

Merging Organizational Learning with Learning Theory – A Task for the 21st Century?

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Abstract

We argue that the discipline called ‘organizational learning’ has a potential to fertilize and catalyze instructional technology, and vice versa. We envision a bridge between ‘organizational’ learning theory and ‘individual’ learning theory in the interrelated features ‘fragmentation and limitations of human knowledge’, ‘quality (or reliability) of individual know-how’ and ‘philosophy of science.’

Introduction

The topic for the One Day Conference at AERA 2000 sponsored by AERA SIG: “Structural Learning, Instructional Systems and Intelligent Tutors” was «Instructional Technology in the 21st Century: Projections by International Leaders». All presenters took a humble stance toward the formidable task of predicting the trajectory of instructional technology into the 21st Century.

In this contribution we would like to interpret the topic for the One Day Conference in the sense of what challenge(s) are promising for instructional technology at the dawn of this century. Our proposals and arguments are, needless to say, colored by our background and research activities.

Instructional technology has been shaped mainly in the perspective of individual learning. Organizational learning does not yet give much attention to individual learning – at least not in the sense learning theorists and instructional technologists do. This peculiar disregard of the individual learning aspect is a weakness of current organizational learning. We envision a bridge between ‘organizational’ learning theory and ‘individual’ learning theory in the interrelated features ‘fragmentation and limitations of human knowledge’, ‘quality (or reliability) of individual know-how’ and ‘philosophy of science.’

We expect that individual and organization learning is enhanced through information feedback from a double-loop learning process (Argyris, 1985) based on models of the real world (so-called ‘virtual worlds’). (Serman, 1994, has provided an excellent case for this contention.) We discuss instructional technology in the joint context of learning theory and organizational learning, so-to-speak in a world in which both branches know of each other. A central consideration is again the fact that human knowledge is highly fragmented, implying that there ought to be in learning theory a

perspective of integrating individual knowledge toward a purposeful organizational goal.

We focus on the following issues:

- What is understood by ‘organizational learning’ and ‘learning organizations’
- Relation between organizational learning and individual learning
- Fragmentation and limitations of human knowledge
- Fragmented and limited knowledge in organizations
- Relation between individual and organizational learning
- Quality of knowledge

Organizational Learning

The notion of organizational learning as a key process within an organization modulating and shaping its performance might be traced back to the beginning of the sixties (Cyert & March, 1963). Organizational learning was conceived as part of the managers’ portfolio, and managers have increasingly adopted the notion, to the extent that many managers see organizational learning as a powerful tool to improve the performance of an organization.

Cyert & March (1963) viewed organizational learning as an adaptive process where goals, attention rules and search rules became adapted to the experiences that are made within the organization.

Later developments include a distinction between adaptive learning – a response to changed environmental conditions – and proactive learning – planned organizational changes going beyond reacting to environmental changes. Adaptive learning is considered more automatic and less cognitively induced than proactive learning. Hence, many theorists consider adaptive learning inferior to proactive learning (Argyris & Schoen, 1978; Fiol & Lyles, 1985; Senge, 1990; Dodgson, 1991). Some authors emphasize that organizational decisions depend on certain rules and, hence, that organizational learning is executed on the basis of rules. (Levinthal & March, 1988; Levitt & March 1988; Levinthal & March, 1993). The rules are determined and (re)shaped by experiences that have been made within the organization.

The reshaping of rules can be affected by false interpretation of experiences or even personal events, such as the impediment of the realization of personal insights, etc (March & Olsen, 1975). These affections of the process of learning suggest that organizational learning can only be regarded as a limited rational process.

Learning Organizations

The concept of ‘learning organizations’ owes much to a Royal Dutch Shell 1983 study of long-lived large companies (called by de Geus ‘living companies’).¹ Referring to this study, de Geus sees as one main characteristic of a ‘living company’: «its adaptiveness to the outside world (learning)» (de Geus, 1997, p. 24). Senge quotes de Geus: «The ability to learn faster than your competitors may be the only sustainable competitive advantage» (Senge, 1992, p. 4).

