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ABSTRACT

With the increasing integration between information systems and the work systems they support, methods that focus on computerized aspects of information systems but skim over the work system are increasingly inadequate. To address work system issues, systems analysis and design methods should apply general principles that help in assessing likely positive and negative impacts of conceivable changes in the information system and/or work system. Such principles apply to the operation of systems in organizations, not to processes for analyzing systems. This paper presents a set of work system principles and gives initial examples illustrating how EMBA students have applied those principles within preliminary analyses of real world systems in business organizations. The principles come from a variety of sources including the sociotechnical literature, TQM, and comments about previous sets of principles. Future research will attempt to improve the set of principles through additional literature searches and through feedback from users.

Keywords

system principles, systems analysis and design, success factors, normative principles, work systems, work system framework, work system life cycle model

INTRODUCTION

Why is the rate of disappointment and failure for IT-related initiatives so high despite the hundreds of books and articles that have been written about systems analysis and design, software engineering, and organizational change? (e.g., Standish Group, 2001) Wand and Weber (2002) say "faulty requirements analysis still remains a major problem during systems development," and imply that better conceptual modeling might address this problem. Although better methods for defining data and processes certainly would be welcomed, the high rate of failure and disappointment is probably more directly linked to confusion and disagreement about big picture issues related to:

- what specific work systems are supposed to accomplish
- how specific work systems currently operate in reality
- how proposed work systems should operate in the future
- how current and potentially revised systems (might) affect other systems
- how foreseeable changes in the environment might affect the benefits of proposed changes that might or might not involve IT.

Progress on these issues requires ideas and methods that help business and IT professionals understand and communicate about the big picture issues rather than minute details of data processing. A long term effort to develop such methods has produced the work system method, a broadly applicable set of ideas that use the concept of work system as the focal point for understanding, analyzing, and improving systems in organizations, whether or not IT is involved. The steps in the process include:

- Identify the problem or opportunity, the smallest work system that has that problem or opportunity, and the relevant constraints.
- Looking at each work system element and the work system as a whole, analyze the system using characteristics, performance variables, and work system principles related to each element and the work system as a whole.
- Identify possible improvements and trace possible positive and negative impacts on other elements of the work system (recognizing that potential improvements in one area might cause problems elsewhere)
- Decide what to do, identifying work system changes that do and do not involve changes in the information system.
- Justify the recommendation using the initial goals and before and after estimates of measures of performance. Sanity-check the recommendations using work system principles and the work system life cycle model.

This paper focuses on the normative work system principles used within this method. Although normative principles related to systems in operation might help in uncovering and resolving system-related problems and conflicts and in designing effective systems, the implicit assumption underlying most systems analysis and design (SA&D) methods in textbooks and elsewhere is that business and IT professionals either don't need or have mastered system principles that help. In relation to Wand and Weber's conceptual modeling framework (grammar, method, script, context), most of these methods focus on gathering, organizing, and documenting descriptive information and on the form of the output ("grammar" and "script"), but provide few normative guidelines concerning the systems that are being diagnosed and improved.

For example, consider the article "Improving information requirements determination: a cognitive perspective" (Browne and Ramesh, 2002), which notes that "the large number of completed systems that do not meet user specifications and expectations" suggests the possibility of improvement in this area. The many techniques they present are clustered under pre-elicitation conditioning, prompting techniques, and external representation techniques. They provide many valuable ideas and insights showing how requirements determination might be improved from a cognitive perspective, but don't mention use of system-related principles, guidelines, or rules of thumb concerning the content of the requirements. Explicit use of normative system principles in SA&D methods might be an important step forward, but a necessary prior step would be the identification of general principles that could be used effectively.

A set of normative principles of systems could serve two purposes, codifying and organizing knowledge about systems and supporting real world SA&D efforts. To help in codifying system-related knowledge, the body of principles might contain 100 or 1000 statements because the goal would include completeness, clarity, and refutability. On the other hand, supporting efficient real world SA&D efforts without overwhelming the analysts might call for explicit use of only a selected subset of the known principles.

