

Socio-Technical Systems Thinking

Appraisal and Prospects

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Introduction

Socio-technical systems thinking (STST) was a model for workplace effectiveness developed in the 1950-60s to understand and improve mass-production work settings. It was applied in a number of companies in several countries by STS practitioners in mostly isolated projects. As work technologies changed, and thereby changed the configurations of workplaces, STS struggled to develop new analytic concepts and tools to exploit those new workplaces. Several developments occurred between the 1970s-early 2000s attempting to rejuvenate STST for new contexts. Over the past 20 years the field of STST has moved into higher level units of analysis, namely, total enterprises and ecosystems. In recapping the history, recent developments and prospects of STST, we draw on literature from systems theory, organization studies, information science, ergonomics and related fields. We focus on the core STS concept as well as a closely related concept, participative design.

The origin story of the socio-technical systems concept has been well documented in both the systems thinking and the organization studies literature [1–4]. It was developed out of a research study led by Eric Trist in the late 1940s on the interaction of technical and social relations in Yorkshire coal mines, and the discovery – or more properly, a rediscovery – of a new arrangement for retrieving coal from those mines [5].¹ Fundamentally, STS has been driven by “...the need to humanize work through the redesign of jobs and democracy at work” [2]. Thus, “[t]here is a normative slant in that the work suggests people should be involved in designing the relationships between technology and work. Quality of work life is a key consideration...” [8].

In the STS field, thinking, theory and practice are intimately connected, due to its origins at London's Tavistock Institute and its promulgation in Tavistock's journal *Human Relations*. “From the beginning, the preferred approach was one of ‘action’ (applied) research, the investigators working with management and labor to introduce change into a work setting and then attempt to learn from its results...” [3,9]. Clark [10] provides some early case descriptions of STS interventions using action research method; Pasmore [11] reviews STS's conceptual connection to it; and Susman [12] lays out the methodological connection.

¹ Rice and Miller's [6] early studies in Indian textile mills and Emery and Thorsrud's [7] studies in Norwegian industries, were also seminal in the origins of STST. The latter are discussed below.

In terms of systems thinking/theory, STS came onto the scene gradually with a series of publications by staff researchers at the Tavistock Institute in the 1950s, synthesized in Emery and Trist [13]. STS is seen as a touchstone for ‘Emery Open System Theory’ [14], one of several systems ‘schools’ [15]. STS is embedded in a broader body of theory, variously called Open Systems Theory [14], social ecology [13] or the Emery-Trist Systems Paradigm [16].

In terms of organization studies, STST holds its place as a distinctive perspective on the design of jobs, work and organizations. Burrell & Morgan [17] classify STS as a ‘functionalist’ theory based on an equilibrium model of open systems.² In Scott & Davis’ [3] classification, STST is a ‘natural systems’ perspective often associated with contingency theory, the prevailing paradigm in organization studies at the time STS was developing.

Hirschhorn et al. 's [18] recap of STST point to the import of the concept beyond the technical: “Sociotechnical systems theory... was a technical, moral and political discipline. Morally, it was based upon the idea that workers are entitled to working conditions that supported their all around competence and their relationships with work mates, politically it was grounded in the movement for industrial democracy, and technically it offered methods for designing work to minimize the errors or ‘variances’.” Thus, STST represented a “liberation from the domination of the machine and mechanization [and] ... liberation from single and meaningless tasks and external control” [16].

History and Key Early Developments

From its beginnings STST was comprised of three key ideas: (a) joint optimization; (b) choice in system design principles; and (c) open systems and environments.

(a) *Joint optimization* is the “object of design” in socio-technical analysis [3], originally and mainly for the group-centered primary work system [1]. This “refers to the optimization of a joint system in which neither part is subordinate to the other. Jobs should be designed to promote autonomy, e.g. not because autonomy makes workers more productive, but because without autonomy people’s needs for fulfilling work will not be met. The system is optimized when the job design simultaneously maximizes productivity and autonomy” [18]. However, Heller [19] believes the principle of joint optimization has lain underdeveloped in STST, has not been operationalized, and must include the environment within which a social and a technical system are correlated. The optimization of the environment was indeed included in the original formulation of STS, as discussed below.

