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Socio-Technical Product Creation
An Exploratory Study Concerning the Improvement of the Cooperation of Professionals in the Product Creation Process

Lianne W.L. Simonse
&
Frans M. van Eijnatten

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Abstract

The environment of industrial enterprises has changed the way managers think about productivity and innovation. To be an innovative firm is the challenge for the nineties.

Of course, the organisation of the product creation is high on the research agenda. Recent literature is showing several attempts to integrate the work of professionals. Managers are increasingly willing to invest in Integral Organisational Renewal of the firm. Boasting on a long research tradition, Socio-Technical Systems Design (STSD) can support this renewal process.

This paper explores the theoretical and practical possibilities of a new flow-oriented organisation of the whole chain of the primary process, integrating product-development processes with each other and with marketing, engineering, production and purchase.

This paper presents some empirical results of a study of product-creation processes in five international operating Dutch companies. A qualitative analysis of the interview results indicate that the internal organisation of the product-creation trajectory will change over the next decade. According to our respondents, professionals of different disciplines already work together in project teams. They expressed that more emphasis must be placed on integrating different perspectives in mutual understanding, while sharing jointly responsibility for planning and decision making.

This paper also present some illustrations of an in-depth analysis of the product-creation function in a particular high-tech company. As will be discussed, the STSD paradigm can offer some clues for redesigning the product-creation process.

This paper concludes with an action research agenda.
Socio-Technical Product Creation
An Exploratory Study Concerning the Improvement of the Cooperation of Professionals in the Product Creation Process

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Introduction

The environment of industrial enterprises has changed the way managers think about productivity and innovation. Clark & Fujimoto (1991) indicate the following three driving forces behind the new industrial climate: Intense international competition; fragmented markets and sophisticated customers; and diversified and transforming technologies. In order to be able to continue operating in a turbulent environment, enterprises must respond to a multitude of market claims: Low prices, short delivery times, uniqueness of products, outstanding quality, and tailor-made variety.

New products account for a growing amount of sales and profits. Except for wanting new products faster, customers also increasingly ask for unique products. To be an innovative firm is the challenge of the nineties. Most attention is paid to reducing the ‘time-to-market’. This is also reflected in the congress theme: ‘Speeding-up innovation’.

Lowering the production leadtimes is only one aspect of reducing the ‘time-to-market’; its scope is broader. ‘Time-to-market’ can be split up in time for product creation, time for production and time for product launching. Regarding the product creation as the new focal point of global competition, this will be the subject of primary interest in this paper.

Let’s first define the term ‘product creation’. Product creation is a process of producing ideas about product and processes which evolve from abstract to concrete. Product creation includes the contributions of many different disciplines: Marketing & Sales, Development, Engineering, Purchasing, Production and Accounting. It even includes contributions of partners from outside the company, as there are suppliers, R&D institutes, software houses etc.

Compared to production, product creation is predominantly a knowledge process with nonrepetitive, nonroutine tasks and with a much longer time horizon. Another very important characteristic of product creation is the uncertainty of output.
This Paper

Exploring the Product-Creation Trajectory

This paper will discuss new forms of internal work organisation from the perspective of speeding up innovation. Boasting on a long design-oriented research tradition, we will use the renewal of the production function as point of reference here, while the product-creation function is subject of exploration, using Socio-Technical Systems Design (STSD) as a theoretical framework. Some experiences from theorists and practitioners will be used for illustration purposes. The concluding remarks will hold a proposal for further research in the product creation trajectory.

The Use of Interview Data

In this paper we deliberately make use of data gathered in structured in-depth interviews with 8 practitioners from 5 different Dutch companies (cf. Simonse, 1993a), and in a recently conducted case study (cf. Simonse, 1993b). In the first research, whenever possible, two experts from each company have been interviewed. The questions raised, were about the present company situation and the prospects in the foreseeable future (5 and 10 years).

Because all respondents are working in the product-creation trajectory, they are very able to detect and handle the real problems. Therefore, we will call them 'experts'. Their respective positions are development manager, functional manager, internal consultant, head of tools drawing room, and project leader.

There was a striking similarity between the pattern of answers of the two experts from each company. Even concerning the future they mentioned the same characteristics. Probably this is due to the fact that strategic and tactical issues are well-communicated at their positions.

All companies operate on international markets. Their products can be identified as complex, which means that a great amount of product-creation capacity is needed. For reasons of confidentiality the companies are coded using the first letters of the alphabet. Their respective core businesses are:

- company A: professional medical systems;
- company B: professional office systems;
- company C: automotive industry;
- company D: automotive industry;
- company E: electrical transport systems.

