Good games

A new perspective on problem situations in the design of complex information systems

Antti Ainamo,
antti.ainamo@hkkk.fi
Academy of Finland Postdoctorate Researcher
Helsinki School of Economics and Business Administration Dept. of Management

Abstract

With growing complexity, information system developers, operators and support personnel increasingly use design strategies that diverge from old and standard ones. The paper argues that one basis for understanding these new strategies is to use the metaphor of "game playing". Game playing, as understood in psychology, means that people try to progress towards a well-defined, predictable outcome through interaction where they go beyond what is considered proper to openly say or show. This paper discusses how designers play as they design complex information systems, how managers play with the designers, how users play with information systems, and how nonliving systems may play with one another. Game playing can be good or bad. When good, game playing incurs psychological or other payoffs without conflicting with social well-being and the design task. The paper provides implications for further research in system compatibilities and systems design of complex systems.

Keywords: AH Systems theory, AP Psychology, Soft systems
BRT Keywords: AH, AP

Introduction

The task of information system designers has always been to conceptualize and refine assemblages of information processing that transmit data input into data output in a predetermined or intelligent manner. Information systems literature informs us these designers have two standard strategies for coping with complexity. One is to be consistent in how to adapt historically transmitted design principles (Alexander 1964, Checkland 1981). The other is to exploit feedback effects from customers to optimize system performance (Hammer and Champy, 1993). Both strategies have good track records. However, system knowledge is by definition context-specific and difficult to articulate (see Polanyi, 1958, Rosenberg, 1982; and Von Hippel, 1990). Recent technological advances have brought about unsurpassed system complexity. Previously separate information systems are increasingly interdependent (Iansiti, 1998, 13; Shapiro & Varian, 1998, 9). Different kinds of platforms, standards, design principles, information system specialisms and user demands, as well as different levels of system maturity, mix in ways that are nonsimple. The design of a simple workstation, for example, includes optimizing interactions between the microprocessor, the memory, the application-specific integrated circuits (ASICs), circuit boards, the disk drive, and hundreds of other parts. Each of these components involves coordinating hugely divergent subsidiary activities to draw from a variety of interacting knowledge domains, such as ASIC design and circuit board simulation (Iansiti, 1998, 13). Given such complexity, system designers, developers, operators and support personnel do not neatly follow one or the other of the above two standard strategies. The trivial conclusion would be to brush aside any new strategies on a premise whereby science and practice are ultimately incommensurable. Design practice would concern systems design for specific contexts, while standard strategies would be practically useless abstractions. In this perspective, there would apparently exist no pertinent gap in knowledge, with all relevant linkages efficiently handled by experienced professionals.

Perhaps a sounder conclusion is to conceptualize *how* or *why* new strategies mirror the complexity of the new task of designing interdependent information systems into compatible and meaningfully useful wholes. This ought to benefit information system scientists and, over time, also system designers and design managers. Dealing with complexity necessitates dealing with the problems in part even before they chrystallize. To be prepared, Iansiti (1998) proposes "technological integration” as a the principle by which to cope with complexity: “Effective organizations ... retain people with the experience base necessary to investigate the broad impact of individual design decisions". There are seminal systematic studies of the benefit of such retention. Kidder (1982) shows how a chief designer can pivotally shape the unfolding of a complex information system. Cringely (1993) reveals how managers can hide or disguise unfolding system system faults or shortcomings.

In this paper, I work towards integrating Iansiti’s, Kidder’s and Cringely’s findings from the strategic organization design perspective (Djelic & Ainamo, 1999) from which I come. For this purpose, I blend general systems thinking and soft systems (Checkland 1981; Dahlbom & Mattiassen 1993) with the psychology of games (Berne, 1964, Maccoby, 1976). The small but perhaps important contribution is that system design can benefit from psychological games where the team works towards a well-defined and predictable outcome but this is not openly articulated. I propose that game playing is a most feasible alternative among the array of design strategies when technological progress is rapid, complexity is growing, the task is to optimize system compatibility, problem situations abound, and design team members coalesce too shakily for soft systems to motivate them.