After distinguishing between normative principles, success factors, and design patterns, this paper explains the original motive for compiling work system principles and presents the most recent version. It explains how a recent EMBA class responded to the principles and explains how these students used them in analyzing systems within their own organizations.

FORM OF NORMATIVE PRINCIPLES

Normative principles are statements about how things should be rather than about how things are in reality. For example, the Ten Commandments speak of how people should act rather than how they do act. In contrast, Bernoulli's Principle describes how fluids actually do flow and therefore is not a principle of the type we are discussing. Table 1 lists recognized sources of normative principles from various fields. Unlike principles in the natural sciences, each set of principles mentioned in the Table is open to debate on practical and cultural grounds.

Field	**Widely recognized source of principles**
English composition	Strunk, W., Jr. and White, E. B. (1979) *The Elements of Style*, 3rd ed, New York: McMillan
Experimental design	Campbell, D. T. and Stanley, J. C. (1963) *Experimental and Quasi-Experimental Designs for Research*, Chicago: Rand McNally.
Total quality management	Deming, W. E. (2000) *Out of the Crisis*, MIT Press (reprint from 1986 edition)
Etiquette	Post, E. (1997) *Etiquette in Business, in Society, in Politics, and at Home*, 16th ed., HarperCollins
Software engineering	Abran, A. J., Moore, W., Bourque, P., Dupuis, R., and Tripp, L. L., (2001) eds., *Software Engineering Body of Knowledge*, Trial Version, Los Alamitos, CA: The Computer Society.
Religion	The Ten Commandments

Table 1: Widely recognized sources of principles from other fields

This paper focuses on normative principles related to work systems. Based on the inheritance relationships explained in Alter (2003), these principles should apply to special cases such as information systems and projects, although those special cases might have additional principles that do not apply to work systems in general. Principles are stated in the following forms:

- Systems {of type X} that are operating well *should* exhibit {a particular property}.

  Or

- Systems {of type X} that are operating well *should* accomplish {a particular goal}.

As with principles in other fields, system principles are potentially very useful even though they do not necessarily describe how systems actually operate. For example, optimization of subjective utility is a principle within decision theory even though behavioral studies of decision-making might show that people may not follow their own stated preferences. Part of the value of the principle is in the way it motivates insight and research about how and why actual decisions deviate from theoretically optimal decisions or from the personal beliefs of the decision makers themselves.

System principles differ from system success factors. Principles are generalizations that apply to all systems of a particular type, whereas success factors are (assumed to be) statistically correlated with success. For example, the principles "systems should please their customers" and "systems should perform work efficiently" apply to almost every system in an organization. In contrast, the success factors "top management support' and "prior experience with the technology" are only correlates of success. These factors may be absent from successful systems, such as systems that are invisible to top management and systems that use new technology but succeed anyway.

Ideally, system principles should be culture independent, and should apply in any national or organizational culture. This criterion fits best with principles that involve characteristics of work practices and less well for principles involving people and their personal well being.

Normative principles also differ from design patterns originally proposed by Alexander (1977) for architecture and later appropriated by software engineers (e.g., Gamma et al, 1995). As explained by Appleton (2000), the following essential elements should be clearly recognizable in a design pattern: name, problem, context, solution, examples, resulting context, rationale, related patterns, and known uses. In contrast, normative system principles are simple imperative statements intended to apply to almost every system of a particular type rather than to just certain situations that might be encountered.

