A Socio-technical toolbox for business systems analysis and design

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Abstract. This paper provides an overview of a socio-technical toolbox (STT) based on a combination of methods from a number of contemporary socio-technical (ST) methodologies. The STT supports a pragmatic ST approach to organizational change practice and job re-design. It has been developed and used in practice in many different types of organizations over a period of many years. The use in practice of STT supports constructive learning and develops critical analysis skills of the students who will be future systems analysts or designers. It also improves companies' understanding of their job practices and enhances their learning about their business sustainability. Our findings show that these experiences of improvements are not dependent on the sector or the size of the involved companies and confirm the perceived usefulness and relevance of ST analysis in practice.

Keywords: Socio-Technical analysis. Systems Practice. Organizational Change. Work Related Learning. Organizational Excellence. Work Design. Organizational Learning. Systems Analysis. Contextual Dependency. Contextual Analysis.

1 Introduction

A wide range of Socio-Technical (ST) methods have been developed and implemented [2; 5; 18]. In Effective Technical and Human Implementation of Computer supported Systems (ETHICS) analysts have support mechanisms and descriptions with advice, comments and examples for over twenty different but related analyses [16; 17; 18]. The ST systems design literature equally put forward evidence of the relevance of contextual analysis within which emphasis is placed on human and technical dependencies in the context of an evolving organizational environment. In the field of information systems (IS), Checkland and Holwell [19] have acknowledged for example that it is beneficial to conceptualize IS as a Human Activity System (HAS) which is a very different problem arena from viewing IS as a data processing system. Just as Langefors [13], Mumford 16] and many others, Alter [1] has also emphasized a need for IS field to address the whole context within which IT-reliant work system is designed, developed, implemented and maintained. IS development process as an

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ongoing contextual inquiry [6; 7; 8] is characterized as an emergent ST change process conducted through sense making and negotiations among stakeholders [14]. In Soft Systems Methodology (SSM) [9; 10] there are numerous supports for complex analysis with the promotion of a multitude of concepts and techniques such as rich pictures and CATWOE (Customer, Actor, Transformation, 'Worldview', Owner, and Environment). In practical industrial applications of Object Oriented Analysis and Design (OOAD) several techniques from methodologies such as ETHICS and SSM are transformed, changed and incorporated with an object oriented focus with tools such as the FACTOR (Functionality, Application domain, Conditions, Technology, Objects, and Responsibility) criteria [15].

The Socio-Technical Toolbox (STT) presented in this paper draws up and extends methods and techniques from a collection of a number of contemporary ST methodologies such as SSM, OOAD and ETHICS. The STT is a framework and collection of tools and methods for an ST approach which is organized in appearance to be aligned with ETHICS [16] as a format. STT is drawing upon lessons learnt from many other methodologies and methods, such as SSM [9; 10], Scandinavian traditions in Participatory Design [12], System Thinking approaches [3; 4], Information Systems analysis and definition [13], Contextual Inquiry, Strategic Systemic Thinking [6; 7; 8], and much more. Some of the often described weaknesses of traditional ST approaches are not necessarily relevant issues for the STT, mainly because the motivation for its use is very different. While the motivation for many traditional ST practices was ethical and emancipatory, the motivation for the application of the STT is professional excellence (job excellence from the professional employee's point of view) in the context of the organizational problem space. *The purpose with the use of STT is to facilitate the transformation of organizational practices in the direction from mediocrity towards excellence in work practice*.

The organization is seen as a continuously changing and evolving human activity system [6; 7; 8]. One of the authors had originally been using informal variants of the STT since 1987 for the purpose to facilitate organizational development and change, mainly in small number of large organizational and industrial settings in the context of simultaneous work-redesign and IT development. Several of the initial projects (but not all) were involving manufacturing industry and so were also heavily engineering oriented. Since it's more formalized description in 1999 the STT has been systematically both re-developed and used in practice in several hundred organizations of different types and sizes. The STT itself when described in 1999 was intended as a complementary overview of ST methods. The purpose was to provide a pedagogical background discussion and a starting point for exploration into different types of contemporary contextual inquiry. The intention was also to provide a foundation for discussions about Strategic Systemic Thinking [6; 7].