(b) *‘Organizational choice’* in terms of the design of work settings and organizations is a crucial aspect of STST. As Passmore et al. [4] explain: “The technology itself didn’t dictate that one and only one way of working was possible. Instead, work systems could be devised that allowed employees to have greater control over technology, working together to enhance results while also experiencing social and psychological rewards.” The intended effects were that “human beings were more committed, technology operated closer to its potential and the organization performed better overall while adapting more readily to change in its environment” (p2).

² Equilibrium models and open systems models were being developed at the same time as STST in the 1950s-60s.

The recognition of organizational design choice led to a major conceptual development. Fred Emery [13] asserted that organizations can choose to design work systems in two fundamentally different ways: “In DP1 [organizations, called *redundancy of parts*], responsibility for control and coordination is vested at least one level above those who are doing the work, learning or planning. By fragmenting tasks into the most narrow, often single skills or movements, each person in such a one person/one job unit is easily replaceable with minimal if any training... In DP2 organizations [called *redundancy of functions*], as many skills and functions are built into each person as possible and responsibility for coordination and control is located where learning, work and planning is being done. This results in a flatter structure... [and] self-managing groups” ([14]. These contrasting design principles were subsequently applied at the level of the whole organization, and to managerial as well as ‘workforce’ tasks and settings.

Autonomous work groups are the prime exemplification of DP2 in STST [20]. They are based on the principle of self-regulation, i.e., control of key variances by the work group itself. Where an organization is designed around autonomous work groups, “the function of supervision is to manage the boundary conditions in the group’s environment...” [1].

Cherns [21] distilled a set of nine STS design principles from the growing body of research, including *minimal critical specification*, *boundary location*, *support congruence*, and the notion that *design* is an ongoing and iterative process (see [2]: 35-36 for a good summary).

(c) The *environment* of a work system is an integral component of the open socio-technical system. Although the environment was considered from the beginning, it was not well developed because the early field settings were on the relatively stable shop floor (or literal coalface) [19]. The originators of STST believed the concept was applicable at meso (organizational) and macro (community, industry, society) levels, as well as at the original micro (work team) level. The inclusion of those broader levels found good expression in the Norwegian industrial democracy program [7] described in Example 1 below.

Practice-based issues related to relations between socio-technical work systems and their environments led to systems theoretic insights. In STST, “[w]ork systems were viewed as open systems, meaning that they existed in a changing environment in which external forces acting on organizations required ongoing changes in operational arrangements to sustain high performance levels over time” [4]. However, these open systems are not those described using the usual organic metaphors [22]. As Barton et al. [15] point out: “...much of systems thinking [including STS] was captured by the structural-functionalist zeitgeist of the 1960s-70s in the social sciences. One unfortunate result was the conflation of open systems notions with organic biological analogies... However, many important developments in systems thinking since then have attempted to resituate the systems project...” In STS’s case this was in terms of a contextualist metaphor.³

It came to be recognized that sociotechnical analysis and design was not diffusing nearly as widely as had been expected; it was largely confined to individual projects infused with intense researcher and managerial attention. Trist [1] believed that for innovations in work organization to survive, the

³A contextualist ‘root metaphor’ views systems and their environments as constituting wholes which are paced and defined by series of events, not by notions of living organisms ‘adapting’ to their environments [23].

organization itself needs to change based on the same principles as those innovations. This was problematic because of power issues in middle management.

To deal with those issues, Merrelyn Emery [14] recounts a break with classic STS methods and the beginnings of a new approach in the early 1970s: STS "... was never the appropriate method for diffusion and once the proof was in, STS had outlived its usefulness. The Participative Design Workshop [PDW]... was specifically invented as a method for diffusion, doing exactly the same job as STS but custom designed to provide the concepts and conditions for speedy and effective redesign of existing organizational structures, i.e. currently bureaucratic or DP1 structures into DP2 structures, by the people who work and live in those structures." The underlying principle of the PDW is that "[f]or continuing long term adaptation, the system itself must be organized as an environment for learning" (p21). Thus, participative design and democracy [14,24,25] emerged as a distinct mode of STS thinking and practice, and those concepts were taken up in the Scandinavian STS model described in Example 1.

Trist and Murray's [26] anthology of STS research papers and field studies emanating from the Tavistock Institute staff and associated scholars helped to consolidate the maturing field. However, by the early 2000s, the rise of BPR, lean management and related industrial rationalization methods redirected the focus of work design back to efficiency and cost cutting. Consequently, "the application of STS design, perhaps too closely associated with employee empowerment and the 'Quality of Work Life' concerns of the '70s, faded from the manufacturing scene" [4]. However, in an important sense, STST was appropriated by mainstream organization theory [27], then swept up in the design craze in organization theory in the past decade or so.