MOTIVE FOR COMPILING WORK SYSTEM PRINCIPLES

The attempt to develop the work system method stemmed from personal experience in a manufacturing software firm in the 1980s. Too often it seemed that customers did not fully appreciate relationships between software they purchased and the operation and performance of their work systems. The work system method (mentioned above) is the result of a long term effort to develop methods that business professionals could use to analyze systems for themselves

Various versions of this method have been used for over eight years in introductory information system courses for employed MBA and EMBA students. The assignments in these courses involved writing group papers analyzing a real world system in an organization in which a team member works. Examination of each successive semester's papers led to modifications of the method and new guidelines for subsequent semesters. The main goal was to help the students understand the nature of systems in organizations and to provide a method that the students could use efficiently, effectively, and reliably. The secondary goal was the continual improvement of the method.

The idea of defining work system principles and incorporating them within the work system method was motivated by difficulties encountered by student teams in accomplishing more than describing a system and identifying several readily apparent weaknesses. The work system elements provided a good outline for describing a system, but many teams had difficulty searching for improvements other than relatively obvious changes such as recording data that wasn't being recorded or sharing data that wasn't being shared. They seemed to need guidelines for thinking about the various types of improvements that might be considered. Introducing a set of system principles seemed a plausible way to make sure the teams would think about each element and would have a basis for comparing the current status and possible modifications to a set of ideals. (Alter, 2002a; 2002b).

CURRENT SET OF WORK SYSTEM PRINCIPLES

The initial set of work system principles included one principle per element for the sake of simplicity. Later it was extended and revised though a literature search, feedback from student users, and feedback from several presentations about the principles. Table 2 presents the current version of the work system principles. Space limitations preclude covering the source of each principle, alternative wordings, and other details.

Work system principle ***(related work system element)***	**Rationale for inclusion of this principle**
#1:Please the customers. *(customers and products)*	Work systems exist to produce things for their customers. According to TQM, customers evaluate the product and the work system is effective if the customer is pleased. Relevant performance variables include cost to the customer, quality perceived by the customer, reliability, responsiveness, and conformance to standards and regulations.
#2: Balance priorities of different customers. *(customers and products)*	Many work systems have more than one customer, and often those customers have different goals and priorities. Ignoring the differences makes it more likely that some customers will be dissatisfied.
#3:Match process flexibility with product variability. *(product and work practices)*	This is the sociotechnical principle that technological flexibility should match product variability. The arrows in the work system framework (Alter, 2003) say that the work practices should match the products and services just as it matches the participants, information, and technology.
#4: Perform the work efficiently. *(work practices)*	Effectiveness is about pleasing customers (principle #1). In contrast, efficiency concerns the internal operation of the work system. Relevant performance variables include rate of activity, rate of output, productivity, consistency, speed, downtime, and security.
#5: Encourage appropriate use of judgment. *(work practices)*	This is a restatement of the sociotechnical principle of “minimal critical specification,” i.e., that no more should be specified in the design than what is absolutely essential. In work system terms this is reflected in the appropriate degree of structure in the work practices.
#6: Control variances (problems) at their source. (*work practices*)	This is sometimes called the “sociotechnical criterion.” It is also consistent with Deming’s view that the people should monitor the quality of their own work and should be responsible for it, rather than making inspectors responsible for quality. Many work systems will have to operate with inputs that contain errors, noise, incompleteness, and timeliness problems whether or not those variances should have been corrected elsewhere.
#7: Monitor the quality of both inputs and outputs. (*work practices*)	This is related to the sociotechnical principle that feedback systems should be as complex as the variances that need to be controlled. In work systems the variances might be observed at the inputs, during the process steps, or in the outputs (the products and services produced).
#8: Boundaries between business process steps should facilitate control. (*work practices*)	This is a restatement of the sociotechnical principle of “boundary location,” i.e., that boundaries between units should facilitate variance control. The work system method assumes a work system’s business processes contain individual steps. Part of the detailed analysis involves revising the business process.
#9: Match the work practices with the participants (*work practices and participants*)	Work practices well matched to some participants might be poorly matched to others with different interests and capabilities. Consequently, different workers may perform even well defined work practices at different performance levels (e.g., great programmers versus mediocre programmers); similarly, different managers may use different types of information when performing the same management role. When the participants have significantly different capabilities and interests, the design of the system may have to accommodate those differences.
#10: Serve the participants. *(participants)*	This means providing healthy work conditions (meaningful work, appropriate levels of challenge, appropriate degree of autonomy, personal growth, etc.) in addition to providing resources needed to do the work effectively and efficiently. This is consistent with the sociotechnical principle of operating consistent with a high quality of work life.