¹ Arie de Geus was at that time Head of Planning for Royal Dutch/Shell and, as such, a major force driving the study of long-lived large companies.

Senge's book "The Fifth Discipline" (Senge, 1992) made 'learning organizations' a trendy phrase and helped to launch 'system thinking' as a managers' conceptual framework.² Senge argued that a learning organization worthy of this title successfully develops five 'component technologies', viz. 'system thinking', 'personal mastery', 'mental models', 'building shared vision' and 'team learning.' Senge considers system thinking the main component: «This is why system thinking is the fifth discipline. It is the discipline that integrates the disciplines, fusing them into a coherent body of theory and practice... Without a systemic orientation, there is no motivation to look at how the disciplines interrelate. By enhancing each of the other disciplines, it continually reminds us that the whole can exceed the sum of its parts.» (Senge, 1992, p. 12.)

Senge emphasizes that the five disciplines must develop as an ensemble. Concerning e.g. system thinking Senge (1992) writes: «... system thinking [also] needs the disciplines of building shared vision, mental models, team learning, and personal mastery to realize its potential. Building shared vision fosters a commitment to the long term. Mental models focuses on the openness needed to unearth shortcomings in our present ways of seeing the world. Team learning develops the skills of groups of people to look for the larger picture that lies beyond individual perspectives. And personal mastery fosters the personal motivation to continually learn how our actions affect our world.» (Senge, 1992, p. 12.)

Organizational Learning vs. Learning Theory

Organizational learning focuses on collective processes affecting an organization. Learning theory is concerned with individual learning. Organizational learning ought to be concerned with learning theory, since individual learning is part of the collective process. At some risk to oversimplify the issue I contend that there is little awareness of the need of learning theory in the organizational learning approach. Key issues in learning theory – such as learning perspective, goals, target users, learner activities and interactions, expected outcomes, and evaluation methods – are not so prominent in organizational learning. None of Senge's five 'component technologies', system thinking, personal mastery, mental models, building shared vision and team learning, maps comfortably into learning theory. Personal mastery could be a likely candidate, since Senge addresses the issue of learning in such connection. However, Senge states: «"Learning" in this context does not mean acquiring more information, but expanding the ability to produce the results we truly want in life. It is lifelong generative learning.» (Senge, 1992, p. 142.) This definition of 'learning' is nonsensical if taken literally. Making some allowances we interpret Senge in the sense that he is emphasizing the lifelong learning *attitude*.

Mental models is primarily concerned with theories-in-use, and with the way perceptions and thinking are affected by them (Argyris, 1982). To be sure, these are 'individual' aspects of cognitive processes but they belong to the largely unconscious frames shaping those cognitive processes, rather than to the conscious, planned activities belonging to learning theory.

System thinking can be viewed as a qualitative branch of system dynamics, which is the discipline of understanding and managing dynamic complexity. Central to system dynamics are causal loops, feedback and simulation models expressed in terms of

² Cf. www.pegasus.com

stocks and flows. During the last decade there has been growing concern in system dynamics about the aspect of learning about complex systems (the so-called 'modeling as learning approach', Lane, 1992). The review article by Sterman (Sterman, 1994) "Learning in and about complex systems" comes quite close to the spirit of learning theory. The issue is learning how to manage wisely, that is to say, how to influence a dynamically complex world in a desired way. From this point of view learning is a feedback process: Sterman argues that learning in and about complex concerns making decisions that change the real world. The real world provides information feedback that changes our mental models according to a double-loop learning process (Argyris, 1985). Changes in our mental models ('learning') make us revise our decisions. Many studies have uncovered that learning in and about complex systems is impeded by numerous factors. Errors and wrong habits creep in. Among the barriers to learning in and about complex systems are dynamic complexity; ambiguous, delayed or lacking feedback; misperceptions of feedback; poor human performance as 'mental simulator'; poor inquiry and scientific reasoning skills (see Sterman, 1994).

