

Science and Technology Studies as Research Strategy for Explaining LEAN Production Implementation

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Abstract

In this paper we present an exploration of how to use Science and Technology Studies (STS) as research strategy for explaining implementation of modern concepts of production systems improvements (like LEAN). We are intrigued by the “nuts and bolts” explaining the changes taking place in the organization as a result of these concepts. Our agenda is a more explanatory approach for understanding how the process is undertaken in an organization, using a traditional process plant in Norway as our context. This is important because going beyond the descriptive and normative level often associated with literature on these concepts, will make us better able to handle and take control over the implementation of modern concepts of production systems improvements.

We focus on the approach given by Latour, Bijker and other in STS. The view of science and technology as socially embedded enterprises, the concept of black boxes, the strategy of focusing on practice and the history behind the facts and the detailed case histories (richness of data) are close to our own ideas on how to explore complex phenomena like science, technology, and maybe modern concepts of production systems improvement. We will use this approach as an inspiration and guideline in our own exploration. Central in this framework for research are the focus on action; to observe the practioners at work and find out what they do, and not what they say. This is important because when first established as a new standard it is difficult to understand and deconstruct how this happened.

We present the research design in details, preliminary findings and discussions on how to use STS as research strategy for explaining implementation of modern concepts of production systems improvements. Our working hypothesis in the development of how to design the workforms, methods and analysis are:

- Social, political and cultural context and technological content are essential for a meaningful understanding of modern concepts of production systems improvements
- These concepts and the way they turn out can only be understood “in action” and by following the transformations taking place in the processes. We can never use the end result alone to explain.
- Many black boxes of traditional literature on these methods needs to be opened and explored in more details, bringing the theories closer to the empirical material.

Introduction

The change project that form the basis of this work, started up as part of the Value Creation 2010 (VC2010) project module in Østfold and has since autumn 2007 continued in the Measures on regional R&D and innovation (VRI) research program. The main objective is to encourage and contribute to organizational development and innovation within enterprises. New forms of co-operation between the industrial social partners and other actors in the value creation processes are central. This is done by active use of researchers as development partners. The project is based on an action research (AR) approach. The project started up in august 2007 and we will take part through the whole process that has a scheduled deadline in spring 2009.

We have been part of the change project introducing new approaches to production in the factory and the enterprise. In the initial phases we introduced an approach to production that may be defined as an early version of lean production, strongly influenced by Japanese production philosophy represented with the works of Edwards Deming and Shoichiro Toyoda and the emphasize on removing waste (muda) to achieve production smoothing (heijunka). But the project is also part of the legacy from the Norwegian Democracy Projects represented with the works of Einar Thorsrud and Fred Emery and the emphasize on participation and work place democracy. There are of course technological elements part of the change project (both on logistics and new machines), but the emphasize is on how we as part of an organization work together, and especially how we can work smarter.

This paper is about how to do research on implementation of modern concepts of production systems improvements (like LEAN). To do that we present and discuss the theoretical hypothesis underpinning the work, the strategic research choices made and the workforms implemented linked to our experiences from a LEAN implementation project.

To understand the paper it is important to note the AR approach given. Keywords are collaborative knowledge development, actions involving the stakeholders and a social change agenda. This approach links validity to solving real life problems and credibility to the arguments that make someone trust the research results. In action research meanings created in one context may be moved to another for interpretation and maybe implementation (Greenwood & Levin, c2007). Because of this there will be references also to the actual LEAN project being an integrated part of the research project and design.

Problem Statement and Research Question

Introduction of technological superior solutions (?) and methods of production don't always have the intended positive effects. This was true 50 years ago with the introduction of the Longwall methods of coal getting in a coalmine, documented by Eric Trist and Ken Bamsforth in the famous article, "Some Social and Psychological Consequences of the Longwall Method of Coal Getting" (1951). Management introduced a new mechanized method (the Longwall method) that organized the work over three specialized shifts, each shift responsible for different tasks of the work, resulting in an increased level of interdependence of tasks. This was a change from the old organization with some degree of autonomy, and argues Trist and Bamsforth, destroyed the social structures present in the organization. The results were difficulties in the co-ordination of the work and low productivity. We experience that the dilemma is still true, but today with the introduction of LEAN, 5S, Six sigma, SMED, OEE, Kaizen, Poka Yoke, and a variety of other modern concepts.

