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STS IS DEAD – LIVE STS!

EMPHASISING THE NEED FOR A MODERN SOCIOTECHNICAL SYSTEM APPROACH ON HIGH-TECH PRODUCTION SYSTEMS

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ABSTRACT

Sociotechnical systems (STS) research has not received much attention in the last decade, at least not in terms of its original foundation in a production system context. The main challenge in modern sociotechnical thinking is that STS has neglected its roots in technology and nowadays focuses more at a general social perspective on work. The “S”-view overshadows the “T”-view, and the fruitful link between the technical system and the social system is thereby lost. In this sense, STS is dead.

Now, due to recent and future developments in technology, strong awareness is called for in regard to a common interplay between the social and the technical system. Increasingly, competitiveness in high-tech manufacturing industries depends on a complex interaction between state-of-the-art technologies such as automation and information systems, and organisational or social factors such as knowledge, learning, communication and innovation. However, up to now, efforts at improvement and development in these industries have been clearly biased towards the technology side. A combined social- and technological perspective is now needed if implementation of further technology shall pay off. This paper argues that sociotechnical systems research, if revised, could be a promising path when preparing for the manufacturing future.

INTRODUCTION

Knowledge-intensive manufacturing of complex high-tech products is expected to build the competitiveness of the Western economies’ industrial sectors in the future. Operational excellence in 2009 is inevitably tied to the use of the latest technology, and recent improvements and developments in high-tech industries have clearly been

biased towards implementation of technology. Too little attention is given to the fact that, while technology is simple to copy across company- and nation borders, work practice, work culture and tacit organisation knowledge that utilise the implemented technology, are much harder to imitate and can be a source for sustainable competitive advantage.

This issue only increases in importance as companies evolve into high-tech industries, where technology is considerably more complex than in traditional industries. The main difference between past and future working conditions that affects modern high-tech production systems is the ever-increasing developments towards complete, intelligent and fully integrated technological systems. State-of-the-art technological systems introduce considerably more technical complexity in organisations than before.

Developments in information technologies

From a technological point of view, recent developments in ICT and business applications clearly create greater distance between the employees in high-tech manufacturing firms and the production systems. Increasing implementation of Manufacturing Execution Systems (MES) closes the information gap between automatic production systems (e.g. Flexible Manufacturing Systems, CNC-machines, material handling robots etc), and the Enterprise Resource Planning systems (ERP). Moreover, auto-ID technologies such as Radio Frequency Identification (RFID) and sensor-technologies are foreseen to lead to conditions such as Ubiquitous Computing and Internet of Things (Glover & Bhatt, 2006). In parallel, intelligent decision support systems such as Business Intelligence (BI) and Business Activity Monitoring (BAM)

systems removes the very last need for top and middle level managers to meet operators face-to-face.

From an organisational theory point of view, this digitalisation of work places leads towards increased rigidity and bureaucratisation. All these systems generate and require numerous amounts of routines, procedures, registrations, analyses and detailed reports. There is a trend emerging which suggests that these bureaucratic systems self-generate more bureaucracy, since bureaucracy and ICT seem to be interdependent. The bottom line is that ICT increases bureaucratic practice, and hyper-bureaucratisation is a result of the increasing use of complex automation and ICT systems (Torvatn et al., 2007). Social science scholars such as Grint and Woolgar (1997) have made considerable contributions on pieces of this puzzle, but the future digitalised working situation where high-tech companies are fully integrated, from auto-ID-labelled materials via automated shop floor machines via MES and ERP systems to top-floor business intelligence, is not much investigated in research and calls for attention.