Developments Extending The Core Concepts And Applications

The original STS model focused on the industrial work team began to expand into new applications starting in the mid 1980s. Three 'waves of evolution' occurred [28]: first, the Emerys' innovation of participative design (discussed above) and the Scandinavian method of democratic dialogue (Example 1 below); second, the application to white collar service industries with new analytic tools for "professionalized work systems"; and third, the designing of interorganizational networks and "issue based ecosystems."

Regarding the second wave, Trist [1] anticipated the emergence and growth of high-technology industries, and hoped that STS could be used to exercise "democratic control over high technology." Pava [29,30] extended the STS model to nonlinear, office-based knowledge work. His fundamental innovations lay in "enlarge[ing] the notion of technology to break it free of hardware constraints;" "break[ing] STS theory free from the monopolizing idea of the autonomous work group;" and creating new analytical methods for nonlinear work conversion processes [26,31]. The essential conversion process in such cases is the transformation of ill-defined issues into actionable problems via *deliberations* among members of *discretionary coalitions*.

This extension swept much professional knowledge work, both technical and managerial, into the ambit of STST, and laid the groundwork for the future of socio-technical thinking. As Pava [29] envisioned: “Opportunities for new applications of the [STS] design are emerging with advanced manufacturing systems, deliberation support systems, direct client transaction systems, artificial intelligence, total work habitats, and the drive to cultivate entrepreneurial effort. But this revival of STS design requires a redefinition of the target of change. Traditionally, a bounded functional operation has been the designated unit of analysis. With the addition of concepts and methods suited to nonlinear work systems – and the pervasive jump in technological capabilities – STS design can focus on a new set of targets: extended information systems and inter-functional activities.”

Following Pava, a number of scholars began to apply STST in novel ways in new domains.⁴ Hirschhorn et al. [18] sought to rework basic STS concepts of autonomy, variance control and redundancy of functions to make STS “more responsive to the challenges of designing learning organizations” and more able to embrace new technologies and industrial work systems. In mass-customization facilities, where “machines control variances, and a small team can oversee an entire factory” (p243), new design principles are needed, e.g., learning from variances instead of limiting variances, dynamic complementarity between roles rather than redundancy of functions, making boundaries rather than managing boundaries, and “meaning ... replac[ing] autonomy as the primary design tool” (p250).⁵

The third wave of STS evolution focused on the environment and trans-organizational systems. As noted above, the environment was integral in the STST concept from the beginning. If the social and technical systems of a work system are jointly optimized without also optimizing the environment, then STS likely will not sustain (or diffuse) because the environment is not (designed to be) conducive to the jointly optimized parts. The environment might be an organization [1], a business ecosystem, an industry or a national industrial sector.

In a provocative paper on “socio-ecotechnical” systems, Heller [19] claimed the ‘classical’ STS model needed to be ‘extended’ with a stronger emphasis on the environment, including the natural environment, in order to be appropriate for the current turbulent and risk-society conditions. In such conditions, the organizational effects on the environment become important and contribute to often damaging environmental volatility. As noted above, the application of STS at the ‘macrosocial level’ was conceived, if not acted upon, from the start. Trist [1] had established the connection between the socio-technical and the socio-ecological ‘levels’ of organizational reality by indicating how different types of environment may impinge differently on work systems and pointing to unexploited STS potential at the level of industry, community and network.

Relatedly, Sinha & Van de Ven [27] observe that “[i]n an increasingly global and knowledge-intensive economy, work design is no longer contained within a job or even an organization; it often transcends the boundaries of organizations, professions, and countries” [4,28]. Selsky et al. [34] sought to theorize an extension of the two contrasting design principles (DP1 and DP2, described above), using trans-organizational systems to suggest a third design principle, *redundancy of potentialities*, which included the crucial view of the future of a work system.

⁴ See Pan & Scarborough [32]; Shani & Sena [33] for STS applications to knowledge work.

⁵ Hirschhorn et al. [18] uses an example of an Exxon pilot plant, that is, a small experimental facility designed not for production but for learning about new processes and products.