But if the new technologies and methods are superior and do work in some enterprises, why does it seem so difficult in many innovation projects to realize the full potential? The literature on implementing modern concepts of production is vast. But the mainstream titles are dominated by "How to ...", "Transforming by ...", "Simple methods for ...", "Shaping ...", "Reducing ...", "Untangling ...". The recipes and methods on how to carry out the implementation are many and detailed and so are the diversity in labels and orientation. The infrastructure supporting the different methods is likewise, where the companies are offered a wide variety of consultant's services and facilitators. Our worries and critics are the normative and descriptive approach, dominated by sales arguments, a consultant profile and idealized cases. The literature is also dominated by cases and experiences from large companies (Toyota, 3M) and different worklife traditions and contexts (Japan, USA, UK). We will argue that the literature is experienced as distant from the daily challenges in a traditional Norwegian process plant.

We are intrigued by the "nuts and bolts" explaining the changes taking place in the organization as a result of modern concepts of production systems improvements. Our agenda is a more explanatory approach for understanding how the process is undertaken in an organization, using a traditional process plant in Norway as our context. In this perspective a new research strategy is important to explore. With research strategy we understand the long term planning of actions designed to explore and explain how the process is undertaken in the organization.

Our research question is: What are the experiences using Science and technology studies as research strategy for explaining LEAN production Implementation?

This is important because a research strategy that enable us to go beyond the descriptive and normative level will make us better able to handle and take control over the implementation of modern concepts of production systems improvements. It will also contribute to the discussions on these concepts by open up some of the "black boxes" often used and present an explanatory/empirical approach for understanding the processes.

Literature review

Science and technology studies (STS) is an interdisciplinary program on how social, political and cultural values shape scientific research and technological innovation and vice versa, how scientific research and technological innovation shape social, political and cultural values. The common ground is in viewing science and technology as socially embedded enterprises.

Bruno Latour's analysis of science (Latour, 1987), arguing how social context and technical content are important to understand scientific activity, can serve as an example of STS writings. Science is viewed as a collective action, and information (facts) about nature is the outcome of this collective action. Latour's point is that facts are constructed and it takes work to establish and maintain them. Central in this framework for research are the focus on action; to observe the scientists at work and find out what they do, and not what they say. This is important because when first established as a "fact" the scientific discoveries are difficult to understand and deconstruct; a black box is created that no longer is discussed and challenged.

STS also include literature on innovations in organizations. Pinch & Bijker (Bijker, Hughes et al. 1987) conceptualize innovations as complex, social processes where construction of new technology is dependent of all involved actors. All actors bring knowledge, ideas and influence into the development of activities. There is no one-dimensional logic that guides the process. Different knowledge, interests, perspectives and social understanding are integrated into the same development activity, where gradually, a shared understanding about what the innovation results should be evolves. The development process is "ended" when a majority of actors with power in a kind of consensus decide that the results are achieved.

Another significant contribution and example of STS writing, that is especially interesting on a more tactical level, is the study of Salk Institute (Latour, 1986). In this study Bruno Latour develop a detailed study "of the daily activities of scientists in their natural habitat". From October 1975 he worked at Salk Institute for a two-year period where he become part of a laboratory "to follow closely the intimate processes of scientific work, while at the same time to remain an 'inside' outside observer, a kind of anthropological probe to study a scientific 'culture' — to follow in every detail what the scientists do and how and what they think". Latour combine participant-observation and an "ethnomethodological approach" (Lowood & Sussman, 2003) in a book length and detailed study of processes and actors linking the theoretical framework and observations close to the empirical material in a transparent way.

Remember that our point of departure was our worries and critics on much of the literature on new concepts of production systems improvements as normative and descriptive, dominated by sales arguments, a consultant profile and idealized cases from large companies and very different worklife traditions and contexts. Our agenda is a more explanatory approach, grounded in data, for understanding how the process is undertaken in a company, using a traditional process plant in Norway as the context.

We are inspired by the approach given by Latour, Bijker and other in STS. The view of science and technology as socially embedded enterprises, the concept of black boxes, the

strategy of focusing on practice and the history behind the facts and the detailed case histories (richness of data) are close to our own ideas on how to explore complex phenomena like science, technology, and maybe modern concepts of production systems improvements. We will use this approach as an inspiration and guideline in our own exploration.

Research Hypothesis

Our working hypothesis in the development of our strategic choices and how to design the workforms, methods and analysis are:

- On context and content: Social, political and cultural context and technological content are essential for a meaningful understanding of modern concepts of production systems improvements
- On understood in action: These concepts and the way they turn out can only be understood “in action” and by following the transformations taking place in the processes. We can never use the end result alone to explain.
- On black boxes: Many black boxes of traditional literature on these methods needs to be opened, challenged and explored in more details, bringing the theories closer to the empirical material.