General systems thinking

The system view calls any group of organisms, objects, components or organizational environments that forms a regularly interacting or interdependent network a system (Francois, 1999). For hundreds of years, the study of systems has been polarized according to whether students consider them “natural” or “artificial" (that is, “man”-made; Simon, 1996)(My apologies for Simon’s/others’ lack of gender-sensitivity). William Paley (1802), an English clergyman coined the creationist “Argument from Design”. He argued that all products, whether artificial or natural, have a God or the “Designer” who created them with a purpose. There are creatonists who hold that some single designer has designed such artificial systems as telephone, heating, highway or information systems for distributing or for serving some other explicit purpose. In contrast, evolutionarists have long held that natural systems result from slow and incremental adaptation of the human and other species to their changing environments (Allen, Bekoff and Lauder, 1998). In the evolutionarist perspective, both natural and artificial systems build on earlier system generations. In other words, systems embed themselves in the past. “Everything must have a beginning... and that beginning must be linked to something that went before... Invention, it must be admitted, does not consist in a void, but out of chaos” (Shelley, 1831).

Systems engineering

In the 1950s, leading engineers considered general systems thinking a rational and efficient methodology for carrying out man-made projects. They developed “systems engineering”. This general methodology worked only in simple or well-defined problem situations that were concerned with achieving objectives that could be assumed as given. However, the general methodology failed in messy, ill-defined problems. This led to an understanding of how there are different kinds of system design. Some design tasks concern systems that ought to be extremely flexible or loosely coupled. Other tasks concern those that ought to be extremely rigid or tightly coupled. In information, these differences lead to appreciation of variants such as the design of decentralized systems and the design of client-server systems.

Some man-made systems are simple, while others are complex (Alexander 1962). Simple distribution systems like local food market involve two-level interaction between essentially nonchanging products and stable environments. Simple systems arise naturally into satisfactory forms or comprise straightforward design tasks. Systems engineering works well in the design of simple systems.

The global ecosystem, the capitalist system, computer operating systems, telephone systems, heating systems, highway systems and information systems are complex man-made systems. Simon (1996) defines "complex" as nonsimple interaction between global and local objects, components and organizations. A complex system involves multiple levels of interplay between technical, social, economic, and political processes within turbulent global environments. Complex arise naturally only over very long time spans. Designing complex systems is slow, many problem situations and team or effort from the organizational environment as a whole, instead of a single designer.

Following March & Simon (1958), teams and organizational environments take in information and put it out in a revised form, thus comprising "information systems" in themselves. System designers in such environments create or develop new systems and embed these systems in those and new environments. The systems they design do not only shape these environments. Also the environments shape both the systems, as well as the process of design (Lewin, Long & Carroll 1999; Djelic & Ainamo 1999). Systems have a tendency to progress towards ultimate fit with their environments (Dahlbom & Matthiassen, 1993). In the short term, progress can take of two routes. With mutual fit, designers, systems and environments all progress in a direction that approximates intentions. With misfit, they “read” each other wrong – direction diverges (Checkland, 1981). Complexity increases likelihood and speed of divergence (Ainamo & Pantzar, 1999; Simon 1996). Within misfit and divergence of success and intentions, people tend to adopt roles that reflect not on superficial biological, demographic or ethnic characteristics, or education or training. Deep analysis reveals that the roles reflect basic psychology.

The psychology of problem situations

On the superficial level, Wheelwright and Clark (1992, 220) find that system design is a trivial problem when the current system design already meets requirements. On the psychological level, trivial problems comprise “filling in time” or “procedures and rituals” (Berne, 1964). Three kinds of “hunger” motivate people – satisfactory levels of stimulus, recognition and meaningful structure – and in that order. People are seldom satisfied with their desired level of stimuli. Normally, however, they are not strictly confined to one or another motivator. They are embedded in diverse functional, psychological, social, and administrative environments. They satisfy themselves by exchanging recognition or meaningful structure for stimuli. People fill in the time that constitutes their life and working hours, or live up to the requirements of procedures and rituals they have learned during their life. Their psychological repertoire sorts out into: (1) roles that have been inherited from past system generations; (2) roles that are autonomously objectively directed by appraisal of current reality; and (3) those that represent experiences people have fixated since their early childhood.

In serious problem situations, people’s roles tend to span a limited repertoire of coherent operations. They being to play “bad games” with an ulterior motive to reach a payoff at the expense of the opponent(s). In bad games, some act like a neurotic child: “infants deprived of handling over a long period[,] will tend at length to sink into an irreversible decline and are prone to succumb eventually to intercurrant disease" (Berne 1964, 13-15). Others start acting like frustrated “parents” (Berne) who position themselves as representatives of the wisdom of past generations, and squarely against innovation. Still others position themselves as young “adults” (Berne) who fail to appreciate both experience and wisdom, on one hand, and innovation, on the other. They fill in their time and carry out rituals of what they consider objective appraisal of reality. What results is a breakdown in social interaction, communication and progress in the carrying out of the design task.