Some Reported Prospects

Concerning the driving forces of international competition mentioned before, all companies experience a more intense competition with respect of the price/performance of their products. 'Cost-down' and 'speed-up innovation' are familiar slogans for them. Time-to-market is a hot topic. Company B, D and E are dealing with fragmented markets and sophisticated customers by giving special attention to 'nice marketing' (company B) and 'building of direct customer relations' (company D and E). For a certain percentage of their output Company D and E prefer to be dependent on 'engineer-to-order' work.

Concerning the diversified and transforming technologies, company A, B and D prospect
for the coming 5 to 10 years a shift in technologies from mechanical hardware to digital electronic, and software-controlled devices. The two companies from the automotive industry view the quality improvement of their core mechanical technologies more important than an innovative shift to new technologies. They mention that in product creation more emphasis must be placed on styling and pollution-control aspects.

The companies’ reactions to the environmental pressures go in several directions. Concerning the internal organisation all experts share the vision of more cooperation of different disciplines, and earlier suppliers involvement or co-design. Most of the experts think cooperation will be facilitated in multidisciplinary teams. Experts of company A, B and D mention that integrated CAD or CAE and software tools for simulation also will achieve a reduction in product-creation leadtime.

More results about how the experts think of their companies will tune their internal organisation structures, processes and workforces to the environment, will be elaborated upon in the next sections of this paper.

A New Paradigm for Production and Product Creation

In order to cope with the increasing environmental pressures mentioned above, it seems evident that the internal organisation of a firm must be changed in a proportional way. The given problems and trends are of such an extent that it urges companies to experiment with new forms of technology and work organisation.

In the last decade, practice and literature have been mainly focused on production. The renewal of R&D, Marketing, Purchase and Sales scored lower on the priority list. Now that this vision has radically changed, it is interesting to investigate if the new solutions, already developed in production, also are applicable to the product-creation process in which both Marketing & Sales, R&D, Purchase and Production are involved.

In this section we want to elaborate on the new paradigm, and the accompanying organisational structures, processes and units. A comparison will be made between new production concepts and product-creation ideas, both from practice and literature.

Alternative Organisational Paradigm

On a high level of abstraction we start with an examination of basic organisation paradigm. Such a consideration is necessary, because leading organisational principles can block or facilitate the speed-up of innovation. Bolwijn & Kumpe (1989) have argued, that innovation presumes flexibility, controllability and quality of work. The integration of knowledge, information, phases, tasks and individuals will be crucial conditions for successfully reducing the time-to-market.

One of the scientific fields that embraces integration is Socio-Technical Systems Design (STSD) (cf. Van Eijnatten, 1993). The contents of this approach can be characterised as a reaction to the unilateral emphasis placed in previous organisational paradigms (Scientific Management: Taylor, 1911; Bureaucratic: Weber, 1947; Human Relations: Mayo, 1933) on either the technical or the social aspects of the organisation. In the new perspective, both factors are integrated as being components of one single ‘sociotechnical entity’.

In an attempt to give a brief and concise typification of Classical STSD, Van Beinum (1990) lists nine characteristics of content of what he refers to as ‘the new organisational
paradigm’. He mentions among others redundancy of functions, internal coordination and control, joint optimisation, optimal task grouping and semi-autonomous work groups. These particular principles can also be interpreted as respectively integration of functions, integration of coordination/control with executive tasks, integration of tasks and integration of individuals.

There is a clear ‘integration philosophy’ behind STSD. Assuming that integration of aspects will be an important factor in actually reducing the product-creation time, STSD can serve as an appropriate conceptual framework.

However, we must be aware of the fact that most STSD-design principles are mainly derived from production contexts. Recently Purser & Pasmore (1991) updated six principles for nonroutine knowledge work settings, such as product-creation. They came to define the following concepts:

- ‘Dynamic synchronisation versus joint optimisation’: Joint optimisation is based on a system in ‘steady state’. In nonroutine knowledge work settings, however, it’s better to take a dynamic point of reference because change in internal and external organisation is inherent in this type of work. Integration of diversified technologies through synchronisation becomes a challenge. Dynamic synchronisation ‘is an ever active, renormalising movement in which non-optimal permutations are dampened and phasic mismatches in knowledge development conversion cycle are brought into harmony’ (Purser & Pasmore, 1991, p11/12). This concept is based on a new theoretical framework, i.e., the ‘catastrophe’/‘order through chaos’ theory that already has been applied successfully in physics, chemistry, meteorology and ecology. Professional work settings resemble chaotic systems in their unpredictable, indecomposable and recurrent way. In this view self-organising systems adapt to turbulent environmental conditions by admitting increasingly complex inputs. As complexity has reached a critical level, the system reorganises itself into smaller parts through a process of ‘willful bifurcation’.