Some Strategic choices and Workforms planned

Based on the literature review and the hypothesis on how to do research on modern concepts of production systems improvements we have made a series of strategically choices on how to do research and what workforms used to implement the strategies. An overview of the hypothesis, strategic choices, workforms and arenas are presented in table 1.

Hypothesis	Strategic choices	Workforms	Arena
On social context	A socio-technical underpinning of the project and explicit focus on systems thinking	Participative process mapping Seminars on socio-technical thinking Search conference	The project team Search conference
On political context	Enterprise with long experience with institutional and voluntary involvement in the NDP projects Trade union representative in the project steering committee	Management – trade union collaboration Three-partite regime workform	Steering committee General meetings
On cultural context	Organizational culture as important parameter	Organizational culture assessment	General meetings
On technological content	Only researchers with know-how on core technology in the industry chosen	Active use of researchers as development partners	Project team Action teams General meetings
On understood in action	Action research as approach “Live” in the factory	Being there when the transformations take place	Project team Action teams General meetings
On black boxes	Establish arenas and forums across traditional boundaries Participative reflections and analysis	Dialogue across traditional horizontal and vertical boundaries	Steering committee Project team Action teams General meetings

Table 1: Overview of Strategic Choices and Workforms

Context and content

We have chosen to discuss in more details three of the hypothesis, choices and workforms above; on social context, on political context and on technological content/on understood in action.

Social context: Our hypothesis is that social context is essential for a meaningful understanding of modern concepts of production systems improvements.

Based on the hypothesis we made a strategic choice of a socio-technical underpinning of the project in the enterprise with explicit focus on systems thinking.

This choice will focus on both social and technological subsystems in the search for the best overall solution (and not only the technical subsystems). We will argue that this will establish social context as important for finding the best overall solution and by that also increase the awareness and legitimacy of focusing on this parameter.

In this perspective the relations between the social and technological subsystems are in focus (Trist, Bamsforth 1951). Susman (Susman 1983) argues that the socio-technical system model search for the best overall solution, with conflicting demands often present in the two subsystems. Tavistock institute used in the 1960's socio-technical system models in the Norwegian Democracy projects (Elden 1979) (Thorsrud, Emery 1970). Vital understanding and knowledge developed in these projects was the importance of participation and ownership among the employees.

The primary arena is the Project team, with regular meetings every 14-day. The project team was designed to establish horizontal and vertical integration with representatives from all involved departments/actors and all levels in the organization. Workforms in the project team supporting the strategic choices made are Participative Process Mapping and Seminars on socio-technical systems thinking. These workforms were part of the mapping and identification of pitfalls (the first phase of the project).

Another important workform is the Search conference. The search conference was planned to take pitfalls identified in mapping and begin the development of measures. The arena in this workform was not isolated to the project team. All staff and management at the display factory and sales, and other involved resources like the cardboard machine operators, transport and logistics and QMS were part of the conference. The factory is to be shut down for one day to make this possible. The conference will use a traditional approach with work in groups vs. plenum and in homogenous vs. heterogeneous settings. The conference should end up with task teams to continue the work on the pitfalls in collaboration with the external researchers.

Political context: Our hypothesis is that political context is essential for a meaningful understanding of modern concepts of production systems improvements.

Based on the hypothesis we made two strategic choices. First we chose an enterprise with long experience with institutional and voluntary involvement (in NDP projects). Second we choose a project design that included the trade union representative as part of the steering committee.

These choices will contribute to a political awareness that make the political context legitimate. The trade union representative will also challenge the traditional management thinking often associated with this type of projects.

The political context was on the agenda from the initial planning of the project. The enterprise and factory chosen have long experience from working in the VRI research program with main objective to encourage and contribute to organizational development and innovation within enterprises, using new forms of co-operation between the industrial social partners and other actors in the value creation processes.

One arena is the Steering committee, with regular meetings. The steering committee was designed to establish a management – trade union team. One central workform supporting the choices is management – trade union collaboration implicit in this design. Another arena is the General Meeting. It is planned to use General meetings on a local level with everyone in the factory but also on enterprise level with all staff and management at the display factory and sales, and other involved resources like the cardboard machine operators, transport and logistics and QMS. The arenas are meant to support a three-partite (management, trade unions and employees) regime workform in the development project.

Understood in action

Our second hypothesis was that these concepts and the way they turn out could only be understood “in action” and by following the transformations taking place in the processes. We can never use the end result alone to explain.