“Soft systems” methodology

Checkland (1981) has codified the practices by which leading-edge designers really deal with problematic situations into what he calls the "soft systems" model. According to this model, designers deal with diversity of subjective interpretations. They combine the wisdom of past system generations, objective appraisal of current reality, and frustrations stemming from as far back as childhood. Problem situations entail many (divergent) perspectives on the very issues to be dealt with – including objectives to be achieved. Taking the subjective mental models of participants and translating them into explicit models improves understanding and learning. In practice, designers who are soft systems managers follow a set of seven stages (The Center for Futures Research, 1999):

1 Given a design team with a serious problem, manager intervenes, entering team
2 Manager matches this intervention with team culture and power relationships

3 Manager and team discuss team members' 'root definitions'; that is, deeper-level systems they think are relevant to the problem situation.
4 Team and manager model situation and map direction of relationships ("arrows")
5 Team and manager compare model with real-world actions to induce learning
6 Team and manager iterate to achieve a common understanding of desirable actions
7 Team takes action, addresses problem and restarts cycle, with or without manager

If system engineering of man-made systems, like industrial psychology, essentially amounts to control, soft systems, like psychoanalysis, amounts to a analyzing psychic phenomena, treating emotional disorders and treatment sessions during which team members are encouraged to talk freely about personal experiences, even about childhood and dreams (see Kvale, 94; see Table 1).

Table 1: Soft Systems Methodology vs. Psychoanalytic Interview Methodology. (Adapted from: The Center for Futures Research, St. Gallen, 1999; and Kvale, 1999, respectively)

SOFT SYSTEMS METHODOLOGY	FREUDIAN ANALYSIS
1. Enter problematical situation / intervene	**1. Individual case study: obtain rich context**
2. Analyze: intervention, prevalent culture, and power relationships	**2. Open mode of interviewing: proceed in an open manner**
3. Explore 'root definitions'	**3. Interpret meaning: full interpretation with analysis**
4. Structure conceptual arrow models	**4. Temporal place: make the unconscious conscious**
5. Common understanding of real/desired	**5. Human interaction: reciprocal involvement**
6. Participating group reiterates prior stages	**6. Symptoms as magnifying glass of pathology**
7. Take action / restart cycle	**7. Change: understand by attempting to change**

The soft systems model is an aid for dealing with mismatches between diverse goals and evaluations of diverse autonomous groups. It provides us with a rich realistic approach to learning and change, but it is difficult to plan or manage.

However, soft systems achieves its objectives at an expense (Dahlbom & Matthiassen, 1993, 58-59). It leads to an increase in the complexity it attempts to treat. Complexity amplifies the forces of divergence. How can soft systems managers ensure that the design team does not lapse into bad games? Also, by all mental models explicit, it treats all team members as adults. I remind that "Children need to play in order to learn" (Dahlbom &

Matthiassen, 1993, 267). Parents need respect as carriers of the tacit wisdom of past generations.

I propose that the alternative to bad games is "good games" (Berne). Good games counter the limits of systems engineering to stimulate learning and innovation. Kidder (1982) provides seminal evidence of system designer's games with computers to learn and to amuse themselves. The most effective organizations grant respect to designers with experience of many system generations with such respect (Iansiti, 1998). The retention and motivation of designers presents a stock of knowledge about past solutions that may someday become valuable in new systems.

According to psychology, "good games" are those that incur psychological payoffs but there is little conflict with social well-being. Meyer and Lehnerd (1997, xii–xiii) partition information systems into a current state, a desired state, and learning about a design that bridges the gap between the current and desired states. In other words, I propose that soft systems can benefit from an element of playfullness, humour and excitement. In the following, I will thus attempt to argue that not all serious problem situations need to be treated seriously.

Winning and losing in soft systems

How do people fill in time, live up to the requirements of problem situations or play games? Maccoby's (1976, 38–42) thesis suggests there exist four ideal types of actors in "new technology", or what we now call information systems.

The first of these is the "craftsman". He or she is carrier of wisdom about past system generations.