- ‘Redundancy of rhythms instead of redundancy of functions’: Rhythmical organising is a tailor-made answer to environmental opportunities. Temporally dynamic groups are the core elements in rhythmical organisations. Those groups are also rhythmical in coordinating the timing and phasing of their activities.

- ‘Multi-phasing instead of multi-skilling’: According to Pava (1983), multi-skilling is not a viable option in nonroutine work systems, because of the high training level of knowledge work professionals. ‘Multi-phasing’ means working together along the different product-creation phases to overcome a narrowing of expertise, ego investments in the personal piece of work and lack of identification with the end-product.

- ‘Multi-phased groups instead of semi-autonomous work groups’: In semi-autonomous groups a collective task lead to a collective groups output. Multi-phased group are described by Purser & Pasmore (1991) as highly differentiated groups of professionals who plan and solve problems in parallel with each other. The group task concerns a more dynamic involvement in creating and bargaining a set of collective criteria related to the collective group output, being the new product. Contradictions and divergent perspectives are surfaced, coupled, and managed in deliberations.

- ‘Removing barriers for learning instead of control variances at their sources’: The STSD concept of variance control does not apply in nonroutine systems (Taylor, 1989), because process deviations are not easily detectable or traceable. This is related to the nature of knowledge work which is unpredictable, nonrepetitive and having a long time horizon. Direct influences of a control structure on knowledge work should be changed in order to remove barriers for learning. A thinking and learning organisation will evolve that possibly produce self-designing knowledge work systems.
'Quality of thinking life better than quality of working life': At the level of professional work, financial benefits seem to score secondary in importance to freedom to decide, and intellectually stimulating colleagues. Knowledge work is primarily a strong intrinsic motivator. In practice, however, not seldom too much variety is much bigger a problem than too little. Because the whole knowledge work process is occurring in peoples' minds, the notion of 'working life' has been adjusted to 'thinking life'.

Research Implications:

The adapted STSD principles of Purser & Pasmore give new impulses for rethinking the organisational settings of the product-creation function. In further research we want to discuss their views with practitioners in order to be able to develop possible and acceptable translations of the above-mentioned principles into practical design concepts.

One of the research questions that can be asked is whether basic tayloristic principles will persist in product creation? We made a kick-off in the interview sessions among the experts, articulating a question in which we consider the functional structure as a main exponent of the tayloristic paradigm. We asked the respondents: 'Do you think the functional structure (i.e. the partition in specialised discipline-specific departments) in your organisation will survive in the foreseeable future?' Two experts answered in a conditional way: They questioned the functional structure for product-development (creation) activities, because of the experienced drawbacks of a matrix-structure. However they asserted that for technology research successfully creating and monitoring discipline-specific knowledge definitely keeps requiring a functional structure. The other six experts answered in an unconditional positive way, arguing that temporary project-organisations create too much uncertainty among professionals. They also prefer a solid home base for communicating discipline-specific knowledge. Apparently, the functional structure has not done away at all!

Alternative Organisational Structure

Organisational structures may support or obstruct effective responses to environmental pressures. On two basic genotypes we want to elaborate a bit. Van Sluis et al. (1991) contrasted a traditional and a sociotechnical organisation structure (cf. figure 1).

Figure 1a represents a traditional organisation with specialised departments. Applying maximum task breakdown, functions of similar disciplines are grouped together. In the first place the control of executive activities is exercised at departmental level. The decisions at the level of overall control are made central in the hierarchy. Other control mechanisms are the procedures that fit the standardisation of product and process. Through the need of more and more coordination as a consequence of increasingly simple tasks, the organisation is becoming quite complex. This way of organising can be characterised by 'functional concentration'.

Figure 1b represents a sociotechnical designed organisation in which the business process is dominant. Activities are arranged in parallel flows of identical work orders. The control of the activities is as much as possible incorporated in the task grouping. Teams take care of a complete, identifiable set of tasks. Here there are complex tasks in a simple, flat organisation. This way of organising can be characterised as 'functional integration'.
In a sociotechnical-designed production structure the horizontal relation is dominant, stressing the wholeness of the business process. In the production organisation parallel flows of grouped work orders are dominant. Applying the sociotechnical structure to the product-creation organisation, product lines become dominant, stressing the wholeness of the product-creation process. Within the main flow, streams of product lines consisting of both succeeding and update projects, can be identified. Another option is to define each individual product-creation project as a parallel stream. Then it must be taken into account that these streams are temporary in nature.