Over the years previous versions of the STT have been used to support analysis redesign of many work-practices and business processes, including such as work in individual warehouses belonging to approximately 10 different supermarket chains in 2007, 60 doctor practices in 2008, 80 pharmacies in 2009 and 50 news agencies in 2010. From 2011 to 2015 the ST toolbox was not limited to be used within any single specified main category of business and there were more than 200 organizations in-

volved of different categories and types. Overall during the last five years the scope of the involved companies ranged from very small shops with only three employees to business entities with more than 200 employees which were part of large international franchises. However, the majority of the organizations involved since 2011 were relatively small businesses with approximately 10 to 20 employees. The activities of these companies cover a large variety of sectors such as manufacturing industry, restaurants, consultancy, education and retail [22].

Companies would commit to give resources (e.g. time allowance to employees) to a small number of employees to participate in the exploration of use of the STT in their job-redevelopment and re-design efforts over a period of between five to eight months. The involvement and commitment to the ST practice varied from one or two consultancy session per month for some companies to weekly sessions for some others, sometimes even more. Mostly sessions would be between one and two hours, they would for example consist of informal discussions, brainstorming, and exploration of problematic situation with the systemic use of Mind-Maps in combination with Rich Pictures [21], semi-structured interviews and conversations, formal and logical descriptions of work activities and work processes and much more. In many cases, additional to these (on site) sessions a number of observations have been conducted in order to understand the business practices as well as a number of out-of-work semi structured interviews and questionnaires have been used.

2 Socio-Technical Toolbox

The STT deals with more than 30 templates organized in 8 themes supporting the application of ST tools for systems analysis in practice, some of the key ideas of the STT are presented in this paper. Figure 1 illustrates the 8 analytical spaces in the STT. It would be a misunderstanding to think that these different analysis (explorations) should be done in a particular order, or indeed that they always should all be done. There are very good reasons for why it is called a toolbox. What specific analysis, if any, should be done, and in what order different methods for analysis should be used is not pre-determined. It all depends on the context, understanding of the problematic situation, and the reason for the engagement and so on. The description of the STT is organized in a particular way only due to pedagogical reasons (to be accessible to inexperienced analysts and students) and this order is not intended to be used as a recipe (the STT is quite comprehensive so below is a short overview overall with only some aspects described in slightly more detail than the rest due to space constraints).

System change analysis: In this theme the analyst (together with the participating employees) considers the problematic situations of existing work system, future needs and potential benefits of a new work system. Questions about the reasons of change are done together with system boundary analysis and analysis of existing and future system. These three analyses can be done in any order and should be revised and revisited several times. Brainstorming, creation of mind-maps and rich pictures are examples of techniques that (together) support the dialogue, exploration and achievement of system analysis step [21].

In the sustainability analysis, which is the part of the STT, the analysis requires to take into consideration three types of sustainability:

a) environmental
b) financial/economic
c) social/cultural

In fact, the work system is intended to be developed towards a higher level of sustainability. Sustainability is not necessarily a choice as there is constant social, cultural, financial and also legislative pressure to move into this direction.

System change analysis • Change Analysis: Why Change? • System Sustainability • System Boundaries • Holistic Multi-Criteria Benefit Analysis • Analysis of FACTOR Criteria • Interaction Analysis • Analysis of Existing & Future System • Logical Analysis of system: Input-Output Analysis • Complexity & Vertical Analysis • Context Analysis	***System purpose*** • Diagnosis of Efficiency Needs • Key Variance Analysis: Matrix-Variance Management • IS and Cyber-Security Management • Diagnosis of Job Satisfaction Needs. • Knowledge & Psychological Contract • Support/Control & Task Contract • Conclusion and Overview of Job Satisfaction Needs
System structure definition • Key Objectives Analysis • Key Task Analysis Key Information Needs Analysis • Coordination of Objectives-Tasks-Information Needs	***System priorities*** • Specification of Efficiency & Social Goals • Resolutions of Efficiency & Social Goals • Conclusions of Socio-Technical Efficiency
System perspectives (time) • Future Analysis	***Desirable system*** • Achieving Objectives
System action • Organizational Possibilities • Technical Possibilities	***System for evaluation & engagement*** • Implementation Diagnosis • Benefit Management Objectives • Benefit Management Plan • Evaluation & Self Reflective Element • Project Evaluation • Case Summary and Overview