Sterman's review – splendid as it is – is not sufficiently aware of Dörner's school of cognitive psychology.³ Dörner's work since the beginning of the 1970's – anticipating and transcending work on learning in complex systems from the 1980's and 1990's – on psychological determinants of human dealing with complexity is spread over numerous publications in German. A recent book for the general reader gives access to this important work (Dörner, 1989, 1996, 1997). There is little doubt that organizational learning would greatly benefit from Dörner's insights.

Fragmentation and Limitations of Human Knowledge

The regrettable incompleteness and fragmentation of human knowledge has been strongly emphasized by Hayek (1973).⁴

«Complete rationality of action ... demands complete knowledge of all the relevant facts. A designer or engineer needs all the data and full power to control or manipulate them if he is to organize the material objects to produce the intended result. But the success of any action in society depends on more particular facts than anyone can possibly know. And our whole civilization in consequence rests, and must rest, on our believing much that we cannot know to be true...

What we must [...] keep constantly in mind..., then, is the fact of the necessary and irremediable ignorance on everyone's part of most of the particular facts which determine the actions of all the several members of human society. This may at first seem to be a fact so obvious and incontestable as hardly to deserve mention, and still less to require proof. Yet the result of not constantly stressing it is that it is only too readily forgotten. This is so mainly because it is a very inconvenient fact which makes both our attempts to explain and our attempts to influence intelligently the processes

³ Very few of Dörner's seminal papers have been published in English. Hence, the low awareness of the width and depth of Dörner's school among system dynamicists can be somewhat excused. In strange «reciprocity,» the highly relevant contributions of the founding fathers of system dynamics to studies of dynamics complexity are so-to-speak absent from the mental world of Dörner and coworkers.

⁴ Although not explicitly worded in terms of fragmentation of knowledge, the classic essay «I, Pencil» by Leonard E. Read (1958) is a wonderful introduction to the basic ideas of knowledge fragmentation. Leonard Read's essay is also found under the internet address <http://www.fee.org/about/ipencil.html>

of society very much more difficult, and which places severe limits on what we can say or do about them.» (Hayek, 1973, p. 12.)

Further:

«Another consequence of this basic fact which must be stressed here is that only in the small groups of primitive society can collaboration between the members rest largely on the circumstance that at any moment they will know more or less the same particular circumstances. . .

The situation is wholly different in the Great or Open Society where millions of men interact and where civilization as we know it has developed. Economics has long stressed the ‘division of labor’, which such situation involves. But it has laid much less stress on the fragmentation of knowledge, on the fact that each member of society can have only a small fraction of the knowledge possessed by all, and that each is therefore ignorant of most of the facts on which the working of society rests. Yet it is the utilization of much more knowledge that anyone can possess, and therefore the fact that each moves within a coherent structure most of whose determinants are unknown to him, that constitutes the distinctive feature of all advanced civilizations.» (Hayek, 1973, p. 13-14.)

Indeed, the issue of fragmentation and limitation of human knowledge *is* readily forgotten. Three decades after Hayek’s admonition it is easy to document that awareness of this uncomfortable fact is more or less absent in disciplines where this crucial aspect is a major determinant. One of this is organizational learning and the related discipline of in system dynamics.

Current organizational learning theories (e.g., Nonaka & Takeuchi, 1995; Nonaka & Konno, 1998; Seufert et al., 1999; Seufert & Seufert, 2000) discuss the relation between individual and organizational learning in terms of ‘dynamic social environments’, ‘spirals of knowledge creation’, ‘dynamic knowledge conversion processes between the individual and the organization’, ‘continuous knowledge creation’, ‘knowledge networking’, and so on. Such issues are certainly important and there is nothing wrong in those aspects *per se*. Our contention is that one essential dimension, viz. explicit consideration of fragmentation and limitations of human knowledge is virtually absent. There is an *implicit* consideration of fragmentation of knowledge in that more current concepts like division of labor, tacit knowledge in individuals and so on are aspects of the former.

