Dimensions of Integration in Sociotechnical Systems

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Abstract

This position paper presents the new idea of dimensions of integration in sociotechnical systems. Instead of assuming that sociotechnical systems consist of a social system and technical system, it uses a single system approach based on treated an STS as a work system (as defined by work system theory). It identifies four dimensions of sociotechnical integration within each of five categories directly related to the work system framework. It uses radar charts to illustrate how dimensions of sociotechnical integration can help in comparing STSs and imagining how they might be improved. A brief conclusion identifies next steps.

Keywords 1

Sociotechnical system, work system, dimensions of sociotechnical integration

1. Introduction

Mumford (2006) and other observers have expressed disappointment about how the sociotechnical systems (STS) perspective seems to have relatively little visible impact even though STS had been discussed for over half a century. Aspects of the STS ethos such as human values, democracy at work, and social welfare are mentioned in many situations, but in today's highly competitive business world (at least outside of Scandinavia) often are treated as no more than "nice to have." Many business leaders, practitioners, and researchers act as though the STS ethos is less deserving of intellectual bandwidth than seemingly higher priorities such as customer delight, digital transformation, artificial intelligence, and a plethora of other topics that seem more innovative, exciting, and profitable.

Part of the STS impact problem may derive from the taken-for-granted assumption that systems in today's organizations resemble STSs as described decades ago and consist of social systems and technical systems that should be optimized jointly. In contrast, many of the leading-edge concerns in the IS literature and in business practice revolve around trends toward digital transformation (e.g., Vial, 2019), new uses of communication and automation technologies, greater automation of tasks formerly performed by people, greater leverage of knowledge work (e.g., Pava, 1986), greater surveillance (e.g., Zuboff, 2015), and greater systematization through defined consistency requirements such as ERP systems. The changing nature of work driven by those trends implies that visualizing STSs in traditional ways may help in some situations but seems questionable as a path to reenergizing the STS movement.

A possible path toward new thinking about STS. This paper presents an approach for identifying important sociotechnical issues as part of taking sociotechnical systems more seriously in research and practice. That approach focuses on the idea of "dimensions of sociotechnical integration" as a way to visualize important sociotechnical issues in operational systems. Very few STS authors say much about sociotechnical integration or dimensions of sociotechnical integration. Google Scholar searches on August 26, 2020 using the search terms "sociotechnical integration," "integration of sociotechnical systems," and "dimensions of sociotechnical integration" returned only 203, 25, and 0 hits, respectively. Most of those papers mentioned sociotechnical integration in passing but did not explain it as a concept. It was difficult to find any sources that went beyond general comments such as "Sociotechnical integration refers to the integration of the social and technical dimensions of engineering problems"

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(Erickson et al., 2020) and "Socio-technical integration entails the human, social, technical aspects of information systems." (Hokroh and Green, 2018). Some papers mentioned social and technical dimensions but did not fully explain those dimensions. In other words, the idea of sociotechnical integration is rare at best and dimensions of sociotechnical integration seems to be a new idea (even though something similar may have been named differently).

We define sociotechnical integration of an STS as the extent to which the various parts of the STS exhibit unity of purpose, are performed by processes that are mutually aligned, are executed by mutually compatible participants, provide shared visibility of information and work status, and operate using interoperable technologies. Those five categories each bring a series of dimensions that have meaningful impact on sociotechnical integration. Looking at those dimensions could provide greater insights about specific STSs than simply trying to identify the social and technical systems and searching for a better degree of joint optimization of the social and technical systems.

Organization. This position paper proposes using a single system view of an STS based on the idea of work system from work system theory (Alter, 2013), thereby overcoming the awkward separation of STSs into ambiguously defined social and technical systems. It uses Tables 1 through 5 to identify dimensions of sociotechnical integration under each of five categories of sociotechnical integration. It uses radar charts in Figure 2 to illustrate how dimensions of sociotechnical integration can help in comparing STSs and imagining how they might be improved. A brief conclusion identifies next steps.

