamiliar territory

To what extent such a mindset actually affects practical outcomes is only tested when things go wrong. I was reminded of the canning plant, and the question of when to focus and rely on the computer and when to retain contact with the operational environment, by a series of recent accounts of aircraft accidents. It seems that aircraft accidents are often associated with the boundary between the computer system and the wider environment, and the relative importance of different degrees of computer accuracy and pilot experience. These are very complex situations, I don't understand the technology well enough and I don't want to be facile about them. But three striking examples have recently come to public attention which highlight the importance of people staying closely in touch with the physical working environment rather than relying on computerised status information. There will undoubtedly be careful scientific analyses of these incidents. In the meantime, knowledgeable journalists and other commentators have contributed theirs:

a) The official report has been issued on the Rio-to-Paris Air France 447 flight which mysteriously disappeared over the Atlantic in 2009, with the loss of all 228 lives on board. It seems that the plane flew into a massive mid-Atlantic thunderstorm and, unlike other planes flying the same route, the pilot chose to fly straight through it rather than go around it. Outside, the pitot tubes that give pilots vital information about the plane's speed had frozen. As a result, pilots with no experience of flying at high altitudes were in fact flying blind. The co-pilot, who was flying the plane, made a series of wrong decisions because, apparently, the flight director – the computer that issues orders to the pilots throughout the flight – was broken and was giving him the wrong instructions.

"The French investigation agency responsible for the report, BEA, makes 25 recommendations to ensure that a disaster of this type never happens again. At the heart of the measures is a profound rethink about the extent to which modern airline pilots depend on their computers, leaving them literally helpless in a crisis like this" (The Independent, 6.7.2012)

b) Two military tornado jets recently crashed in the Moray Firth. At the time of writing there has not yet been an investigation, and there is only a great deal of discussion about the possible cause or causes. One comment was striking: "You want to keep your eyes outside the cockpit, but the temptation to look down at the computer is considerable..."

c) And then there is the incident known as "the Miracle on the Hudson". In January 2009 US Airways Flight 1549 had just taken off from La Guardia Airport in New York when it was struck by a flock of Canada geese which disabled both its engines. There has been much analysis since then of the processes by which Chesley Sullenberger, the plane's very experienced pilot, interacted with Air Traffic Control, rejected a number of options they suggested, and eventually made his own decision to ditch in the Hudson river, with the saving of all 155 lives on board (see, for instance, Langewiesche, 2009).

One feature of the very complex situation and context is that in the early 1970s it was found that lightweight digital computers could be linked to electrical control circuits, leading to fundamental changes in the relationship between pilots and their machines. It was known as "fly-by-wire", and was based on working at all times through the interventions of computers. Bernard Ziegler, the engineering Vice President of the Airbus consortium in Toulouse, led the effort that produced the Airbus A320 incorporating a full-on fly-by wire interface between pilot and aircraft control.

The resulting fly-by-wire interface between pilot and aircraft control managed the responses of the plane very precisely. The pilot could rely on it to do this and was left able and free to use his judgement. So now the behaviour of the pilot of Flight 1549 is described as "a joint venture with multiple onboard computers responding to him in consultation with Bernard Ziegler and the Airbus cowboys years ago in Toulouse". In the words of The Spectator's technology column, "instead of ... consulting instruments, calculating his rate of descent and working out his range, he simply looked out of the window". (Sutherland, 2012).

Going back to the control operator in the canning plant: in the context of technology development the design engineer was in transition – he had an intuitive sense of something that has later proved vital. There is no way of knowing whether the operator would have put the operation at risk if he had stayed in his control room and had not had any physical, visual or aural contact with the wider environment; but the situation seems to me to be analogous.

Moreover, it is not new. In a study of vocational training in the light of technical change, carried out for the European Productivity Agency at the end of the nineteen-fifties, David King documented a number of breakdowns in chemical plants and investigated the training which the operators involved had received. He wrote of the difference according to whether an operator had been merely trained to respond to signals, and did so automatically, or whether he understood what lay behind the signals, for instance knew what it meant if there was blue smoke coming from somewhere, and was able to take remedial action before there was a breakdown; and he calculated the waste which resulted from the more limited kind of training (King, 1960). I remember that in Esso the control room operators said that going out of the control room to sniff the air told them what was happening in parts of the plant before the computer told them.

Throughout these examples there is also a sub-text about the difference between short-term consequences of technical change and long-term consequences for perceptions, attitudes and behaviour – for instance, overdependence on computer technology – when a new system has bedded down.

7. In conclusion

It is not the case that, if we could only do much more research, we would find lasting answers. The variables are too many, their interactions too untrackable as they change over time, Hawthorne Effect in all its forms too pervasive. But within this complex field, if one looks at the interdependencies between 'hard' and 'soft' factors, there are many areas where one can make predictions and where one can help to improve fit. There is no justification for the repeated re-invention of wheels, where both researchers and research funders find it easier to start again from scratch than to translate and make use of what exists already.