Figure1: The eight analytical spaces of the Socio-Technical Toolbox

The sustainability analysis is about the support of development of sustainable every day work practices. For example, social sustainability deals with how work practices in a Human Activity Systems are experienced as fair and responsibilities are distribut-

ed in a socially and culturally just fashion. It is directly related to Human Sustainability and is at the core of ST development efforts. Employees and groups of employees' interests should not be realized at the cost of other groups. Unfair treatment of individuals and groups creates tensions and does not support the social development of collegiality and enthusiasm for work. Social and Human Sustainability is necessary to support loyalty and the development of quality work results and excellence in work practices. It is also about promoting continuous learning, human health and wellbeing as part of work practices. Issues of Social Sustainability are often visible also in indirect metrics, such as employee statistics. One example is when companies find it difficult to be satisfied with their employees - when they change employees often, or if they cannot get 'the right' employees with the right training or education. Perhaps the requirements need to be changed. Perhaps the organizational practices need to be optimized to those employees that can be found. Social sustainability is related to in what way any company have practices in place to help them keep their employees long term, if they have trainee programs for the purpose to see to it that they have available the right staff with the right competences and the right attitude and so on. Examples of objectives in the sustainability analysis within the STT are the assessment of:

a) Existing Sustainability Practices: How does existing organized activity (jobs) address these issues? What is done, in what way, by whom, in what context and when?
b) Potential for Future Sustainability Practices: How could the organized activity (jobs) address these issues? What could be done differently, in what way, by whom, in what context and when?
c) Environmental Sustainability: This is about ways in which work practices in a Human Activity System are related to and influence use of natural resources. How are existing work-practices 'green'? How are they not? And how could they become 'greener' in the future?
d) Sustainability Impact of System: This should cover an overview and conclusion of the direct sustainability impact of the Human Activity System in question. It is to be highlighted so that it clarifies what is the expected impact specific to a particular Human Activity System. In other words, what real world support is provided to help the human actors to choose and pursue better sustainable work practice, and what benefits could be realized?

In the holistic multi-criteria benefit analysis, the participants are making an effort to develop an understanding of what the benefits are in the current system and what the expected benefits are in the promoted future system which it is re-designing. This requires the identification of key stakeholders of the problem space and formulation of root definitions by considering the element of CATWOE. There will be at least one different Root Definition and CATWOE from each stakeholder worldview ('point of view'). Most likely there will be several of these from each individual stakeholder. The analysis of Functionality (The system functions that support the application domain tasks) Application domain (Those parts of an organization that administrate,

monitor, or control a problem domain) Conditions (The conditions under which the system will be developed and used) Technology (Both the technology used to develop the system and the technology on which the system will run) Objects (The main object in the problem domain) Responsibility (The system's overall responsibility in relation to its context) criteria includes evaluation and choice. The participants are trying to understand and agree upon overall system characteristics. They are trying to create a reasonably concise description of a system expressed in natural language. The effort is about systematically clarifying interpretations, possibilities and consequences of several alternative solutions.

The interaction analysis addresses the effective use of information and communication practices to support knowledgeable actions and interactions in the organization considered as a HAS. People have to talk to each other and mentor each other in context of a problematic situation. The complexity of sense-making needs to be taken into consideration. Descriptions can be based on a simple model of communication and analysis of communication behavior with a focus on sense-reading and sense-giving in an organization viewed as a knowledge community. This interaction analysis is an inquiry into a series of questions about the nature of and reasons for particular re-presentations made by the involved human actors. Supporting questions include: What incentives are there for individuals to share and represent knowledge effectively, and for others to use those representations? What forms of representation of knowledge should be chosen? How can the quality of individual sense-making practices of knowledge and knowledge sharing be helped? How can individuals be helped to make better representations and sharing of knowledge? What is required for all this knowledge sharing and development to happen and for what purpose?