Developments in automation technologies

In parallel with the development of ICT-applications, the focus on automation and integrated manufacturing systems in Western manufacturing industries continues. According to Manufuture SRA (2006), reconfigurable manufacturing with rapid and adaptive design, production and delivery of highly customised goods, is the future of European manufacturing. It embraces manufacturing systems and equipment, incorporating automation and robotics, cognitive information processing and production control by high-speed information and communication systems. Adaptive

manufacturing enterprises are expected to achieve required flexibility and velocity by linking technology to factory processes, production equipment, and factory systems (SAP AG, 2003). The embedded intelligence in the production system will respond automatically to changes in the operating environment. The integration of sensors within the control units of robots is required to replace human sensorial capabilities by machines (Scholz-Reiter & Freitag, 2007). Thus technology is moving towards more embedded intelligence and even self-learning abilities.

From an organisational theory point of view, automation potentially brings along alienation. According to Blauner (1964, p 15) "alienation exists when workers are unable to control their immediate work process, to develop a sense of purpose and function which connects their jobs to the over-all organisation of production (…)". But alienation is not bound to occur even if new technology is implemented; if workers are properly educated, involved and able to "see" themselves as a part of the total production system there is per definition no alienation taking place.

A need to align the technological system and the social system

On the technological side, the modern production systems are potentially extremely vulnerable where everything is dependent on everything else. Not if but when a failure occurs, potentially the whole system stops. And detecting the problem somewhere inside the complexity of the integrated production system requires a highly competent engineer, knowledgeable in both manufacturing and information technology. On the social side the concern is on increased alienation, reduced control over work and reduced Quality of Work Life by reducing operators to mere "button-pushers".

An efficient and effective manufacturing enterprise is a result of mutual adjustments of demands from both the technological and the social system. But there is no simple procedure to achieve mutual adjustment since the social and technological realities are investigated through two widely different logics, that of the social sciences and that of the natural sciences. The original sociotechnical systems (STS) research can provide a promising path to merge these parallel perspectives in order to meet the requirements of the future.

METHOD

This paper is part of the early theoretical development in a four year (2008-2011), €4 million, Norwegian, research project called Ideal Factory. Irrespective of whether the research is descriptive, exploratory or confirmatory, development of conceptual constructions is often one of the first steps when conducting research. In this paper we combine insight from practice, operations management theory and organisation theory to build a common platform that can help better explain the studied problem.

The project Ideal Factory is funded by the Norwegian Research Council and the two involved industrial partners Kongsberg Defence & Aerospace (KDA) and Volvo Aero Norway (VAN). The project aims at creating the ideal factory and production system for high-tech manufacturing companies in Norway. KDA develops and produces high-tech products within communication systems, weapon systems, command- and control systems and advanced carbon composite materials. VAN is a manufacturer of high-tech airplane engine components. Both companies are global players and deliver

to highly demanding customers such as the US Department of Defence, Pratt & Whitney, General Electric, Snecma and Airbus just to mention a few.

ORIGINAL IDEAS IN SOCIOTECHNICAL SYSTEM RESEARCH

The sociotechnical systems (STS) concept has its origin in the British coal-mining industry and is developed through the analysis of several mine studies in England in the early 1950s (Trist 1981). STS grew as a result of apparent short-comings in the previous eras of work organisation and management. Taylor's Scientific Management (1967) focused on the mechanics of management and organisation and tended to ignore the human side of manufacturing. The next landmark era of management, the Human Relations movement (Mayo, 2003), focused more on the human side, omitting, for the most part, the technical considerations of manufacturing. The objective of sociotechnical systems was to define a structure that responded to the requirements of the job tasks and the technologies, as well as the psychological needs of the people involved. Furthermore, given the interdependence of systems and the environment, the sociotechnical approach attempted to structure the system of work so that it could respond to environmental changes and demands in a rapid and flexible manner.