Fragmented and Limited Knowledge in Organizations

The existing knowledge in an organization is fragmented and scattered across many heads. We visualize the individual (fragmented) pieces of knowledge available to an organization as small ovals, the ovals’ localization within the ‘total’ ideal knowledge (large oval) denoting the knowledge associated with individuals and its relation to other knowledge pieces (Fig. 1). Individual knowledge resources may overlap. Also, individual ‘knowledge’ may be unreliable or even wrong.

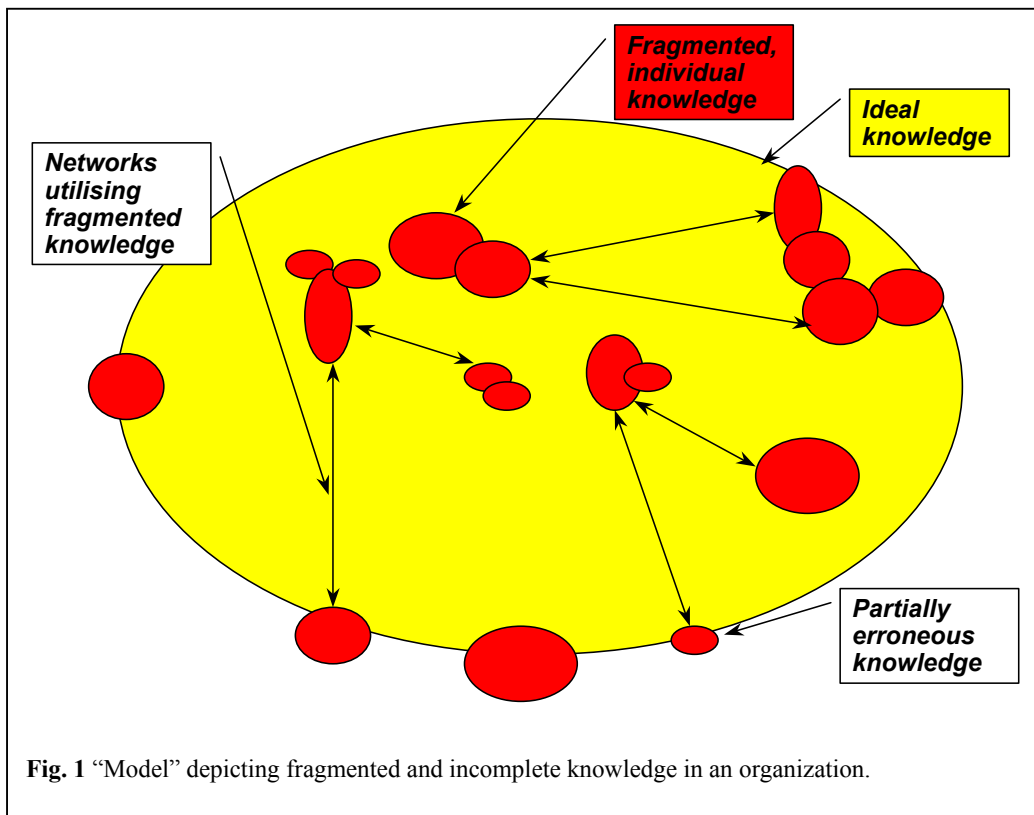
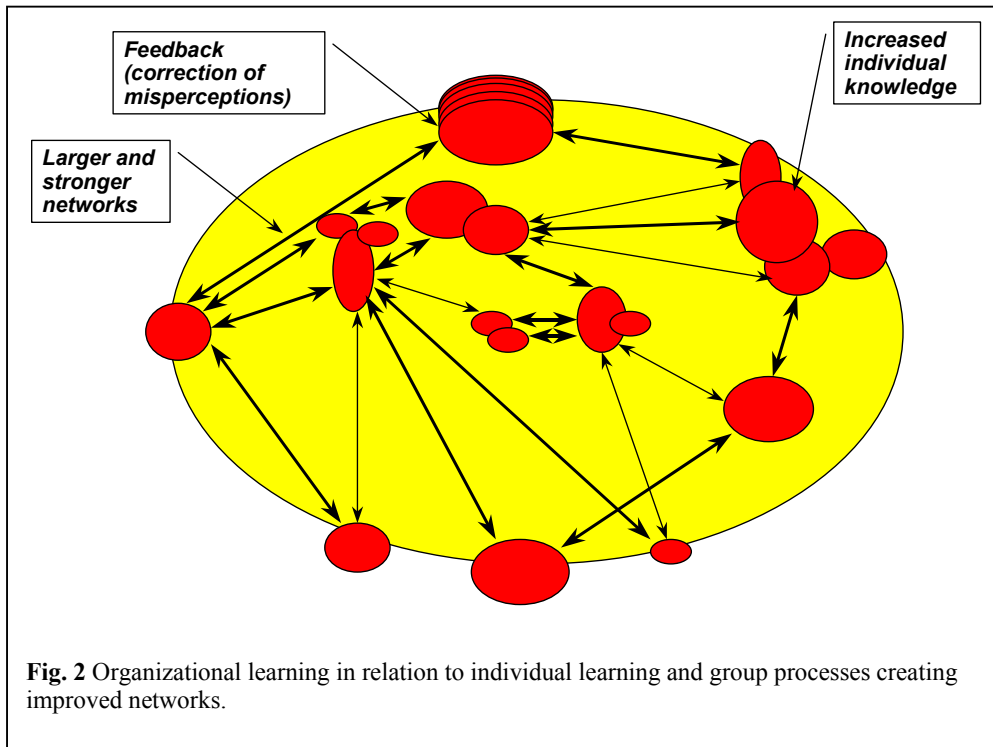