The context analysis consists of multiple related key aspects of system (HAS) and (work) process such as: Pre-Check – History (history may influence what needs to be done in any following application of the process); Condition – Aging (check of condition as a result of previous engagement and application); Ingredients – Input (need to have some way of checking and requesting relevant input); Activity – Life (process often needs to be able to give users some feedback whether or not it is actually on or not); Requirement – Context (a HAS or process to be adopted to the relevant objectives. This often means that there are some contextual requirements that may be dynamic and flexible); Elegance – Appearance (a HAS or process often needs to behave or be done in a "nice" way. The process should be accommodating to non-functional but social and cultural requirements). The focus of this analysis is upon revealing contextual dependencies which are complementary to the pure logical description of a system activity and process flow.

System structure definition: This theme deals with the identification of key objectives, key tasks, information needs and coordination of objectives-tasks- information needs. This analysis benefits from focusing on the future system, e.g. appreciation of how things ought to be, from the involved stakeholder's point of view. This is done by also reflecting on how 'things are' in the current system. Outlining key objectives requires exploring questions about the system purpose, responsibilities and function and relevance. Once key objectives have been specified then what are the key tasks which must be carried out if the objectives are to be achieved? The quality of task and

activity is directly influenced by the quality of data (and information). Quality of data is dependent on understandability, relevance, reliability and timeliness among many other aspects. The key information needs analysis identifies at least 4 categories of information: Operating information (e.g. what data and information is needed for stakeholder's action/operation to be possible?, Problem prevention /solution information (e.g. what data and information are needed to be able to help actors and stakeholders to prevent problems and to solve issues?), Co-ordination information (e.g. what data and information is needed to for actors and stakeholders to be able to coordinate activities and sub-processes?), Development information (e.g. what data and information are needed to be able to continue to develop the activities/sub-processes?), Control information (e.g. what data and information are needed to be able to assess ?). Once key information requirements are specified it becomes relevant to outline the associated co-ordination aspect of each process itself. In this analysis specification and description is produced on how to coordinate key aspects of processes previously analyzed and documented in analysis of 'key objectives', 'key tasks' and 'key information'.

System purpose: This theme includes diagnosis of efficiency needs which can be identified by looking for variances. A variance is a tendency for a system or part of a system to deviate from some expected or desired standard or norm. In other words it is a weak link, a part of the system where problems tend to occur. Variances can be of two kinds: key (or systemic) variances and operating variances. Key variances are potential problem areas which cannot be eliminated although they may be effectively controlled (managed). They are built into a system and arise from the key objectives and key tasks which the system has been designed to meet. The three categories of issues cover:

a) Issues within a particular system of interest (problem area). For example problems arising from interactions within the system we focus upon (internal);
b) Issues between systems internal, for example between one work system and another, or between the department of interest and other departments within the same organization;
c) Issues between the system and external systems, for example between one work system and external agencies or stakeholders, or business to business, or work system vs. customer.

When a new system is designed many of the operating variances can in principle be eliminated altogether. Participants are usually aware of many key variances but operating variances may only be known to those specific individuals who have to cope with them in their work. The output of key variances analysis is a matrix that needs to be tailor-made for each system or process. The operations should be the same as those specified in the logical analysis. The analysis would normally need to be iterated for the alignment between the logical analysis (e.g. horizontal analysis) and the key variance analysis to happen because of initial incomplete understanding of each process which is analyzed.

To manage key variances, it is important to have a formal agreement from the management how known potential variances are to be dealt with (e.g. plan 'B', plan 'C' etc.). A list of all variances identified should be made and each one should be described with regards to legal obligations, professional requirements and best practices. For each operational variance it should be explained with recommendations for how it can be avoided. For each key variance it should be explained what recommendations there are for how it can be managed if it occurs. In the variance management analysis aspects such as "delay" of activities, interruptions and lack of possibility to fulfill normal work expectations etc. should be covered. In this analysis the known key variances should be mentioned and the management of them should be described explicitly. For each key variance – if there is an expected practice - what is the practice and how is it supposed to work (e.g. who is responsible for making decisions in an emergency and of what kind). If not – what should it be, and how would it work. Descriptions should answer questions such as done by whom? And who is supposed to be allowed to make relevant decisions in context? What kind of decisions? And with what kind of limitations?