One of the most famous and important STS studies was performed by Eric Trist and Kenneth Bamforth (1951). This study of post-war British coal-mines revealed that the use of self-managed work teams improved both the performance and the psychological well-being of the workers. In one of his further analyses, Trist put forward seven significant aspects of which he speaks of as "a first glimpse of the emergence of a new paradigm of work in which the best match would be sought between the requirements of the social and technical system":

1. From single jobs focus to work system
2. From individual job-holder to work group
3. From redundancy of parts to redundancy of functions
4. From considering individuals as an extension of the machines to seeing them as complementary to the machines
5. From variety decreasing to variety-increasing
6. From external to internal regulation of individuals
7. From prescribed part of work to discretionary part of work (1981:9)

In essence, these seven principles form the underlying fundamental platform for the design of sociotechnical systems. The study of Trist and Bamforth (1951) revealed an alternative way of organising work and utilising technology. Since this actually contradicted the thinking in British decision making spheres at the time, industries' goal of increased efficiency and productivity through mechanisation and strong political forces put a lid on the study. But the principles and their embedded values of democratisation, participation, empowerment and self-regulating teams were, due to close relations between British and Norwegian researchers and the much less hostile Norwegian political-economic context, brought into further development through the Norwegian Industrial Democracy project from 1962-1969. These studies resulted in several field experiments where self-managed work groups where implemented as alternative forms of organisation to increase participation and reduce alienation of work (Emery & Thorsrud, 1969, 1976; Thorsrud, 1977).

The sociotechnical systems theory and subsequent experiments had a profound impact on work redesign for many years and more recently we experienced a re-emergence

of these principles for work team design (Wilson & Whittington, 2001). Such teams have many labels: self-regulating, autonomous, semi-autonomous, self-directing and so on. In part, the numbers of terms and distinctions have evolved to describe and distinguish varying levels of autonomy and different types of internal or external leadership and supervision. However, all of the definitions embrace the notion of a workgroup that has the opportunity for greater independence of decision making than is conventionally available. Self-managed work teams may be defined as teams that are able to regulate their behaviour on relatively whole tasks for which they have been established, including making decisions about work assignments, work methods, and scheduling of activities (Cohen et al., 1996).

The key question in STS is how can the relationship between the two parts, the social and the technical, best be designed in terms of creating attractive manufacturing and positive results for both parts? One attempt to an answer is a set of principles that will improve the way work is organised, that fulfil the ideal on joint optimisation. Based on Hertzberg's Two Factor Theory and psychological job requirements (1959), sociotechnical practitioners and theorists have developed such a set of principles for work design (Cherns, 1976,1987). In essence, these nine STS principles in table 1 form the underlying fundamental platform for the design of sociotechnical systems.

Table 1 Cherns' (1976) nine STS design principles

Principle 1: Compatibility
System design must be compatible with the organisation's long term objectives, and this is achieved by involving employees in the planning process.
Principle 2: Minimal critical specification
As little as possible should be specified about how jobs are to be performed, so that employees can contribute with their creative skills.
Principle 3: Variance control (the Sociotechnical Criterion)
Variations from what is planned or expected should be controlled as closely as possible to their point of origin, as workers are in the best position to act on them.
Principle 4: The Multifunctional principle
Individuals and groups need a range of tasks to provide satisfying jobs and for redundancy

and flexibility.
Principle 5: Boundary location
Departmental boundaries should be drawn to encompass tasks that are sequentially related to one another as opposed to technically similar to one another.
Principle 6: Information flow
Organisation should provide workers with the right feedback so that they are able to control variance that occurs within the scope of their responsibility, and information should flow initially to the prime user group.
Principle 7: Support congruence
The system of social support should be designed in a way to reinforce the behaviours that the organisation structure is designed to bring forward.
Principle 8: Design and human values
The organisation has to be sincerely concerned with the human needs of the employees and Quality of Working Life (QWL) must become an important consideration for the organisation.
Principle 9: Incompletion
Organisation design is a continuous process and there is no such thing as a final design.