Organisation of Product-Creation Structure in Practice

In the schematic representation of organisation structures as showed in figure 1, also a matrix structure can be easily recognised. Wheelwright and Clark (1992) assume the horizontal flow representing a project. They distinguish between two different types of matrix structures: A light-weighted and a heavy-weighted matrix structure. Besides they classified two additional, more extreme forms of organisation structure for product-creation: One based on functional concentration and the other based on functional integration.

In order to compare the organisation structures of the five different companies, we use an adapted version of this classification (cf. figure 2).

For company C figure 2.1 is most applicable. After reorganisation a situation has been created in which the functional manager is the same person as the project manager. The experts remarked that the 'functional' units don't fit the well-known technology disciplines like mechanics, electronics and software, but merely match the four main parts of the product. Furthermore the coordination is not only formal or procedure-driven, but also informal, organised in a 'simultaneous engineering' way.

Figure 1: A Schematic Representation of Organisational Structures.
2.1 Functional structure

The disciplines are organised in functional departments, and engineers are relatively specialised. Senior functional managers are responsible for allocating resources. The responsibility for the total product is not allocated to a single person. Coordination occurs through rules and procedures, detailed specifications, shared traditions among engineers and meetings (ad hoc and structured).

2.2 Light-weighted matrix structure

The basic organisation remains functional and the level of specialisation is comparable to that found in the functional mode. What is different, is the addition of a product manager who coordinates development activities through liaison representatives from each function. Their main tasks are: To collect information, to solve conflicts, and to facilitate achievement of overall project objectives. Their status and influence are less as compared to functional managers, because they have no direct access to working-level people.

2.3 Heavy-weighted matrix structure

The organisation exists of a matrix with dominant the project structure and underlying the functional departments. The Product Manager (PDM) has a broader responsibility and clout. Manufacturing, Marketing and Concept Development are included. The status and influence of the PDM, who is usually a senior, is the same or higher as compared to the Functional Manager (FM).

2.4 Pure project structure besides functional structure

The basic organisation exists of product-oriented flows: Project and teams. The project members leave their functional department and devote all their time to the project. They share the same location. The professionals are less specialised and have broader tasks, skills and responsibilities. The FM is responsible for the personnel development and the more detailed technology research in the functional groups.

Figure 2: Four Modes of Product-Creation Organisation

The expert of company E pointed at figure 2.2 as most resembling his company's organisation structure.
The expert of company A felt that their organisation had the characteristics of both figure 2.2 and 2.3. It should be noted that in this company the status of the project manager is lower. On the other hand there are also more disciplines involved. They have a project management of two professionals: A marketing professional and a development professional.

Depending on what project they want to refer to, the experts of company D agreed on figure 2.3 and figure 2.4. This duality is caused by different visions of a Swedish and a Japanese shareholder. The Japanese partner wants to have a transparent functional organisation structure with teams in the departments led by heavy-weighted project leaders. The Swedish partner wants multidisciplinary teams placed outside the functional structure, composed of members who work for 100% on the same project.

The experts of company B chose figure 2.4 as most resembling their own organisation structure. There is one difference with the appointed genotype: The functional manager is primarily a resource manager and therefore not responsible for the technology research. That function is set apart from development and has its own place in the organisation structure.

These results lead to the conclusion that the whole array of different organisation structures can be identified in the five Dutch firms.

The experts were also asked to prospect the organisation structure 5 years and 10 years later. The expert of company A prospects a shift to the model of figure 2.4. Most managers of his organisation have visited company B to get an impression of its organisation.

The two experts of company B agree that in 1998 they still will have the same structure because the current organisation is implemented only one year ago, following the advice of a leading consultancy firm. One of them thinks that in 10 years time they will arrive at a combination of figure 2.1 and 2.3, because that will suit better a policy of commonality parts in the different apparatus.

The experts of company C are reserved about the future because they just survived a reorganisation. They experienced the matrix structure with its dual power relations has been eliminated. For the time being, the management prefers an organisation structure, which shows unity-of-command.

In the future the development unit of company D has to serve several different customers, markets and shareholders. Their goal is to become a ‘rhythmic’ organisation with temporary structures which must serve the customers’ purpose for the best. Sometimes figure 2.4 will have to be applied in case of customers others then the shareholders. However they ‘fear’ a dominant Japanese influence that will drive the organisation to a model like in figure 2.2.