#11:Align participant incentives with system goals. (participants)	Participants in many systems have incentives that are inconsistent with system goals, for example, when management says that quality is the top priority but only rewards people based on their rate of production. The sociotechnical principle "support congruence," i.e., systems of social support should reinforce the desired behaviors, addresses one of many aspects of this issue.
#12: Provide information where it will affect action. *(information and work practices)*	This is the sociotechnical principle of "information flow." Participants in many systems have access to information that is never used; participants in other systems lack access to information they need. In both cases, better system performance might result from system changes that facilitate creation of value from information.
#13: Protect information from inappropriate use. *(information)*	As system-related information is increasingly computerized, protection of information has become more important because of the threat of information misuse and heightened vulnerability to misuse, inappropriate modification, and theft.
#14. Use appropriate technology. (*technology* and *work practices*)	This is a sociotechnical principle. The frequent use of inappropriate technologies (both inadequately powerful and excessively powerful) dictates that this should be included as a separate work system principle even though "performing the work efficiently" (principle #4) implies the availability and use of appropriate technology with appropriate interfaces and other features.
#15: Minimize effort consumed by technology. *(technology)*	Unfortunately, even seemingly appropriate technologies consume effort in learning about the technology, performing set-ups and technology tweaks, recovering from crashes and mistakes in using the technology, and generally just "futzing around" with the technology.
#16: Take full advantage of infrastructure. *(infrastructure)*	There are sometimes improvement opportunities involving better, fuller use of shared human, informational, and technical resources that the work system can use but does not own or control. For example, it may be possible to offload effort and improve productivity by using slack resources that are readily available in the infrastructure. A related sociotechnical principle is "core absorbs support." (Reunite core and support functions to adjust to variances more expeditiously.)
#17: Minimize unnecessary conflict with the external environment *(environment)*	Systems that fit the organizational, cultural, competitive, technical, and regulatory environment typically operate with less stress and excess effort than systems containing inherent conflicts with the environment.
#18: Support the firm's strategy *(strategy)*	Consistent with the many articles that have been written about business/IT alignment, the form and operation of work systems should fit with the firm's strategy and definitely should not oppose it.
#19: Minimize unnecessary risks. *(system as a whole)*	Most work systems have meaningful risks related to at least several elements. Risk cannot be eliminated, but unnecessary risk should be avoided.
#20: Maintain balance between work system elements. *(system as a whole)*	System performance depends on the balance between the elements. If the system contains inherent conflicts, such as a mismatch between participants and the work practices, system performance will often suffer and other negative consequences such as employee turnover may occur. From a different direction, productivity will suffer if the system contains slack resources or uses excessive resources.
#21: Maintain the ability to adapt, change, and grow. *(system as a whole)*	Because a system's environment will probably change over time, the system should have the capability of adapting, changing, and growing. In some cases the use of computerized information systems supports adaptability, but in other cases, the computerized capabilities seems like "electronic concrete" that prevents change.

Table 2: Latest Version of Work System Principles

It would be nice if work system principles led directly to easily supported system improvement proposals. Unfortunately, groups of two or more principles may contain mutual contradictions. Consider the three principles #1 (please the customer), #4 (perform the work efficiently), and #10 (serve the participants). These were the first three in the shorter set of principles that was used initially. (Alter, 2002a; 2002b) Assume the system involves a service situation such as providing medical care or teaching. Typical customers would like to receive services when, where, and how they want those services, regardless of the convenience or efficiency of the providers. Typical system participants and their management would prefer to provide those services in an efficient way that does not put the participants under undue stress. The system design issue is finding an appropriate compromise. Many other combinations of principles call for similar tradeoffs.