DISCUSSION ON CONTEMPORARY STS RESEARCH

In the 1970s and 1980s, an extensive number of researchers were focused on sociotechnical systems thinking and extended this concept from the Norwegian Industrial Democracy project, with its principles, values and experiences. Today at least four different tracks and perspectives of sociotechnical systems research are identified around the world:

1. Participatory design (the Australian track)
2. Integrated Organisational Renewal (the Dutch track)
3. Empowerment (the North American track)
4. Democratic dialogue (the Scandinavian track)

Track 1 Participatory design (Australian track)

Fred Emery gained a lot of experience from the participating into the Norwegian Industrial Democracy Project, especially in regard to the lack of diffusion of the concept in the participating companies (Eijnatten et al., 1993). According to Emery, this was mainly caused by the researcher's expert approach in the project and by that insufficient internal support from the people in the involved companies. Bringing this

knowledge back to Australia, Emery developed what he called “Participatory Design” based on the method known as “the deep-slice approach” (Emery, 1977; M. Emery, 1999; Crombie, 1985). This method made it possible for employees, middle management and union representatives jointly, from the beginning of a project, to take responsibility for the task of organisational design.

Later on this technique was exported to India, the Netherlands and (back to) Norway. And the long awaited diffusion took place in Norway in 1972 when the companies by them self took control of the development, but not until disappointed researchers had withdrawn (Elden, 1979). Presently this non-expert approach has very little practical impact and theoretical influence.

Track 2 Integrated Organisational Renewal (Dutch track)

A second track developed in the Netherlands (e.g. de Sitter et al., 1994, 1997; van Eijnatten & van Beinum, 1993) where researchers answer to the diffusion challenge was labelled Integrated Organisational Renewal (IOR). The IOR approach is based on four basic concepts. Firstly all organisational elements (individuals, tools, systems and machines) are tied together in time as a function of the systems structure. The second concept is controllability, and is defined as the system’s ability to reach a wide range of objectives regarding efficiency and performance. The third concept is the combination of production structure and control structure, which are defined as the two organisational action systems. And the fourth concept is structural parameters. In essence, an enterprise’s complexity is dependent upon the number of structural elements. Traditional bureaucratic manufacturing systems tend to maximise the number of structural elements, and hence they are complex. Increased complexity is

caused by increased process variability, increased probability of interference, and increased sensitivity to interference. Thus the aim of IOR is to reduce the probability of interference by decreasing variability and by reducing sensitivity to interference by increasing control capacity. To accomplish this aim, IOR has developed a strategy to implement a successful redesign process.

The IOR approach is an attempt to change focus away from the old functional oriented production thinking to more of a flow and process oriented production thinking. But this is mainly theory development and the process description is characterised by detailed control and expert solutions.

Track 3 Empowerment (North American track)

In North America we find a third track. The efforts in this area are an evident continuance of the classical sociotechnical thinking and the experience from England (van Eijnatten & van Beinum 1993). Probably the most influential contribution stemming from this work in the 1970s and 1980s is the concept of empowerment. Empowerment appears when power is transferred to employees and they experience ownership and control over their tasks and work. This is a concept that has made some impact, but its essence is similar to what is already embedded in self-regulating groups.

Several of the intrinsic aspects of group work as involvement, participation and quality of work life in STS diffused to the USA (Pasmore, 1988). In the end of the 1970s we find these elements in the STS-spin-off “Quality of Work Life” project with General Motors and “Employee Involvement” with Ford (Durand et al., 1999).

Presumably, “consultants” such as Deming and Juran, brought these concepts and values with them to Japan and in their work with Japanese automotive industries. And in recent times Japanese automotive industries have brought the concepts and values back to Europe and the USA, re-branding these concepts as “teamwork” in lean production.

Track 4 Democratic dialogue (Scandinavian track)

In Scandinavia the main focus has been to solve the problems of distribution that become evident through the Norwegian Industrial Democracy project. Scandinavian researchers have focused their research on designing development networks between companies from communication theories based on dialogue methods labelled as democratic dialogue. The Industrial Democracy Project (Emery & Thorsrud 1969; Gustavsen 1992) launched in the 1960s, supported by the Confederation of Norwegian Enterprises, the Norwegian Confederation of Trade Unions and the Social Democratic Government, became the back-bone of a practice of collaboration between shop floor workers’ unions and management as to institutionalise industrial democracy in the workplace.