Based on the hypothesis we made strategic choices of Action Research as approach to doing research and researchers as development partners that take active part in the project and that of “living” in the factory for a long period of time as a “friendly outsider“ (Greenwood & Levin, c2007)

We will argue that taking part in the project and the research “with people” approach in AR and the closeness to the practitioners, as a “friendly outsider” will open up arenas of action otherwise closed for the researcher and provide us as researchers with a richness of data not possible in the traditional approach. “Living” in the factory is maybe the only way to achieve a rich and sensitive empirical material on the transformations taking place in the processes.

Several workforms chosen support the strategically choices made. This is done by active use of researchers as development partners that take roles and actions in the actual project, being there when the transformations take place. This implies both work in depth and over time in the enterprise project in arenas like the project team, the action teams and the search conference.

Scenes from the factory

Finding solutions together

Spring 2007 a research team from Østfold University College and Østfold Research Institute together with management, trade union representatives and staff, started the initial reflections and discussions on a possible lean production innovation project. A rudimentary mandate was established and a project team with representatives from all involved departments (display factory management and staff, sales department, researchers, transport and logistics department) started the work august 2007. The work was supervised by a project steering committee consistent of managing director, trade union representative and head of two main departments. The trade union representative becomes part of the steering committee after pressure from the researchers. Management chose the arena (the display factory) for the project and the composition of the project team. On both a social and political context, personal qualities and values were emphasized in the composition of the project team, further, the importance of designing a participative and involving process reflecting a three-partite workform between the management, the employees and the union was emphasized. Further, the management realized that the long experience in both institutional and voluntary

participating should be fully utilized in the project. One example is the link between this project and participants from an earlier NDP project in the same enterprise, but a different factory.

One of the reasons to initiate the zero-errors project was the quality problems on supply of cardboard and display paper from the internal supplier, and the problems that lead to in production. The products from the Display department are relative expensive and complaints have serious economical consequences. The company can't afford to make these mistakes. The goal was zero-errors on products to customers. That means that the internal routines shall uncover errors before the products reach the client. Internal supplier /client relations have been created.

A project plan was early agreed upon and the project was split into three phases over a period of 18 months:

- Mapping of the processes, organizational culture and pitfalls relative to the zero-errors goal
- Development of measures and actions both technical and organizational
- Implementation (three sub-phases to make possible reflections and corrections)

The approach used to reach zero-errors may be defined as a version of lean production, strongly influenced by Japanese production philosophy represented with the works of Edwards Deming and Shoichiro Toyoda and the emphasize on removing waste (muda) to achieve production smoothing (heijunka). But the approach was also part of the legacy from the Norwegian Democracy Projects represented with the works of Einar Thorsrud and Fred Emery and the emphasize on participation and democracy.

A friendly project

From the first initial talks about the project, the importance of close collaboration and trust between the actors taking part in the work have been emphasized. So has broad participation from staff as an important condition for learning, development and innovation. To be able to reach these "requirements", staff and management needs to speak the same "language" and share the same goals demanding broad communication using different channels to be able to reach all participants. Trust was another important aspect. Industrial change processes are often associated with downsizing and change to the worse for the employees. The managing director was very clear in the initial phases and on the kick-off presentation in the Display department that this is not a project about downsizing the workforce, but on motivation and participation in the continuous improvement and development of the factory and the products. Real redistribution of power on decision making to the operators and resources made available to earlier projects in the same tradition the year before, gave the statement credibility. The project was very open. All project documentation could be found on the intranet to avoid the development of discussions on a "hidden agenda" or any suspicion based on someone having more knowledge about the project than other. Openness and broad information have been fundamentals in the project from the start, to prevent and reduce the uncertainty often associated with change projects. All project meetings reports and documents are therefore published on the intranet for all to read, with hard copies of the same documents available at the factory recreation room. Key figures and information are also published on the digital information boards available in every department.

The friendly outsider

In the mapping phase we started addressing these issues direct, and took on maybe the most difficult area regarding the tensions between the different departments. The project team carried out a collaborative process mapping. The external researchers with know-how on core technology and with an AR approach took active part as development partners during the whole project period. Their roles were both as project manager and as members of the project team for the whole 18 months. Taking part in the challenges, victories and problems in the project as a friendly outsider (Greenwood & Levin, c2007).