The "craftsman" as a carrier of the wisdom of past system generations

"The craftsman holds values such as worth ethic, respect for people, concern for quality and thrift. When he talks about his work, his interest in the *process* of making; he enjoys building. He sees others, co-workers as well as superiors, in terms of whether they help or hinder him in doing a craftsmanlike job... Although his virtues are admired by everyone, his self-containment and perfectionism do not allow him to lead a complex and changing organization. Rather than engaging and trying to master the system with cooperation of others who share his values, he tends to do his own thing... enjoying whatever opportunities he finds for interesting work... Some of the most created and gifted scientists are included in this type... many are fascinated by esoteric issues (e.g., outer space or eternal life), only tangentially related to either corporate goals or social needs". (Maccoby)

In contrast to the tacit wisdom of the craftsman, the "company man" does not consider the past very important. He or she has a mind for what he considers objective appraisal of current reality.

The "company man" as the analyzer of current reality

The "company man['s]... sense of identity is based on being part of the powerful, protective company... [He feels] concern with the human side... and his commitment to maintain the organization's integrity... cooperation, stimulation , and mutuality... [and motivation to] share in the glory [characterize the company man.] " (Maccoby)

The craftsman and the company man do not play games. In contrast, “the gamesman” does. He or she is the player of what earlier I have called “good games”.

“The gamesman” as the instigator of experiments

“His main interest is in challenge, competitive activity where he can prove himself a winner... He responds to life and work as a game... He is a team player whose center is the corporation. He feels himself responsible for the functioning of the system... he sees people in terms of their use of the larger corporation... To function, the corporations need craftsmen, scientists, and company men (many could do without jungle fighters), but their future depends most of all on the gamesmen’s capacity for mature development.” (Maccoby)

The jungle fighter” can be a craftsman, a company man or a gamesman. However, his characterizing feature is that he or she plays bad games.

“The jungle fighter” as the catalyst of new problem situations

“The jungle fighter’s goal is power. He experiences life and work as a jungle (not a game)... defense... winner destroys the losers. Jungle fighters tend to see their peers as accomplices or enemies and their subordinates as objects to be utilized.... [Jungle fighters] when successful may build an empire... [or they] make their nests in corporate hierarchy and move ahead by stealth and politicking.” (Maccoby)

The pragmatic of good game playing

Kidder (1981, 18) provides support to Maccoby’s (and this paper’s) craftsman ideal type. In the early days of information, “the work of craftsmen inspired widespread awe in the popular press”. Albeit it was difficult, they could manage information systems almost single-handedly: computers’ data processing capacity was a more critical shortcoming than that of humans. Today, treating problems on the basis of such crafts traditions still works in many small-scale information systems projects. There is no need to make explicit their tacit practices. Differences between the current state and the desired state are trivial enough so that craftsmen can know more than they can tell (Polanyi, 1958), or will tell.

As computers’ data processing capacity has increased, information systems have become teamwork that necessitates what Maccoby calls company men and gamesmen. Company men design, develop, operate or support informations systems professionals in a way where they treat symptoms of user-system interfaces and other problems piece-meal. It is the company man’s responsibility that roles inherited from the past system generations and roles that realistically appraise current reality have mutual recognition. Otherwise team members will be able to treat the current problem situation. Social interaction and team effort would at length sink into an irreversible decline and intercurrant disease.

In the 1990s, especially, managing the establishment, classification and organizing of conventional information processing routines or symbolizing and schematizing neural ones into harmonious arrangements or patterns has become next to impossible for even the most talented and experienced company men. Piece-meal treatment hinders compatibilities between information systems. Company men do not have a holistic outlook, which is necessary to manage the full complexity of design information systems in and for modern organizational environments. The modern degree of complexity of the design and management tasks necessitates more than individual fiat of a brilliant designer to design, develop, operate, support, organize, or sometimes even use modern information systems. These require gamesmanship, the ability to intervene and manipulate reality to imagine and communicate systems that cannot yet exist. Within this perspective, everything that is tacit does not have to made explicit. Craftsmen, company men, and even jungle fighters, have to be motivated. Maturity in the case of the gamesman is measured as a capacity to balance past generations and objective facts but to invite imagination and consideration of future generations that do not yet exist. Leaps of faith and bold assumptions cannot always base on wisdom or objective appraisal.

Maccoby's typology is a "stages" model that demonstrates how the careers of craftsman, company man and gamesman can all coexist as "healthy" phenomena. In contrast, jungle fighters are those designers who hide or disguise problems to remain beyond the power of the organizations that employ them to fully direct and monitor what they are doing and, thus, "technological integration" (Iansiti, 1998). Sometimes, of course, jungle fighters remain not beyond managerial control but beyond the power of the customers (Cringely, 1993). The tragedy is that the way they hide or disguise their faults may mean that they will not develop personal awareness of the deficiencies in their knowledge of design (Alexander, 1964), or that superior design and management skills will have to be used to monitor them creation (Kidder, 1982). Finally, the hiding or disguising may mean that they will not be able to receive customer feedback (Hammer & Champy, 1993).