Opposing the classical and participatory design approach, where the focus is on the content of the design, democratic dialogue is focused on the process itself as the point of departure (Gustavsen & Engelstad, 1986; Pålshaugen, 1997). The main tool within this tradition is a conference, called dialogue conference, where the participants by thirteen criteria of good communication are guided through the conference Gustavsen, 1992). Even though this tradition has some foothold, we will argue that its main focus is basically on the social dimension.

Contemporary STS-research has lost its origin in a production system context

Even though the term sociotechnical was introduced in a production system context, there has been a shift away from the technical towards the social aspects of sociotechnical systems thinking in the latest decades. Apparently, during the 80s, and especially the 90s, STS has shifted focus to topics such as "democratic dialogues" (e.g. Gustavsen, 1992), "the learning organisation" (e.g. Senge, 1990; Chawla & Renesch, 1995; Garvin, 2000) and knowledge development and organisation (e.g. Nonaka & Takeuchi, 1995; von Krogh et al., 1998).

Thus, the main challenge in modern sociotechnical thinking is that STS has left the origin in technology and nowadays focuses more at a general social perspective on work. Today, sociotechnical systems theory typically deals with topics such as motivation, process improvement, job satisfaction, self-managing teams, job design and enrichment, job rotation, and empowerment through communication, participation and so on. The "S"-view overshadows the "T"-view, and the fruitful link between the technical system and the social system is thereby lost. In this sense, the original STS is dead.

Revolutionary with sociotechnical systems thinking was that it postulated mutual dependency between an organisation's technical and social systems. More precisely, if your intention is to optimise the technical system, you need to relate it to the social system (vice-versa if your objective is to develop the social system, you need relate it to the technical system). We might assume this important knowledge to be obvious or taken for granted, but in reality it is not. Examples of great sociotechnical practice in organisational design or development are as rarely present today as it was 50 or 60

years ago. In the near future, however, the pace of introduction of complex technological systems, will force high-tech manufacturing companies to reconsider the importance of optimising the organisational and social systems in parallel with the technological system, and not solely focus on technology as the key to competitiveness. Hence it is crucial to bring a modernised STS thinking into focus again, not by itself, but as a vital part of a company's competitive edge. In this sense, original STS-perspectives should again be brought to life.

CONCLUSION

Operations management theory and practice aims at building better manufacturing systems that are more productive (efficient) and profitable (effective) than what we have today, whereas social research on work practice today generally aims at building better work places that are more humane, attractive, educational, and that bring along Quality of Work Life workers. We argue that the key to future competitiveness will be to manage both these perspectives in an integrated manner.

In our conceptual perspective we argue that in order to increase future competitiveness, high-tech companies need to have a two-sided focus on the value creation, rather than solely focusing on the traditional economical and technological perspectives. On one side such industries need to continue with increased value creation along the track of advanced utilisation of technology and operational excellence. On the other side the companies need to increase value creation by improving the Quality of Work life dimension. Even though sociotechnical systems research (STS) today is too much about social research and too little founded in the

technological system, its inherent and original ideas from the 1950s-1970s are still valid and should, in a modernised form, be brought back into focus.

Further research

The authors will address the discussed issues in the remainder of the research project Ideal Factory. We have put forward a vision named Attractive Manufacturing (Knutstad et al., 2009) that aim to cover this joint sociotechnical and operations management perspectives. By “manufacturing” we refer to operational excellence. By “attractive” we encompass the Quality of Work life dimension. When merging “attractive” and “manufacturing” we emphasis the link between the social and the technical system. Much research, both conceptual and empirical, remains, and we hereby invite the international research community to contribute.

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