2. Viewing sociotechnical systems as work systems

This paper views STSs as work systems as defined in work system theory: A work system is a system in which human participants and/or machines perform processes and activities using information, technology, and other resources to produce product/services for internal and/or external customers. A work system operates within an environment that matters (e.g., national and organizational culture, policies, history, competitive situation, demographics, technological change, stakeholders, and so on). Work systems rely on human, informational, and technical infrastructure that is shared with other work systems. They may be governed to some extent by explicit strategies. The work system framework in Figure 1 identifies nine elements of even a basic understanding of a work system. The definition of work system implies that an information system can be viewed as a work system whose primary activities are devoted to processing information, i.e., capturing, transmitting, storing, retrieving, deleting, manipulating, and/or displaying information.

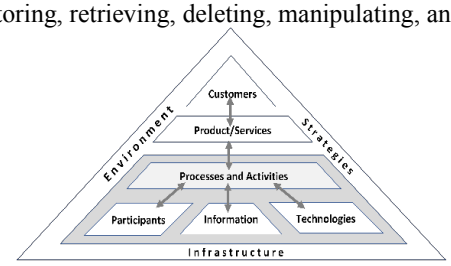

Figure 1: Work system framework

Seeing an STS as a work system that can be understood based on the work system framework provides a single system approach that is more effective than a "social system + technical system" approach in dealing with many of the challenges that limit the current impact of the STS movement. Viewing STSs as work systems avoids confusions that result from seeing an STS as a combination of a social system and a technical system: Structure is both social and technical. Tasks performed by people with the use of technology are both social and technical. Information generated by tasks performed by people is both social and technical. Even technology may be viewed as social and technical in today's world of "bring-your-own-device." As discussed in greater depth in Alter (2019), a work system approach can support typical managerialist concerns but also can be used consistent with many ideas in the STS ethos as described by Mumford (2006): STS is "more a philosophy than a methodology" … Its two most important values are "the need to humanize work through the redesign

of jobs and democracy at work." Furthermore, "although technology and organizational structures may change, the rights and needs of the employee must be given as high a priority as those of the non-human parts of the system" (p. 338). As in any real situation, stakeholders will decide on the relative priority of business and humanistic concerns and goals.

All of the following STSs can be described as work systems, i.e., by identifying their customers, product/services, processes and activities, participants, and so on (see Figure 1)

- Producing coal in an English coal mine in 1950 (an STS studied by early STS researchers)
- Producing cheese in Cheddar, UK in 2020
- Presenting a course about STS presented through videoconferening
- Developing software through cooperation of teams in different time zones
- Producing a monthly financial closing in a large company
- Designing a new type of food packaging
- Outsourcing of shirt production to Vietnam
- Training a football team

Broadbrush generalizations about the nature and philosophy of STS will do little to help in comparing those markedly different STSs because such generalizations tend not to address specifics of particular STSs. This paper's new idea of sociotechnical integration of an STS might help in visualizing important differences between real world STSs, in comparing STSs, and in visualizing ways in which specific STSs can be improved.

3. Dimensions of Sociotechnical Integration, Organized by Category

As noted earlier, we define sociotechnical integration of an STS as the extent to which the various parts of the STS exhibit 1) unity of purpose, 2) mutual alignment of internal processes, 3) mutual compatibility of participants, 4) mutual visibility of information and work status, and 5) interoperable technologies. The dimensions of sociotechnical integration shown below are organized around those five categories, each of which is related to elements of the work system framework (Figure 1). Unity of purpose is about producing product/services that meet needs of customers. The other four categories are directly related to processes and activities, participants, information, and technologies, respectively.

Those five categories each contain four dimensions that have meaningful impact on sociotechnical integration. (Other dimensions might have been included.) Looking at those dimensions could provide greater insights about specific STSs than simply trying to identify the social and technical systems and searching for a better degree of joint optimization (Mumford, 2006) of the social and technical systems.