While a system designer remains jungle fighters he or she cannot rise beyond the programming of the past and learn the intimate rewards from acting out the role a craftsman, company or gamesman. He or she cannot enjoy the intimacy of craftsmanlike learning by doing, the security of shared company identity, or the superior payoffs of gamesmen. Thus, in the final analysis, the ignorance of a jungle fighter hinders the development of order into information systems practice and science, recognition of the information systems profession, as well as the improvement of relevant education. Jungle fighting is a pathological "disease" (Maccoby, 1976) or symptom that craftsmen ignore and company men prevent or control.

Despite their faults, jungle fighters can be good system designers. The art of gamesmanship entails knowing how to build sometimes shaky coalitions that include also junglefighters (see Kidder, 1982). Gamesmen need to direct the energies of the jungle fighter when he or she is the best or only man or woman for the given task at hand.

Implications for further research

Information systems science includes as one of its basic tenets that information systems are not ends in themselves. Within this perspective, this paper has sought to make a small but accumulative contribution by identifying a new perspective on how and why information systems can benefit from the retention of ideas and actions of experienced professionals. The overall proposition is as follows. Retention of experienced system engineers or soft systems designers ensures fit of the design process or outcome with past system generations (see Iansiti, 1998). Objective appraisal of current reality contributes to handling problem situations and fit with current demands (Checkland, 1981). In contrast to both of these strategies, playing games with conflicting views, developing scenarios and simulating alternatives contributes to developing fit with systems so far ahead in time that they cannot yet exist in any form but imagination. Within the last strategy, "good games" represent progress towards series of well-defined and predictable targets, which are not openly communicated to team members in order not to constrain their creativity. The last strategy need not be at the expense of the two other strategies. It is a new member to the array of strategies, which design managers can use simultaneously for different aspects of design.

With high cross-disciplinary content and little empirical data, the paper presents an understanding that is as of yet partial. The paper contributes more by opening rather than by closing discussion, more by presenting propositions than by testing them. Its strength and weakness of this perspective is that a very diverse range of topics for new research topics flow. These topics include, but are not limited, to the following:

Games system designers play with managers
On the basis of the foregoing, it would appear that the system designers and managers play both bad games and good games with one another. This suggests several topics. (a) Do different kinds of problem situations (bad games) appear with different kinds of dominance of one system designer role over the others? (b) Do managers intervene with different kinds of soft systems or good games, given different kinds of role dominance? (c): Does gamesmen lead to a dominance of either craftsmen, company men or jungle fighters (d) Does the dominance of either craftsmen, company men or jungle fighters lead to gamesmanship?

Games system designers play with systems
Maccoby's (1976) study is now quite old and information systems have changed substantially. (a) How has the validity of these findings about the bad and good games of craftsmen, jungle fighters, company men and gamesmen changed? (b) How do different roles differ in how they design a new information system?. (c) Are the designer roles valid for other information systems specialisms such as development, operations, support or use?

Games system users play with managers and systems
Cringely (1993) presents seminal discussion about good or bad games managers play with users of information systems. (a) What kind of good or bad games games users play with the managers? (b) What kind of good or bad games users play with the systems? (c) Do users hide or disguise these games?

Games nonliving systems play with each other
Two or more autonomously operating information systems represent "users" for other information systems. (a) Do " nonliving systems" (see Francois, 1999) play games, as outlined in this paper? (b) How can managers systemize nonliving networks of autonomous objects, components, or virtual organizations so that they will "play" with one another and compatibly process, store and retrieve information?

Imagining and carrying out these kinds of topics enables imagining and carrying out more ambitious ones. How do the different roles differ in how they construe new economics of information (Evans & Wurster, 1997)? How do the different roles differ in how they construe interaction of system design hierarchies and new market concepts (Clark, 1986)? The challenge is to ultimately move towards an integration of technical and psychological processes. How do such phenomena as software platforms (Meyer & Lehnerd 1997), product versioning (Varian & Shapiro, 1998) or new organizational forms (Ciborra 1997, Lewin, Long & Carroll, 1999, Djelic and Ainamo, 1999) connect with game playing, as outlined in this paper?