The internal contradictions between different work system principles do not make them invalid. Our everyday lives at work and at home are filled with compromises between valid, but contradictory principles (e.g., being ambitious but not trampling others, using resources efficiently but not being a miser, disciplining children but not being a drill sergeant, and so on). Although there is no formula for making the tradeoff in most of these situations, greater consciousness of the underlying principles can help in making informed decisions and not ignoring important factors that should be considered.

Exploring the Usability of the Principles

For purposes of analyzing and designing systems, both the number of plausible principles and the frequent contradictions between the principles lead to questions about the best way to use normative principles. Experience to date in requiring MBA and EMBA students to apply work system principles in analyzing real world situations has provided preliminary justification of the approach. The most recent results are from two EMBA class meetings in which the principles were introduced (along with a great deal of other material) and a subsequent group paper in which students applied the principles in their analysis of a real world situation in their organizations.

Table 3 summarizes results of two classroom exercises in which a slightly different version of the principles in Table 2 were introduced to 24 relatively junior EMBA students in September, 2003 as part of their information systems course. During the second four-hour class meeting within this course, students received a response form listing 21 principles that were introduced as a *tentative* set of design principles. The students were asked to rate the likely degree of usefulness and applicability of each principle on a scale from 1-5 (from not useful to very useful) and to jot down comments, clarifications, and suggested improvements for each principle. The students knew that they would be expected to use these principles in part of a group paper due a month later. In the next class meeting a similar form was distributed. After further explanation of each principle by the students themselves (going around the room, with each student in turn explaining a subsequent principle), the students were asked to estimate on a scale from 1-5 (from atypical to typical) the extent to which each principle described key work systems in their organizations.

Table 3 presents average values for each principle. The "acceptance" score refers to whether the principle seems applicable or useful. The "reality fit" score refers to the estimates of whether the principles are typically followed. The "difference" score represents the difference between applicability and reality. As might be expected, scores for applicability of principles were higher than scores for following principles in practice.

Principle	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Acceptance (average)	4.5	4.2	4.1	4.3	4.1	4.1	4.4	3.9	4.1	4.4	3.5	4.5	4.0	4.2	4.0	4.3	4.1	4.4	4.0	4.2	4.7
Reality fit (average)	4.1	4.1	3.3	3.8	4.0	3.1	3.5	3.3	3.3	3.4	2.9	3.3	4.0	3.7	3.5	3.3	3.3	3.6	3.2	3.4	3.4
Difference	0.4	0.1	0.8	0.5	0.1	1.0	0.9	0.6	0.8	1.0	0.6	1.2	0.0	0.5	0.5	1.0	0.8	0.8	0.8	0.8	1.3

Table 3: Acceptance and Estimated Fit to Reality for Work System Principles in Table 2

The average applicability score across all of the principles was 4.2, with scores for individual students ranging from 3.4 (relatively skeptical) to 5.0 (fully accepting all principles, but possibly not thinking about them carefully). The principles with the highest degree of initial acceptance (4.7, 4.5, 4.4 and 4.4, respectively) were (#21) maintain the ability to adapt, change, and grow; (#1) please the customers; (#7) monitor the quality of inputs and outputs; and (#12) provide information where it will affect action. The principles with the lowest degree of initial acceptance (3.5, 4.0, 4.0, and 4.0, respectively) were "accommodate individual differences" (which was subsequently modified to "match the work practices to the participants" in

Table 2); (#13) protect information from inappropriate use; (#15) minimize effort consumed by technology; and (#19) minimize unnecessary risks.