Assume that any particular STS might be described and evaluated along multiple dimensions of sociotechnical integration and that descriptions of specific sociotechnical systems along those dimensions might bring important hints for how to improve results for all stakeholders, including work system participants, owners, and customers. The dimensions are real dimensions, not just topics of interest. Imagine that those dimensions go from 10 to 0:

- 10 would express maximum similarity to coal mining and other work situations of the type that the first sociotechnical researchers analyzed many decades ago.
- 0 would express minimum similarity to those situations, i.e., would involve distributed knowledge work occurring across time zones and performed by people with different native languages , different cultures, different levels of expertise, and different personal ambitions, working for different companies that might or might be pursuing different goals and opportunities.

Category 1: Unity of purpose. Sociotechnical integration is greater if the various parts and subsystems of a sociotechnical system pursue the same purposes. This is worth noting because many STSs produce different product/services for different groups of customers. For example, a hiring system serves needs of the hiring manager, the applicants, and probably the HR manager who wants to analyze the applicants as a group.

Table 1
Dimensions related to unity of purpose for sociotechnical systems

Dimension	High sociotechnical integration	(assessment from 0 to 10)	Low sociotechnical integration
Alignment of goals	Common goals	<---------->	Different goals
Responsibility for results	Internal group responsibility	<---------->	External responsibility
Commitment to goals	Commitment to group goals	<---------->	Lack of commitment
Psychological ownership	High	<---------->	Low

Category 2: Mutual alignment of internal processes. Higher mutual alignment of processes usually calls for a higher degree of structure, conformance to group decisions, local control rather possibly inconsistent guidance from a matrix management approach, and tighter coupling between the various subsystems.

Table 2
Dimensions related to mutual alignment of processes and activities in sociotechnical systems

Dimension	High sociotechnical integration	(assessment from 0 to 10)	Low sociotechnical integration
Degree of structure	Highly structured	<---------->	Unstructured
Operational discretion	Group decisions	<---------->	Individual preferences
Locus of control	Focal work system	<---------->	Matrixed responsibilities
Internal coupling	Tightly coupled	<---------->	Loosely coupled

Category 3: Mutual compatibility of participants. Mutual compatibility of participants is usually higher with shared language and culture, expert knowledge (which provides guidelines for decisions and action), and longer group membership (because incompatible people tend to leave if possible).

Table 3
Dimensions related to mutual compatibility of participants involved in sociotechnical systems

Dimension	High sociotechnical integration	(assessment from 0 to 10)	Low sociotechnical integration
Culture	Shared culture(s)	<---------->	Incompatible culture(s)
Language	Shared language	<---------->	Different languages
Expertise relative to task	Expert	<---------->	Novice
Group membership	Long-term	<---------->	Temporary

Category 4: Shared visibility of information and work status. Mutual compatibility of participants is usually higher with shared language and culture, expert knowledge (which provides guidelines for decisions and action), and longer group membership (because incompatible people tend to leave).

Table 4
Dimensions related to mutual visibility of information and work status in sociotechnical systems

Dimension	High sociotechnical integration	(assessment from 0 to 10)	Low sociotechnical integration
Information accessibility	High	<---------->	Low
Communication richness	Face-to-face	<---------->	Distant
Geography	Co-located	<---------->	Dispersed
Time	Same time zone	<---------->	Different time zones

Category 5: Technology interoperability. By definition, technology interoperability calls for consistent standards for hardware, software, interfaces, and data. Inconsistencies in any of those areas can cause significant inefficiencies and other stresses on work system participants trying to fulfill their responsibilities.