The expert of company E thinks about model 2.3 as a desirable future scenario in 5 years time. Within 10 years probably the matrix structure has been left. There will be no distinction in different knowledge disciplines on the organisational level, only on the individual level. Professionals in his company have to act like ‘entrepreneurs’ asking other professionals to work with them for a short period of time. Those entrepreneurs have direct contact with customers.

Concerning the future, none of the identified organisational structures is generally regarded as ‘universally best practice’.

Research Implications:

An organisational structure based on ‘functional integration’ puts the product-creation process in the centre. Because all barriers between departments are gone, actions reducing the time-to-market can be more effectively and more easily implemented. Therefore organisational structures resembling figure 2.4 are most preferable. However, looking at the expectations of
experts about the future, it might be that other organisational structures will match the main strategy of individual companies better. We want to discuss these different organisational options with practitioners, because there might be other structural alternatives, that balance functional concentration with functional integration.

**Alternative Organisational Process**

The business process (or primary process) is of focal interest in determining effective (re)actions to turbulent environmental pressures.

In a traditional production organisation a sequential process causes a lot of time-consuming coordination activities. In such a functional-organised production (for example a traditional machine-bureaucracy) a sequential process occurs when manufacturing activities are grouped on the basis of technical disciplines. After one day or one week all finished work orders are transferred to the next manufacturing station.

The same sort of sequential process occurs in product-creation organisations. Takeuchi & Nonaka (1986) used the metaphor of a ‘relay race’. In a sequential product-creation process one group of functional specialists pass the product-creation task (the baton) to the next group, in accordance with the different phases that are defined in a product-creation process.

**Parallelisation in Production**

In production the first step to a more flexible process was parallelisation of different work flows. Production orders were classified and clustered. The redesign of the production process can lead to substantive time reductions (from 9,5 weeks to 2 weeks, cf. Joosse et al., 1991). Hoevenaars (1991) designed a special tool for the parallelisation of the production flows. Activities related to the same sort of orders are grouped. The tool can't right away be applied to product-creation activities, although Eppinger (1991) proposed similar techniques. Some further research is needed.

**Parallelisation in Product Creation**

In a sequential product-creation process, the product-creation task moves from the concept phase to feasibility phase, from design phase to development phase, from engineering phase to the pilot-production phase. Before a next phase is started, a 'milestone' must be passed. This means that a decision of 'go/no go' is made. Before deciding, all requirements of the preceeding phase must be satisfied: Thus one bottleneck can slow down the entire process.

Observations in Japan led to an alternative approach. Takeuchi & Nonaka (1986) and Clark & Fujimoto (1991) modelled parallelisation in the product-creation process. These concepts are generally labeled as 'Simultaneous or Concurrent Engineering' (SE). The five dimensions of integration and overlapping interfaces are described by Clark & Fujimoto (1991, p.211). They are as follows:

1. An overlapping timing of upstream-downstream activities;
2. A high bandwidth (face-to-face) information transmission;
3. A fragmented (piece-by-piece) frequency of information transmission;
4. A bilateral (feedback) direction of communication;
5. An early release of preliminary information.
Overlapping of activities seems directly to reduce the product-creation time. Takeuchi & Nonaka (1986) propose a 'rugby' approach: "The phases overlap considerably, which enables a group to absorb the vibration or 'noise' generated throughout the development process. The knack lies in creating rhythm and knowing when to move from one state to the other. When a bottleneck occurs, the team of professionals pushes itself forward" (p.141).

In figure 3 three types of development phasing are depicted.

![Figure 3: Phasing of Product-Creation Process](image)

Type II can be seen as an intermediate step from sequential (Type I) to overlapping (Type III). This method reduces the number of phases by redefining them and aggregating them differently.

The aim of Simultaneous Engineering is to integrate or group activities, but, unfortunately, here the word 'parallelisation' has another meaning. In production it means that the same sort of activities on different production orders are performed in parallel. In product creation different activities of the same sort of product-creation tasks are now executed in a parallel way.

Product-Creation Process in Practice

According to the respondents, all companies mentioned before, use a phasing of their product-creation process for planning purposes and for controlling decisions of profitability that goes to the upper-management. Company A uses the 6 phases of systems management. Traditionally this is a sequential process (Type I). Although they experiment with more overlapping phases, the expert of this company sees more in reducing the number of phases instead of an early start of parallel activities. Company C and E also use 6 sequential phases (a mix of type I and II, dependent in the project phase), bearing company-specific names. The experts don't expect a pure overlapping of these phases in the future.