Information and cyber-security management covers the exploration of scenarios, risk analysis and protection plan. These all include technological aspects as well as social and organizational. The exploration of scenarios addresses a number of questions such as: What information assets are critical to the Human Activity System (and work system) you are redesigning? What kinds of risks could it be exposed to? What legal and compliance requirements is your organized activity subject to? How would the activities be able to continue if a threat is materialized? How can risks be managed as part of everyday practices? The risk analysis is focused more on the potential damage and its consequences for the human activity system. It starts with consideration of organizational and personal data issues, financial transactions and information assets critical to the organizational activities. For each risk, it is important to identify the system entity, threat, damage and probability and to describe how the threat influences the task/entity. Risk analysis scope also includes the assessment of organizational dependability and the seriousness of potential damage to the organizational activity. Questions about the availability of appropriate training, resources and equipment are directly linked to the elaboration of a protection plan which specifies the security controls to implement. The threats are related to key variances while others will be related to operational variances. Operational variances should be eliminated through security practices while key variances should be managed with action plans etc. This includes recovery and backup practices for example. The protection plan needs to incorporate aspects such as what is to be prioritized, when and under what circumstances etc. Information Security Management needs to be both ongoing and reviewed as part of normal practices. There is a need to specify how effectiveness of existing controls, practices and review of new threats etc. is to be incorporated in the everyday organizational activities. The protection plan consists of a systematic description of all identified key threats, potential damage and consequent protection. The consequences of the plan should be implemented in the redesign of the work-activities in the overall ST Systems analysis. The protection plan must be revised

together with the work system until it fits the organization and everyday practices of the Human Activity System.

The diagnosis of job satisfaction needs includes an analysis of a questionnaire covering data about: Knowledge needs: The extent to which employees think their skills and knowledge are being well or poorly used. How would they ideally like their skills and knowledge to be used? Psychological needs: The extent to which their needs for advancement, recognition, responsibility, status and achievement are being well or poorly met. These are the factors (as identified by Herzberg) as leading to work motivation. Efficiency (support / control) needs: The extent to which they have the kind of support services and control systems which they believe will assist their efficiency. Task needs: The extent to which the way their work is structured meets their needs for work interest, the opportunity to take decisions and to perform a set of tasks which they regard as important. Ethical or moral needs related to personal values: The extent to which the human relations policies and practices of the firm fit their own views on how they should be treated. This diagnosis of human needs enables the participants to set some job satisfaction objectives. That is, improvements to the human situation which they will try to achieve through the way they design the human part of the system.

System perspectives: In this theme, the analyst and participants assesses future changes (e.g. technological, regulatory, economic, social, and organizational) with potential to affect the system within the next five years. This analysis is mainly focusing on known developments, existing technologies, existing regulatory, economic and organizational trends, and the potential impact of implementation of these which perhaps have not yet become widespread in the industry (or the organization, country etc.).

System priorities: In this theme the analyst and participants specify efficiency and job satisfaction needs and social goals. This is an analysis explicitly focusing on the priorities with the re-design of work (the relationship with what is important for a job from the perspective of the job and workers doing the job) and the (re-) design of technology (the relationship with what is important for the use of technology from the perspective of the operational functionality it represents). Objectives are derived from the careful diagnosis of efficiency, job satisfaction, and future needs that has been carried out by the participants. These objectives will provide the basis for the redesign of the new work system. Alternative strategies will be matched against them and the selected option will be the one that fits the objectives. It is essential, at this stage of the design task, to be aware of the wishes and priorities of all groups who will be affected, either directly or indirectly, by the new system. External groups such as customers and suppliers must not be forgotten. All social priorities have relation to some technical priorities and vice versa. Often this analysis is incomplete – as is easily recognized when looking at it closely - the social priorities and the technical priorities which have been identified often ‘do not have its counterpart expressed in the analysis. In other words the social priorities often cover some areas while the technical priorities cover some other. From the social priorities as a starting point - the matching technical priorities have not always been mentioned - instead other technical

priorities may have been mentioned - and for these the social ones were often missed. The participants need to examine the results closely and try to resolve conflicts.