Table 5
Dimensions related to technology interoperability in sociotechnical systems

Dimension	High sociotechnical integration	(assessment from 0 to 10)	Low sociotechnical integration
Hardware standards	Consistent	<---------->	Inconsistent
Software standards	Consistent	<---------->	Inconsistent
Interface standards	Consistent	<---------->	Inconsistent
Data standards	Consistent	<---------->	Inconsistent

4. Using radar charts to characterize sociotechnical systems

Three radar charts (Figure 2) generated in Excel represent hypothetical views of three of the STSs that were mentioned earlier. Each STS is rated from 0 to 10 along the same two dimensions within each of the five categories of sociotechnical integration. The ten ratings (Table 2) used to produce the charts are imagined totally for illustrative purposes. The coal mine has very high sociotechnical integration along most dimensions except for technology interoperability, where that may not have been an issue at all. The STS course by video conferencing has a very high degree of structure because the instructor defined it that way. Other courses based on video conferencing might be delivered much more loosely. Notice how information accessibility and communication richness are quite low in this example. The students are probably bored and uninvolved. The design of the food packaging is being done by a team of packaging experts that has some inherent conflicts of interest regarding who will get credit. Hence it is evaluated at only 7 with regard to common goals and psychological ownership. Those imaginary details are included to illustrate that while the three examples are all STSs, they are quite different and those differences probably call for different approaches in any attempt to understand what is happening and to improve their performance. At minimum, values related to humanizing work and democracy at work will be only part of the rationale that guides any attempt to improve those STSs.

Table 6
Imagined ratings for ten dimensions for three illustrative sociotechnical systems

Dimensions (two each in five categories)	Coal mines in the 1950s	STS course by videoconference	Designing a new food packaging
common goals	9	7	7
psychological ownership	9	5	7
degree of structure	8	10	6
locus of control	9	5	9
shared language/ culture	9	5	7
expertise relative to task	9	5	10
information accessibility	7	3	9
communication richness	8	5	7
hw/sw standards	0	5	7
data standards	0	5	7

Figure 2 shows radar charts summarizing sociotechnical integration for the three examples. The main point is that the three examples look quite different when displayed in that way. Notice how the coal mine and food packaging examples seem to have higher overall sociotechnical integration based on the area enclosed by the polygon. On the other hand, the shape of the polygons indicates that different aspects of sociotechnical integration may require attention.

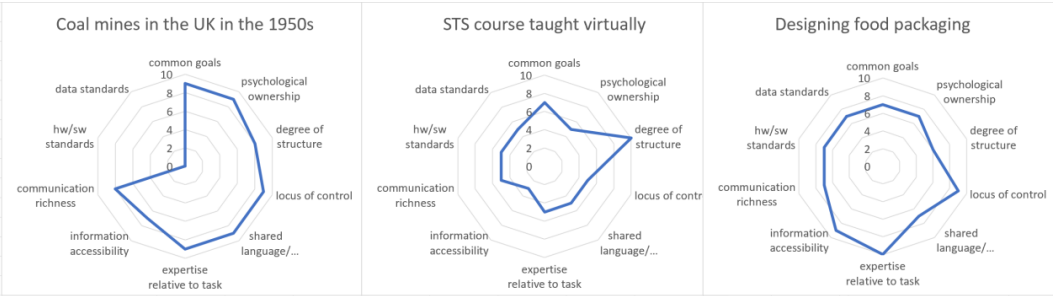

Figure 2: Three illustrative radar charts

5. Next Steps

1. Test the possible usefulness of the dimensions of sociotechnical integration when applied to a number of accounts of sociotechnical systems. Note how well each dimension applies to each account. Notice whether attention to the dimensions reveals or emphasizes important issues.
2. Revise the dimensions of sociotechnical integration based on discussions related to the clarity and applicability of each dimension, the desirability of eliminating overlapping dimensions or other redundancies, and so on.
3. Repeat step 1) applying the revised dimensions to either the same accounts of sociotechnical systems or other accounts that are potentially more instructive. Possibly use radar charts that can be produced using Excel to compare the accounts. Examine the radar charts to see if they provide genuinely useful comparisons.
4. Explore and apply ways in which dimensions of sociotechnical integration can be used in practice or in research. In practice the dimensions might be useful for identifying important issues and thinking about directions for improvements in sociotechnical systems, i.e., making changes in positioning along the dimensions. For research the dimensions might be useful in comparing research results from the past and might be useful in comparing multiple sites that are used in comparative research.

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