Company B and D have just implemented a four-phases approach for product creation. Company B has a total of 7 phases from concept to market (production included). Overlapping
phases for development and engineering from the beginning of a project has been practiced for 20 years now, resembling Type III. However, the overlap with production and suppliers is a more sequential overlapping (Type II). The experts of company B prospect a much more overlapping process in the future. Company D prospects a reverse trend under influence of the Japanese partner: A sequential process is more preferable. Now they are putting emphasis on defining input and output of the different transformation processes in each phase.

Research Implications:

Performing product-creation activities in a parallel way seems a direct action to respond faster to the market. The question remains how this can be implemented? We investigated a form of implementation at case-company F:

At case-company F there was a special interest in SE related to time-to-market. They choose a project which served as a pilot project. From the beginning it was a primary goal to create a product in the shortest possible leadtime. A project-start-up session was dedicated to this goal. The number of prototypes was reduced, and the sequence of activities was discussed. Suppliers were also present at the meeting. In the end the participants of the multi-disciplinary project team tuned their personal activities as close as possible. The result was a committed planning schedule of all activities.

In further research we want to discuss the implementation of overlapping activities. Both parallelisation experiences in production and the respective tools used, can perhaps give some clues for the grouping of tasks. This needs some further research.

One aspect directly linked to the phenomenon of overlapping activities is cooperation of professionals. This is explored in the next section.

Alternative Organisational Units

Integrating and overlapping activities can partly be realised in information systems, but the key factor is the professional: The bearer and manager of ideas and information. Most of the activities in the product-creation process need knowledge interpretation and therefore are human-dependent. For implementing a process of ‘overlapping’ phases cooperation between professionals of different disciplines is needed. Several authors suggested teams as an ultimate concept of cooperation, speeding up communication at the interface of different disciplines. However, they all give different names to the teams in the product-creation process: ‘skunkwork teams’ (Quin, 1985); self-organising project teams (Takeuchi & Nonaka, 1986); ‘multi-phased groups’ (Purser & Pasmore, 1991); ‘cross-functional teams’ (Clark & Fujimoto, 1991).

In production teams are becoming more and more familiar. A survey conducted in the US (Wellins et al., 1990) conclude that 27% of a sample of 800 firms currently use ‘self-directed teams’ and 47% of the responding executives predict that more than half their workforce will be working in self-directed teams in the next five years. Up until now STSD is mostly applied for implementing self-directed teams in production.

(Self-Directed) Teams in Production

In the Netherlands we have a specific STSD tradition which has concentrated on the Integral Organisation Renewal (IOR) engineering method. IOR redesign principles are currently implemented by a variety of companies. Van Amelsvoort & Scholtes (1993) stated some principles for designing self-directed teams.
The major benefits resulting from implementing self-directed teams in The Netherlands were listed by Joosse et al. (1990). We sum up: A reduction of delivery time from 9.5 weeks to 2 weeks; 50% reduction of errors; 40% reduction of complaints; higher productivity varying from 1.5% to 10-15% on a yearly basis; reduction of stocks, resulting in a 4-60% reduction of costs; reduction of material waste, varying from 4-50%; and 25% wages cost reduction of indirect personnel.

The US study (Wellins et al., 1992) listed top benefits derived from self-directed teams (cf. figure 4).

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Improved Quality</td>
<td>30%</td>
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<tr>
<td>Improved Productivity</td>
<td>24%</td>
</tr>
<tr>
<td>Heightened Morale</td>
<td>21%</td>
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<tr>
<td>Fewer Managers</td>
<td>14%</td>
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<tr>
<td>Lower Labor Costs</td>
<td>5%</td>
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<tr>
<td>Decreased Turnover</td>
<td>5%</td>
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<tr>
<td>Lower Absenteeism</td>
<td>5%</td>
</tr>
<tr>
<td>Others</td>
<td>7%</td>
</tr>
</tbody>
</table>

Figure 4: Benefits of Self-Directed Teams

Other interesting results were the observed obstacles in implementing self-directed teams. The major barriers are listed in figure 5.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Insufficient Training</td>
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<tr>
<td>Incompatible Organisational Systems</td>
<td>47%</td>
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<tr>
<td>First-Line Supervisors' Resistance</td>
<td>47%</td>
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<tr>
<td>Lack of Planning</td>
<td>40%</td>
</tr>
<tr>
<td>Lack of Management Support</td>
<td>31%</td>
</tr>
<tr>
<td>Lack of Union Support</td>
<td>24%</td>
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<tr>
<td>Others</td>
<td>12%</td>
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Figure 5: Barriers Encountered While Implementing Self-Directed Teams

Teams in Product Creation

In the late seventies the development of new products in special designed projects became
booming. The matrix structure flourished. An important reason for working in projects was trying to find a balance between goal direction, efficiency and adaptability (cf. Wijnen et al., 1984).