Much of this has been a discussion of boundaries - between institutions, between long-term and short-term consequences, between what is accepted as given and what is considered susceptible to change, between operating systems and information systems. We need to locate our work more precisely in relation to these boundaries.

My thinking about where future developments in sociotechnical concepts might lie was triggered by developments in computer-integrated manufacturing. We had been used to working at two levels: one was the work system level, where the sociotechnical ideas were developed and had been applied. The other was the organisational level, where the most relevant approach, in my view, has been contingency theory. With the increasing use of technology for integration, that difference was becoming less relevant. One notices it in hospital organisation, and one notices it in computer-integrated manufacturing, where it makes less and less sense to postulate boundaries between what happens on the shop floor and what happens elsewhere. Operationally I have never found that difficult but conceptually I have, because habits of thought take some effort to unscramble. But the resolution of this particular dilemma is staring us in the face: as integration of computer technology with manufacturing and other work systems advances, we need to conceptualise organisations as open socio-structural systems. Not sociotechnical; socio-structural.

In all this conceptual and ideological turbulence, Ken's early scientific training has stood him in good stead. He has found ways of systematic analysis of data which are neither merely what his much admired teacher, Marie Jahoda, called "counting noses", nor merely anecdotal (though this is one area where we can differ: I often find anecdotes relevant). He has in turn generated in countless students excitement and enthusiasm for the subject and its complexities. And he has become an expert in a centrally important part of the field. What I want to say to him, with appreciation and love, is that the job is not over. This has been a pause for reflection and for saluting him. Now we have to get back to work - there is a lot to do.

References

Burns, T., Stalker, G.M., 1961. The Management of Innovation. Tavistock, London.
Cherns, A., 1976. The principles of sociotechnical design. Human Relations 29 (8), 783–792.

Cherns, A., 1987. Principles of sociotechnical design revisited. Human Relations 40 (3), 153–162.
Eason, K.D., 2005. 'Exploiting the potential of the NPfiT: a local design approach. The British Journal of Healthcare Computing and Information Management 22 (7), 14–16.
Eason, K.D., September 2007. Local sociotechnical system development in the NHS National Programme for Information Technology. Journal of Information Technology 22 (3), 257–264.
Euler, H.P., 1977. Zur empirischen Kritik von Konzepten der Arbeitsstrukturierung. Fortschrittliche Betriebsführung und Industrial Engineering 26 (5), 303–312.
King, D., 1960. Vocational Training in View of Technical Change. European Productivity Agency. Project No. 418.
Klein, L., 1976. A Social Scientist in Industry. Gower Press, London.
Klein, L., 1994. Sociotechnical/organizational design. In: Karwowski, W., Salvendy, G. (Eds.), Organization and Management of Advanced Manufacturing. Wiley, New York.
Klein, L., 2005. Working across the Gap: the Practice of Social Science in Organizations. Karnac Publications, London.
Klein, L., 2008. The Meaning of Work: Papers on Work Organisation and the Design of Jobs. Karnac Books Ltd, London.
Klein, L., Eason, K., 1991. Putting Social Science to Work: the Ground between Theory and Use Explored through Case Studies in Organisations. Cambridge University Press, Cambridge.
Langewiesche, W., June 2009. US Airways Flight 1549: Anatomy of a Miracle. Vanity Fair Dispatches.
Lawrence, P.R., Lorsch, J.W., June 1967. Differentiation and integration in complex organizations. Administrative Science Quarterly 12 (1), pp. 1–47.
Lezaun, J., 2011. Off-shore democracy: launch and landfall of a socio-technical experiment. Economy and Society 40 (4), 553–581.
Sutherland, R., 28 April 2012. Not-so-basic instinct. The Spectator, p. 69.
Thorsrud, E., Emery, F., 1969. Form and Content in Industrial Democracy. Tavistock, London.
Trist, E.L., Bamforth, K.W., 1951. Some social and psychological consequences of the longwall method of coal getting. Human Relations 4, pp. 3–38.
Trist, E.L., Higgin, G.W., Murray, H., Pollock, A.B., 1963. Organizational Choice: Capabilities of Groups at the Coal Face under Changing Technologies: the Loss, Rediscovery and Transformation of a Work Tradition. Tavistock Publications, London.
Trist, E., Murray, H. (Eds.), 1993. The Social Engagement of Social Science: a Tavistock Anthology. The Socio-technical Perspective, vol. II. University of Pennsylvania Press, Philadelphia.
Woodward, J., 1958. Management and Technology. Her Majesty's Stationary Office, London.
Woodward, J., 1965. Industrial Organisation: Theory and Practice. Oxford University Press, Oxford.
Woodward, J. (Ed.), 1970. Industrial Organisation: Behaviour and Control. Oxford University Press, Oxford.