Some STS scholars over the years have attempted a rejuvenation of the concept by latching onto contemporary fads and concepts related to organization performance and design – such as lean management, design thinking and employee commitment/empowerment – as well as by taking up the expanded knowledge-work ambit of STST described above. For instance, Griffiths and Dougherty [8] refer to an “explosion of STS-like work in technology management, at all different levels of analysis and focused on [a wide]... variety of problems.” Similarly, Winby and Mohrman [35] apply STS concepts to the digital platforms now becoming ubiquitous in many societies. The example of Wikipedia as a STS in Example 2 below is in this spirit.

We believe the status of STS today is similar to what Mumford [2] saw at the turn of the century: “...the emphasis in Australia is on participative design, Scandinavia favors a democratic dialogue between management and workers, and the expert group of socio-technical consultants belonging to the Socio-technical Round Table assists American companies. Many U.S. projects are based on the development of high commitment and high performance work groups based on the cooperative sharing of power between workers and management.”

Over the years STS has been used in two ways: for active intervention to (re)design work systems that meet both organizational and human needs; and for work systems viewed as socio-technical systems in order to gain “critical insights for understanding relationships between people, technology and organizational outcomes” [8]. Next, we offer an example of the former use; towards the end of the chapter we recount an example of the latter use.

Example 1: Scandinavian Model Of Work, Regional And National Developments

What Gustavsen [36] calls a ‘Scandinavian’ model of work was the result of a remarkable reframing of classic STS design (adjusting the social system to technological changes) towards a more purposeful multi-level, multi-nation set of interventions for developing not only workplaces but also the wider society. This has been done through persistent democratization efforts and through constructing cooperative institutional mechanisms with different actors in the development and innovation domains.

This model can be traced to the initial Norwegian industrial democracy program [7] mentioned above. In the period 1966-73 three plants within a Norsk Hydro production complex became the last in the series of four pioneering “field experiments”, testing new participative forms of management and organization [36]. That program was followed by various initiatives in Sweden such as new Volvo factories at Kalmar and Uddevalla that showed how advanced factory design could change the production system to make it manageable by autonomous work groups. Traces of those experiments are still evident in Norway’s regional and national development agenda today. Similar long-term workplace development programs involving multiple enterprises, even entire sectors and regions, took place in Denmark [37] and Finland [38].

The remarkable accomplishment of the Scandinavian model was the systemic weaving among the micro, meso and macro levels. The program approach used in those countries is flexible, and links work unit experimentation to firm level initiatives to other firms, all supported by regional and/or national level

labor, industry and government interests, and with assured financial and professional support over a period of 3-5 years depending on the program. These programs have proceeded sequentially, e.g., the Swedish Work Environment fund, then the Swedish LOM (Leadership, Organization and Co-determination) program; and the Norwegian SBA (Quality of Work Life Center), then the Enterprise Development 2000, then Value Creation 2010. This sequential approach has enabled not only different actors to be pulled in to sponsor the programs as they proceed but also the continuation of the processes generated in the previous programs through the support for clusters, networks, regions, and hundreds of enterprises engaged in these development initiatives. Thus, almost from the start, multiple levels were engaged simultaneously – workplace improvement (classic STS design), firm democratization, and community and regional development – signaling a broader, *socio-ecological* strategy. Moreover, it is notable that management fashions like lean and six sigma have not taken hold in the Scandinavian region.

This nested approach produced a number of significant conceptual advances in STST, such as democratic dialogue [39], development organization [40], development coalition [41], and concept-driven development [42]. Moreover, there have been important insights that (a) the learning organization must be built upon trust and worker autonomy; and (b) social context – in the case of Scandinavian societies, cultural values of cooperation, trust, experimentation and awareness of choice in work and organization design – is a crucial factor in successful development [36].

The importance of the Scandinavian model lies in demonstrating the success of a broad STS approach in an entire geography through using a multi-level programmatic approach that includes: autonomous work groups and self-regulating work systems, collaboration among the organizations in a cluster or network, and financial and administrative support by all the main societal stakeholders (unions, industry, government). The STS/participative design practitioners who have driven the Scandinavian model have made the vision of good work and more social democratization work for sixty some years.