Fig. 1 “Model” depicting fragmented and incomplete knowledge in an organization.

The organization’s knowledge is a ‘sum’ of the individual, fragmented pieces of knowledge. Admittedly, the concept of ‘sum’ of knowledge is a vague one, but for the purpose of the present discussion one can imagine such sum as an integration of the fragmented pieces of knowledge through processes and networks operating in the organization. The kind and quality of these processes and networks determines to which extent the organization is able to utilize the potential knowledge existing in the organization. As emphasized by Hayek the total available knowledge (i.e., the ‘sum’ of the individual ovals) is significantly smaller than the ideal knowledge that the organization would need to have in order to perform perfectly (Hayek, 1973, p. 12). That is why organizational learning ought to be focused, in demand for a well-defined corporate challenge. Again, this consideration implies that organizational learning must be framed in terms of an approach that identifies corporate issues, elevates messy challenges to well-defined problems and provides appropriate coaching and feedback in a problem solving spirit. We note that system dynamics is an appropriate approach for problems characterized by dynamic complexity (Coyle, 1996; Forrester, 1971; Richardson, 1981; Sterman, 2000).

Figure 1 represents a metaphor for a knowledge map in that the varying localization of the ovals corresponds to different individual knowledge pieces. To be successful the organization’s total knowledge and the processes integrating fragmented knowledge to a whole must provide enough information to handle the current enterprise issue. Often the available organizational knowledge is not sufficient, or not adequate, to handle the current enterprise issue. Accordingly, many organizational learning tasks include processes that run (or ought to run) in the spirit of scientific discovery.



Relation between Individual and Organizational Learning

Figure 2 visualizes organizational learning as a process involving individuals and groups. Individuals are the ‘members’ (e.g., employees) of the organization. Groups are interacting individuals according to formal and informal networks within the organization. (In a more complete picture one would have to consider interactions with individual and groups outside of the organization, too.)

Organizational learning is a highly composite process involving increase of knowledge and improved knowledge (e.g., correction of faulty knowledge through some kind of feedback) in individuals as well as better utilization of fragmented knowledge through communication and interaction processes running in the formal and informal networks within the organization. In fact, an essential part of organizational learning is creation and improvement of knowledge networks.