Desirable system: This theme consists of development of organizational and technical design of the new work system. Organizational design refers to different ways of organizing the human activity system so as to achieve the efficiency and job satisfaction objectives, it should affect the technical options that are considered, and vice versa. Each organizational option should contribute to the achievement of efficiency and job satisfaction objectives set out. The identification of organizational and technical options should be done in parallel, not sequentially with at least two technical options specified. Technical options will include hardware, software and the design of the human interface. Technical options should be evaluated against efficiency, job satisfaction and future change objectives in the same way as organizational options. It is a good practice to have one option as a change in work system but only limited change in technological resources. Sometimes revised objectives can be achieved successfully with re-design of work system (investment in work organization) without any significant investment in technology.

System action: This theme consists of preparation of a detailed work design for the chosen organizational and technical option (or a subset of alternatives under consideration). Particular attention must be paid to the creation of effective relationships and procedures across the boundary between the design area and adjoining departments (e.g. actors and stakeholders) with which it interacts.

System for evaluation and engagement: This theme includes the implementation diagnosis, the realization of benefit management analysis and the evaluation and self-reflective element in terms of improved efficiency and job satisfaction. The best designed work system is not going to achieve its objectives unless it is successfully implemented, and many good systems encounter problems at the implementation stage. It is therefore opportune to explore what:

a) Problems that are likely to be encountered on implementation and how can these be avoided?
b) Activities will have to be coordinated, during implementation, both within the design area and between it and other areas?
c) Training is necessary, in what format, when, how and by whom could this be provided?
d) How much time is expected to be required for implementation and how can progress best be monitored?

The benefit management analysis consists of a) identifying the benefit management objectives and b) to develop a benefit management plan. It is about supporting the management of the realization of the expected benefits. It is about intentionally exploring the possibility not only to promote expected benefits but also to be able to recognize and manage the expected benefits. The purpose is to be able to identify if benefits have happened, if they have materialized or if they are recognizable and how. The system expectations need to be described in such a way that they can be managed and implemented through action which is identifiable and which can be pursued in the real world.

3 Conclusion

The use of ST methods in professional practice continues to pose a number of challenges [5] and is not always adequately supported. This paper is giving a brief overview of the STT. Our experience has been that the STT continues to be positively appreciated by the vast majority of all involved organizations and businesses. Often the use of the toolbox is seen as a learning experience which the workforce and management see as contributing to long term work development and long term business change. The attitude supporting the use of the toolbox is purely pragmatic, the main positive feedback always tend to focus on the conclusion that employees and managers become more familiar and knowledgeable about their contextually relevant work system and business practices. This conclusion is constantly present in the evaluations of projects year after year. It is also what is seen as the great value and contribution to development of future competitive advantage of their businesses. Many organizations were happy to use the STT repeatedly after they were introduced to it.

It has been our experience that ST approaches are welcome and popular within organizations in practice, but that people need to have some familiarity with simple ST tools to be willing and able to use them. In Academia however recently arguments have been presented suggesting that ST approaches are not necessarily popular or even used in practice [19]. As we understand our experience this conclusion about practice does not seem to be straightforward. On the surface it might seem appropriate to conclude that in the current organizational climate there are businesses that are not interested to invest in a wholehearted promotion of ethical focused change activities. However in most of the larger organizations that we encountered there were often several ST techniques and methods used already in their normal business development practices, many of which were easily recognizable from Socio-Technical methodologies such as ETHICS as developed by Enid Mumford and Systems approaches such as SSM as developed by Peter Checkland. But the methods and techniques were pragmatically applied with a focus on organizational effectivity (not intended to be emancipatory for example). They also tended to have local names and the users and analysts that we encountered often did not know the origins of their own locally used methods, often thinking the methods they knew and used were uniquely developed at their own company.

Our conclusion is that the socio-technical dimension is alive and well, perhaps leaving some of the emancipatory perspective behind and instead embraced the notion of professional excellence focusing on mutual perspective of benefits for the common good of the organization – from the professional employees point of view [20]. To move from organizational mediocrity to excellence in practice.

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