The team started in the end and traced the product backwards to the start of the cardboard machine. All the different processes, different fields of responsibilities and different tasks involved were discussed in detail. After the mapping most of the members expressed surprise in the complexity of what they thought was a simple process! The exercise was repeated for the other parts of the production chain to ensure a shared understanding of the complete line. It is interesting to note how the change project in this way created new arenas for dialogue and knowledge transfer between colleagues and between departments. The arenas were created in the boundaries between the different departments, made available due to the broad participation. After the mapping process each member of the team started to think of his/hers work as part of a whole that they now knew, and a holistic view of their own work gradually started to evolve. During the process “obvious” pitfalls were identified and preliminary measures and actions were proposed. The mapping was work intensive and demanding. One member of the project team suggested that the experts (the one responsible) on the process studied, should do the work and present it for the group as an alternative to the collaborative approach involving also they who not was involved in that exact part of the process. It is interesting to note that the project team emphasized that the importance of knowing the what, why and how emerging from the collaborative approach was essential, as was the ideas on measures and actions coming from friendly outsiders in the process.

Quality Management System for everyone

After the initial process mapping the team concentrated on the pitfalls and the identifying of indicators describing the pitfalls. In this work the quality management system (QMS) and the accompanying divergence (internal complaints) – complaint database became pinpointed as one major source of data. Adjustments were done to the databases to address the pitfalls in even greater details (the responsible of the QMS was part of the project team). The importance of the divergence – complaint ratio was discussed and a shared goal to increase the ratio was agreed on, based on the need for more knowledge on the reasons for the divergences and the level of impact from the different divergences. The importance of both the QMS and the divergence – complaints statistics grew in the group, and as a result several procedures were changed or removed and new one established. The one actual doing the job, writes the procedure changes – not management or the responsible for the QMS. It is also important to note that one leading member of management joined the team in this phase, thus influencing both the possible impacts from the teams work and the agenda. Quick fixes and small continuous developments were given more priority. The introduction of the new member also increased the team’s ability to make changes in areas of importance for the project (the project can suggest changes, but still every decisions are made in the formal organization hierarchy).

Discussions

How did our choice of a socio-technical underpinning of the project and explicit focus on both social and technological subsystems influence the awareness and legitimacy of

focusing on the social context? From the case we see the development of a systems thinking approach to development as in participative process mapping where the members of the team starting to think of his/hers work as part of a whole that they now knew, and a holistic view of their own work gradually starting to evolve. The social context becomes visible for us as researchers in greater details.

How did our choices on political context contribute to a political awareness, legitimize the political context and challenge the traditional management thinking? From the case we see that the project have created openness and transparency in the way we work that make hidden agendas and closed networks less powerful like human made bottlenecks stopping actions taken. The shift from management to the one actual doing the job writing the procedure changes and reporting divergence and complaints in the QMS database strengthen this visibility becoming part of the official system. We will also argue that including the trade union representative in the steering committee created a new management attitude where the trade union was seen more as a development partner. The trade union perspective challenged the traditional management perspective. The political context becomes visible for us as researchers in greater details. The openness and transparency have created increased trust between the actors leading to an environment that appreciate challenges and humility towards established facts as in the project team emphasizing that the importance of knowing the what, why and how emerging from the collaborative approach.

How did our choices on understanding in action contribute to opening up arenas of action and topics otherwise closed for the researcher and providing us as researchers with a richness of data not possible in the traditional approach? Being active part of the change project for a long time we become an insider. We took part in discussions on topics normally closed for an outsider. These topics were important for understanding the processes taking place. The researchers knowledge on core technology in the industry established a positive authority on the researchers and by that a credibility made the researchers able to understand and interpret actions and events associated with this. The researchers could ask meaningful questions on technological content and better understand the local dialects. Finally the researcher contributed to the actual problem solving and was a natural part of the project. The research “with people” and the closeness to the practitioners as friendly outsiders opened up arenas of action otherwise closed and provided us as researchers with a richness of data not possible in the traditional approach. “Living” in the factory gave us a rich and sensitive empirical material on the transformations taking place in the processes. The “living” in the factory made cyclic phases in the analysis a natural part of the process.

References

- Bijker, Hughes, & Pinch. (1987). *The social construction of technological systems*. Cambridge, Mass: MIT Press.
- Greenwood, D. J., & Levin, M. (2007). *Introduction to action research: Social research for social change* (2nd ed.). Thousand Oaks, Calif.: Sage Publications.
- Latour, B., & Woolgar S. (1986). *Laboratory life: The construction of scientific facts*. Princeton, N.J.: Princeton University Press.
- Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Milton Keynes: Open University Press.

Lowood, H., & Sussman, S. (2003). *Stanford presidential lectures and symposia in the humanities and arts - bruno latour*, from <http://prelectur.stanford.edu/lecturers/latour/>

Trist, E., & Bamforth, K. (1951). *Some social and psychological consequences of the longwall method of coal getting*. *Human Relations*, 4, 3-4-38.