Quin (1985) reported that every high-innovative enterprise uses teams that function in a ‘skunkwork’ style. Skunkwork means continuously reaching beyond the established performance limits: “Small teams of engineers, technicians, designers, and model makers were placed together with no intervening organisational or physical barriers to developing a new product from idea to commercial prototype stages. (…) The skunkwork approach eliminates bureaucracies, allows fast, unfettered communications, permits rapid turnaround times for experiments, and instills a high level of group identity and loyalty” (p 753).

Takeuchi & Nonaka (1986) observed at Honda a ‘self-organising project team’. In such a structure the core project members stay at the team from the beginning till the end. They are responsible for the overlapping of all phases. They stated three conditions for self-organising teams: Autonomy, self-transcendence and cross-fertilisation.

Henke et al. (1993) did a research on cross-functional teams. They found out that there are 4 reasons for companies to make use of cross-functional teams (p 217):

1. The shortcomings of hierarchical structures are overcome by the team’s ability to cut across traditional vertical lines of authority;
2. Decision-making is decentralised;
3. Hierarchical information overload is reduced at higher levels;
4. Higher quality decisions can have a significantly greater potential of occurring than with individual decisions.”

They conclude that, even if good processes and well-designed structural mechanisms are in place, firms that embedded team-based decision making activities into their structural design benefitted most.

The aim for teams in product creation is to stimulate cooperation between professionals. This serves a better communication and motivation of the professionals and an overlapping of activities. Sharing of knowledge, information and experiences can lead to more quality of decision making.

Teams in Product-Creation Practice

In all companies mentioned in the exploratory study, project teams are installed in the product-creation trajectory. These teams are temporary and the number of people fluctuates. Most of the time professionals work in more than one project team.

In company A two kinds of teams exist: A project-management team on the level of controlling the priorities of the different projects; and a project-development team that executes the creation of the product. The first team consists of a marketing specialist as product manager, and a development specialist as program manager. The second team is temporary and exists primarily of developers who consult other professionals from different disciplines. 10-20% of the developers work full-time on one project. The interviewed expert does not regard this projects as real team work because a lot of decisions are made individually. Besides, the cohesiveness of the project team is not so high, because professionals work at different work places in different functional departments and they normally work for different projects. The expert hopes that in the future more multidisciplinary decision making will evolve, so that communication will be more effective.

At company B both project teams, work groups and task forces exist. The project team is
dedicated to a product-creation task. Members are developers, engineers and sometimes suppliers or other participants from research institutes or production. The team members work 100% full-time on a specific project, on the same location in the building. The team varies in the number of people employed (cf. figure 6). Removal or replacement of furniture is common practice.

Figure 6: A Schematic Representation of the Respective Involvement of Different Project Team Members in the Product-Creation Trajectory in Company B (Different Disciplines).

The work group at company B exists of representatives from all disciplines at business unit level. There are three business units in company B. The task force is responsible for the initiating and proceeding of a particular product-creation project. They give orders for market research and define the requirements.

In company C there had been pilot experiments with Product-Advice Groups and Supplier-Involvement Product-Development Groups. These groups supported interdepartmental communication with increasing involvement of down-stream professionals. However, influenced by Lean Production, the management has chosen for a clear departmental structure. Within a department the project-development task is formulated. Nobody works for 100% full-time on the same project. One of the experts of company B also finds this not a clear option, because projects are becoming smaller.

In company D the same sort of experimental teams had existed. Those teams were named: Product-Optimalisation-Process Teams. They functioned as supporting teams for the primary product-creation process. Implementing these multidisciplinary teams meant another kind of teams besides monodisciplinary project teams and functional departmental projects. More parties and more opinions led to conflicts among the different disciplines. This built resistance against implementing the multidisciplinary teams. Now they have task teams in the development departments, and ‘meeting teams’ with engineers on the same project.

In company E there are also project teams, consisting of developers who consult other disciplines when necessary. 50% of the developers work full-time on a project. There also exist a project-management team with three members: Program manager, functional manager (possessing
the technology knowledge) and the project leader.

The teams in the different companies are hardly comparable to each other. There are differences in full-time or part-time allocation of professionals to projects, and there are variations in the involvement of different disciplines. Company B seems to have the most radical form of teams, resembling most the ideal-type of a multidisciplinary team. It should be noted that this company has different teams on distinct levels in the organisation, for several purposes.