Acknowledgements: The author thanks the Academy of Finland for financing the research.

References:

Ainamo, A. & Pantzar, M. Design for the Information Society: The Research Paradigm. *Design Cultures: semiannual European Academy of Design Conference*, Sheffield, United Kingdom, March 30 to April 1, 1999.

Alexander, C. *Notes on the Synthesis of Form*. Harvard University Press. USA 1964.

Allen, C. Bekoff, M. & Lauder, G. (editors). *Nature's Purposes: Analysis of Function and Design in Biology*. The MIT Press, Cambridge, Massachusetts , 1998.

Berne, E. *Games People Play: The Psychology of Human Relationships*. Penguin USA 1964.

The Center for Futures Research, St. Gallen. Soft Systems Methodology: Systems Thinking Practice. http://www.sgzz.ch/links/stp/softmod/ssm.htm, 1999, June 2.

Checkland, P.B. *Systems Thinking, Systems Practice*, John Wiley & Sons, Chichester 1981.

Ciborra, C. The Platform Organization, *Organization Science*, 1993.

Clark, K. (1986): The Interaction of Design Hierarchies and Market Concepts, *Research Policy*, Vol. 14, No. 4, 235–251.

Cringely, R. (1993): *Accidental Empires: How the Boys of Silicon Valley Make Their Millions, Battle Foreign Competition, and Still Can't Get a Date*. Harper Business. U.S.A.

Dahlbom, B. & Matthiassen, L. *Computers in Context: The Philosophy and Practice of Computer Systems Design*. Blackwell, Great Britain 1993.

Djelic, M-L. & Ainamo, A. The Coevolution of New Organization Forms in the Fashion Industry: Historical and Comparative Study of France, Italy and the USA, *Organization Science*, Special Issue on Strategic and New Organizational Forms, 1999 (forthcoming), September–October.

Evans, P. & Wurster, T. Strategy and the New Economics of Information. *Harvard Business Review*, 1997, September–October, 71–82.

Francois, C. Systemics and Cybernetics in a Historical Perspective, *Systems Research and Behavioral Science*, Vol. 16, 1999, 203–219.

Freud, S. *Therapy and Technique*. Collier. New York 1963.

Hammer & Champy, J. *Business Process Reengineering*. USA 1993.

Iansiti, M. *Technology Integration: Making Critical Choices in a Dynamic World*. Harvard Business School Press. USA 1998.

Kast, F. & Rosenzweig, J. *Organization and Management: A Systems Approach*. MaGraw-Hill Series in Management. USA 1970.

Kidder, T. *The Soul of the New Machine*. USA 1982.

Kvale, S. The Psychoanalytic Interview as Qualitative Research. *Qualitative Inquiry*, Volume 5, 1999, Number 1, pp. 87–113.

Lewin, A., C. Long and T. Carroll. Co-evolution of New Organization Forms, *Organization Science, Special Issue on Strategic and New Organizational Forms*, September-October, 1999 (forthcoming).

Maccoby, M. *The Gamesman: Winning and Losing the Career Game*. Simon & Schuster. USA 1976.

Meyer, M. & Lehnerd, A. *The Power of Product Platforms: Building Value and Cost Leadership*. The Free Press. USA 1997.

Paley, W.: Natural Theology – Or Evidences of the Existence and Attributes of the Deity Collected from the Appearances of Nature (1802). Referenced in Dawkins, R: *The Blind Watchmaker*. Longman. Great Britain 1986, pp. 4–37.

Polanyi, K. *Personal Knowledge*. Towards a Post-Critical Philosophy. University of Chicago Press. Chicago 1958.

Rosenberg, N. *Inside the Black Box: Technology and Economics*. Cambridge University Press. New York 1982.

Shelley, M. Preface to the 1831 3rd edition (First edition 1818). In: *Franskenstein or the Modern Promotheus: the 1818 Text. With a Foreword and Notes by M. Butler*. Oxford University Press. Great Britain 1994.

Simon, H. *Sciences of the Artificial*. Third Edition (1st edition 1969). The MIT Press. USA 1996.

Varian, C. & Shapiro, H. Versioning: The Smart Way to Sell Information Products, *Harvard Business Review*, November-December, 1998, 106–118.

Von Hippel, E. *Task Partititioning: An Innovation Process Variable*, Research Policy, Vol. 19, 1990, No 4, 407–418.

Wheelwright, S. & Clark, K. *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality*. The Free Press USA 1992.