Critiques

Critiques of STST have centered on three issues:

Narrow impact and limited diffusion. Viewing workplaces broadly in terms of STS concepts – such as considering human as well as technological needs in designing work settings – has in some ways become a standard part of workplace management. However, the actual practice of STS intervention, design and change has had both narrow impact and limited diffusion [43]. This was a problem from the very start; Trist and his Tavistock colleagues were unable to persuade the UK National Coal Board to implement the changes they found to be effective in their study of the Yorkshire coal mines in the late 1940s [4]. This was partly due to resistance from managers fearful of relinquishing their power (see next critique). That problem led to the Emerys' critique of STS and advocacy of participative design, as discussed above.

This problem continues to this day, at least in industrial settings. As Mumford [2] states: “In the 1970s, many companies accepted [the STS] message and tried to restructure their procedures and change their cultures to meet new kinds of objectives, both human and technical. Unfortunately, few of these endeavors had any long term success. The attraction and validity of bureaucracy was seen as stronger and safer and the new humanistic approaches as over-risky.”

Lack of attention to power. Hirschhorn et al. [18] point out that, “When management sponsored an STS design, it had no intention of relinquishing ultimate control of the plant to the workers.” This was largely because “executives and owners worried that any technique even loosely associated with industrial democracy would raise costs and erase the boundary between workers and managers.” This critique goes back to the original positioning of STS “primarily in normative and not in political terms” [43]. Thus, Barton et al.’s [15] argument that “[Emery’s Open System Theory] deals with power in terms of participative organizational designs and legally binding agreements for the relocation of authority” leads back to the critique of narrow impact above. Moreover, that way of dealing with power is narrowly inscribed, not accounting for the institutionalized Foucauldian power embedded in capitalist systems.

Failure to keep up with recent social or technological developments. Hirschhorn et al. [18] suggest: “When [STS] first emerged as a discipline its moral roots in a worker’s right to competence and its political roots in industrial democracy enabled its practitioners to reach beyond the narrow issue of industrial efficiency, but the era of mass customization has so up-ended the occupational structure – the distinction between working and managing is slipping away – that STS, a creature of the era of mass production, may slip into history.” In organization studies, the displacement of contingency theory as the prominent paradigm in the late 1970s by institutional theory, population ecology and resource dependence theory also had a role, as the environment supplanted technology as a major factor shaping organizational form and function [44].

Although technology has enjoyed a recent resurgence of interest in organization theory, STS analysis, built on the foundations of traditional industrial technologies, has scarcely touched such things as the “smarting of everything”, blockchain, social media, free (Google) and sharing (Uber, AirBnB) economies, and virtual reality. This may be part of a larger, cultural issue, namely, the slower pace of social systems relative to the introduction of new technologies, as discussed below.

Prospects For The Future Of STST

Long-time advocates point to the promise of STS going forward, albeit with caution. For example, Bill Passmore and colleagues [4] offer that “[a]t a time when the landscape for the global economy and its work systems are being reshaped by the burgeoning of information technology, digitization, and advanced technologies, the precepts of STS would seem to be more relevant than ever. Nevertheless, the evolution of social systems is not keeping pace with the exponential advance of technology, let alone anticipating more pervasive changes yet to come.”

Thus, one may now ask, How is the digital transformation, with its new technologies, changing the workplace, and what are the implications? This question mirrors that posed by the original Tavistock researchers confronted with seemingly new work practices in the Yorkshire coal mines 70 years ago. The essential question remains the same, but the answers are vastly different because the technical system, the social system and the environmental context have changed dramatically. But the question also recapitulates a longstanding debate in the STS field about technology. The standard view, of STS thinkers as well as most technology researchers, is that “technology [is] an actual system of physical, social, and cognitive elements that are built, used, and rebuilt by people in everyday practice. We can observe,

manipulate, change, and make sense of technology... and its relationships to the social setting” [8]. However, the critical view is that STST “subordinat[es]... human-centered criteria to the dictates of efficiency” [43] and contributes to what in effect is a technological determinism. Critics believe that STS, with its consistent focus on technical systems, has neglected the nature and meaning of the actual technology(ies) deployed in workplaces. We offer comments about this issue in the Conclusion.

We, along with other observers, believe an ongoing reinvigoration of STST is needed because it continues to hold such promise for human development via collective action in and around enterprises in turbulent environments. Passmore et al. [4] envision next generation STS being about “balanced optimization... predicated on the notion that everything is in motion. As the external environment changes, the design of the four components (ecosystem, organization, technical system, social system) need to evolve and align.”