The average reality fit score was 3.5, with scores for individual students ranging from 2.9 to 4.1. The principles with the highest reality fit were (#1) please the customers; (#2) balance priorities of different customers; and (#5) encourage appropriate use of judgment (4.1, 4.1, and 4.0, respectively). The principles with the lowest scores were “accommodate individual differences” (later revised as mentioned above); (#6) control variances (problems) at their source; and (#19) minimize unnecessary risks (2.9, 3.1, and 3.2, respectively). The largest differences between applicability and reality were for (#21) maintain the ability to adapt, change, and grow; (#12) provide information where it will affect action; and (#6) control variances (problems) at their source.

Exemplifying the challenge of identifying broadly accepted principles related to people, the principle “accommodate individual differences” appeared in the tentative list presented to students but was replaced with “match the work practices with the participants” for Table 2 because the students found it controversial. As defined, these principles should apply to any work system. They are neither success factors (statistical correlates of success), nor beliefs that some people hold strongly but others may disagree with, nor legislated rules. Interestingly, Majchrzak and Borys (2001) encountered a similar issue when they asked working masters students at USC students to apply a carefully developed sociotechnical theory to non-manufacturing settings. An earlier version of the theory treated quality of worklife as a separate objective, but some users ignored that objective even though it is a traditional tenet of sociotechnical analysis. In the revised theory they made “it impossible for users to ignore quality of worklife” by incorporating “quality of worklife as an essential component in achieving any business strategy.”

The responses summarized in Table 3 demonstrated that most students understood the principles and believed they were applicable. Beliefs and estimates aside, a better test of the principles involves whether they are helpful in an analysis. In October 2003 students submitted group papers related to the following real world systems in their organizations: an online retailer’s system for responding to customer inquiries, a beverage company’s system for developing regional marketing plans, an insurance agency’s system for coordinating insurance renewals, a software company’s system for scheduling custom training programs, the staffing system of a chain of fitness centers, and the budgeting system for a large bank’s IT division. The justification of each group’s recommendation had to contain a table listing each principle and summarizing “the likely extent of improvement in regard to the principle.” All six groups used the table in a meaningful way. Each group identified improvements related to some principles and no change related to other principles. For each principle, the analysis for the online retailer noted separate effects involving the online shopper and the retailer’s internal operations. Several other groups made similar distinctions in relation to each principle. On the other hand, several teams estimated improvements that seemed over-optimistic. In summary, it appeared that the work system principles helped in searching for potential improvements, in evaluating potential changes, and in organizing part of a justification, but the students’ experience and critical thinking skills determined whether they applied the principles realistically.

Conclusion

Although success and risk factors (statistical correlates of success or failure) have been studied frequently, principles of systems have received relatively little attention beyond largely symbolic nods to general systems theory and references to sociotechnical principles by a small number of researchers. In particular, SA&D textbooks and methods say very little about system principles that might help in evaluating how well systems in organizations currently operate and assessing whether potential changes might have positive or negative effects throughout the system. Given the appallingly high rate of disappointment and failure of information systems and IS-related projects, it is surprising that work system principles receive so little attention in SA&D training or techniques.

This paper described an attempt to develop a set of broadly applicable work system principles that might be a step toward filling the current void. It summarized how a recent version of those principles was presented to EMBA students, informally evaluated by them, and then used in analyzing real world systems as part of an introductory information systems course for EMBAs. The students believed the principles were applicable, and demonstrated that applicability by using the principles to justify recommendations in group papers they wrote.

Many questions remain for future research. Use of the work system method has demonstrated the potential applicability of work system principles to systems analysis. Links need to be built between the big picture analysis in the work system method and the techno-centric, detail-oriented methods of analysis and design for IS professionals. The role of work system principles within those unspecified links is unknown. Within the work system method itself it is not clear how many principles are enough, and when the number of principles might become overwhelming. The principles themselves need to be refined through additional literature searches and experimentation.

Progress to date illustrates the practicality of making work system principles visible in systems analysis and design. Table 2 demonstrates the feasibility of compiling usable lists of principles. Work by EMBA students demonstrates the feasibility of applying the principles in practice. There are many directions for research, but substantial benefits seem attainable.

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