In the case study-company F another type of teams was applied. A permanent team of 8 to 10 professionals exists for both the product lines. Both marketing, development and engineering disciplines are represented. These teams are called ‘special groups’. Their task is to create new systems out of existing components on customer order. The team members have broader skills and experiences. They are allowed to determine their own (flexible) work. This kind of team exists as a sort of ‘tiger team’ besides the heavy-weighted structure that is in use at company F.

**Research Implications:**

From a theoretical point of view teams are a fruitful concept for better cooperation of professionals. In production some interesting results are reached through working in teams. A research subject for further investigation is the commonality between self-directed teams in production and teams in product-creation. We are planning to research what spin-off principles for self-directed teams might have for product-creation teams. We can learn from the barriers already experienced by implementing self-directed teams.

From a practical point of view it’s hard to tell when teams are most ideal-like. Teams can become manifest in different forms, at distinct levels in the organisation, with all kind of purposes. More detailed descriptions are needed in order to analyse their make-up and functioning.

Further investigation could go into team building and the benefits of it for the professionals’ work-appreciation and for implementation of SE philosophy. Other aspects worth considering are: The gradation of work dedicated to a team; collocation of team members; the amount of responsibility and control power the team needs; the decision-making process; knowledge and information sharing; education and training; stability and temporality; capability of self-organising; and self-design of the team structure.

**Action Research Agenda**

In the ‘research implications’ we argued that further discussions with practitioners are needed to find out the feasibility of the production-based theoretical concepts in product creation.

In line with a long sociotechnical tradition, and in order to establish a mutual learning process, we suggest an action research approach in which experiments with new forms of internal work organisation in the product-creation trajectory are discussed and eventually executed in close collaboration with all professionals involved.

A useful methodological framework for this action research will be the ‘basic scheme for design-oriented research’ (cf. Van Eijnatten, 1993; see figure 7), that describes the multi-cycled approach of STSD.
Figure 7: A Schematic Representation of Developed 'Temporary' Methodology: A Basic Scheme For Design-Oriented Research.

Van Eijnatten (1993)
The research starts with a diagnosis of the product-creation trajectory in a carefully selected high-tech company. A detailed description is made, using the professionals' and researchers' knowledge and skills. As in the case study at company F, the 'open-systems' approach is used (cf. Simonse, 1993b).

The 'diagnostic part' in the cycle leads to a subsequent typification of both the dominant organisational paradigm, structure, process and units, and the diagnosis of bottle-necks. When the management of the company expresses the wish to change the current practice, for instance in order to reduce the time-to-market, the next step can be made.

The 'therapeutic part' of the cycle consists of establishing a work team by the selecting/inviting of members from the unit under consideration. The researcher is just another member of the work team, mere facilitating the deliberations and the development of alternatives. In mutual knowledge exchange, theoretical and practical options are proposed, while actions of each team member are discussed and evaluated. In this stage the earlier mentioned 'research implications' are of use. All knowledge that is exposed, should be communicated to each team member. Discussions/deliberations can be initiated by everybody about one of the following subjects:

- sociotechnical theory and methods;
- new design principles for product creation;
- alternative organisational structures;
- parallelisation in product creation;
- the overlapping of activities;
- cooperation at the interfaces of departments;
- design principles of self-directed teams.

In this part of the redesign the researcher should focus her attention to blockades in the process, and to the interplay between all subjects, so that an integral approach is guaranteed. By managing its own work and developmental process, the design team will grow, and learn. The applied method is called 'Participative Design'.

This leads to action-planning and redesign of process, organisational units or organisation structure. A process of change is started and, if required, can be supported by a researcher as a process consultant (cf. Box B in figure 7). The implementation of the action leads hopefully to a new, desired practice.

The successful new practice can be seen as a N=1-local theory-of-practice, that can be applied in different settings, while evaluating it in a next step of research, in order to try to generalise the practical solution to the level of a middle-range theory-of-practice (cf. box C in figure 7). In the course of time his theory will be documented in the STSD literature and communicated to practitioners and consultants (cf. box D in figure 7).

Summarising, we suggest an action research approach. In order to experiment with new forms of internal work organisation in the product-creation trajectory, we propose the following basic research steps:

1. A detailed description of the product-creation trajectory in carefully selected high-tech environments in industry, using an open-systems approach;
2. A subsequent typification of both the dominant organisational paradigm, structure, process and units, and the diagnosis of bottle-necks;
3. The participative redesign (planning and implementation) of structures, processes and
organisational units in (parts of) the product-creation trajectory, using a sociotechnical approach.

4. Evaluation of results.

References


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