Thus, going forward, STST needs to continue to commit to the promise of the three original key ideas as it evolves and embraces new contexts and applications:

- Joint optimization explicitly with the environment : “While in traditional organizations joint optimization is an internal goal, in the future joint optimization will concern the external network ecosystem” [4];
- Choice in design principles for organizing work, explicitly extended to interorganizational work systems, such as sharing-economy enterprises (Wikipedia, Uber, AirBnB etc.), and to future potential [34]; see also [35]; and
- Whole, open work systems, explicitly recognizing their coevolution with their social contexts and natural ecosystems, so that work design becomes inextricably iterative and learning-ful, and thereby adaptive to turbulent conditions.

In short, socio-technical systems needs to become *socio-ecological* systems in analysis, design and template for interpreting work settings. The Scandanavian STS model in Example 1 appears to embody these three key ideas and the socio-ecological shift, with its multi-level programs, interweaving of levels and democratic transformation of whole systems beyond the workplace.

Example 2: Wikipedia As A Socio-Technical System

Niederer and van Dijck’s [45] interpretation of Wikipedia as a socio-technical system focuses on “the intricate collaboration between large numbers of human users and sophisticated automated systems that defines Wikipedia’s ultimate success as a knowledge instrument” (p1370). The authors claim that “[t]he online encyclopaedia’s success is based on sociotechnical protocol-logical control, a combination of its technical infrastructure and the collective ‘wisdom’ of its contributors” (p1373). An analysis of that control reveals that “[s]ince 2002, Wikipedia content has been maintained by both tool-assisted human editors and bots, and collaboration has been modulated by protocols and strict managerial hierarchies. Bots are systematically deployed to detect and revert vandalism, monitor certain articles and, if necessary, ban users, but they also play a substantial role in the creation and maintenance of entries” (p1382).

Viewing Wikipedia as a STS yields important insights. For example, “[r]ather than assessing Wikipedia’s epistemology exclusively in terms of ‘power of the few’ versus the ‘wisdom of crowds’, we propose to define Wikipedia as a gradually evolving sociotechnical system that carefully orchestrates all kinds of

human and non-human contributors by implementing managerial hierarchies, protocols and automated editing systems” (p1373). Drawing a longer bow, Niederer and van Dijck suggest that

“It is important to question the assumptions of the internet as a merely social laboratory of human interaction, instead analyzing and interrogating the sociotechnical system that lies at the core of Web 2.0 platforms. Human and machine contributions are complementary parts of a society of control in which social interactions are increasingly facilitated by means of coded, automated processes. Human judgements such as reliability, accuracy or factuality are turned into machine-coded and regulated alert systems, as illustrated by Wikipedia’s mechanisms for generating and checking content” (p1383).

This example illustrates the promise of STS analysis (in the ‘viewing as’ mode) for coming to terms with the digital transformation and its social implications.

Conclusion

In a sense, STST is everywhere today, but hidden in plain sight. It has become a bedrock assumption in almost all discussions of work (re)design, and sometimes of organization and ecosystem design as well. Over the years STST has sought, with some success and some missed opportunity, to attach itself to popular management concepts like TQM, lean, agility, learning organizations, network forms of organizing, ICT systems, etc. However, STS has not penetrated very deeply into the burgeoning high-technology sector, which is the leading edge of social as well as organizational and ecological change in many societies today.

Today, it appears that technology is more of a joint optimizing agent than the social scientists and consultants engaging with enterprises on work improvement projects. They, as well as managers, are inclined to take technology advances as given, then ‘jointly optimize’ the technical and social systems that are built upon those technologies. For example, the Wikipedia example illustrates the intricate and even intimate blending of human and ‘bot’ intelligence in collectively creating and editing content. In this way high technology – AI, bots, surveillance systems, crowdsourcing, etc. – now appropriates the brain, not the hand, of the postmodern worker. For this reason it is imperative that STS as a field establish – rediscover? enrich? – its relationship with the ‘high’ technologies that lie at the heart of today’s technical and social systems. If it does not do so, the spectra of technological determinism will continue to shadow our technological advances, with the new technologies determining not only our social relations but also the shape of our societal systems. Hence, deeply examining the nature, meanings, effects and consequences of those technologies as part of intervention plans would help to reinvigorate STST for the mid-21st century.

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