The author has worked as consultant to various European enterprises in projects involving system dynamics modeling of corporate issues. Our experience corroborates the dictum expressed by many system dynamicists that most of the insights gained from models are conceptual (as opposed to instrumental)⁵ and that most learning occurs during (as opposed to after) the model-building process.⁶ This would imply that some very important kind of organizational learning occurs as a major result of system dynamical modeling of corporate issues. Given the commonplace nature of the dictum it is curious that not much has been done to analyze the learning outcomes accompanying system dynamical modeling.⁷ What is learned and how? How can the

⁵ See e.g. Meadows and Robinson, 1985; Vennix, 1996, p. 97.

⁶ See e.g. Greenberger, Crenson and Crissey, 1976; Vennix, 1996 p. 98.

⁷ There is, however, a very strong perception of the fundamental difficulties in assessing such kind of learning (see, e.g., Vennix, 1996, p. 28ff.).

learning outcome be measured and evaluated? How do learners interact? Such key issues from learning theory must be introduced into organizational learning – certainly a worthy task for the 21st Century.

Assessment of the learning outcomes accompanying system dynamical modeling of corporate issues is admittedly a very difficult (but highly desirable) task. Interactive learning environments (ILE) using system dynamics – called ‘management flight simulators’ by Sterman (1988) – provide a more accessible platform for assessment of learning effects. Learning effects in such ILE’s, especially those involving transfer of learning, appeared highly dependent on follow-on discussion and exercise (cf., Sterman, 1994). Spector and Davidsen comment on such learning effects: «These interactions were external to the computer-based learning environment. Most significant of all, we found almost a complete lack of measures of learning effectiveness.» (Spector and Davidsen, 2000a, p. 17 om manuscript.)

Spector and Davidsen have pioneered constructing interactive learning environments using system dynamics with a tight foundation in cognitive science (Spector & Davidsen, 1997; Spector & Davidsen, 1998; Spector & Davidsen, 2000b), and cognitive foundations for decision support and for learning in complex domains (Davidsen & Spector, 1997; Spector & Davidsen, 2000a). The recent article by Spector (2000a) is a fine review of the progress to date and perspectives for the future. Related pioneering work is been done at the University of Mainz but so far this work has not been published other than in conference abstracts (see e.g. Breuer, Hillen, Berendes, 2000).

Explicitly stated learning goals and mechanisms to facilitate progress towards those goals (e.g., linkage to things already known, assessment of progress, helpful guides to improve performance, etc.) are claimed to be critical to learning by no less authority than Gagné (Gagné, 1985). How is one to reconcile the ‘modeling as learning approach’ (Lane, 1992) – where learning goals are mostly tacit and implicit – with Gagné’s claim? We need to explore the differences between individual learning in organizations and ‘curriculum’ learning. Is serendipitous conceptual learning an added dimension in individual learning within organizations? If the answer is «yes», and this dimension is essential, learning theory and the implementation of learning theory by instructional design will have to pay more attention to discovery learning including scientific discovery methods. Indeed, scientific methods including philosophy of science would be (again) much-needed subjects in secondary school. The thought-provoking paper by Spector in this journal issues (Spector, 2000b) is very timely indeed.

Together with Agata Sawicka we are implementing a group knowledge eliciting and component-based system dynamic modeling process. The traditional approach to group model building is a process of consensus building (Vennix, 1996). Because human knowledge of complex domains is fragmented shared knowledge of all details of the total model is of questionable validity. Hence, we propose to decompose the problem to be modeled into a set of subproblems. Identified subproblems should match strongholds of expertise. As starting hypothesis, strongholds of expertise are supposed to be aligned with organizational structure (i.e. every manager is supposed to be the authority in his/her domain).

A component is a model piece that can be used as a building block of another component. As such, the component corresponds to a class in the object-oriented world (Myrtveit, 2000). Central to our approach is the assumption that model components can be aligned with strongholds of individual knowledge (domain

expertise) through careful composition of groups in the group knowledge eliciting and modeling process (Gonzalez & Sawicka, 2000).

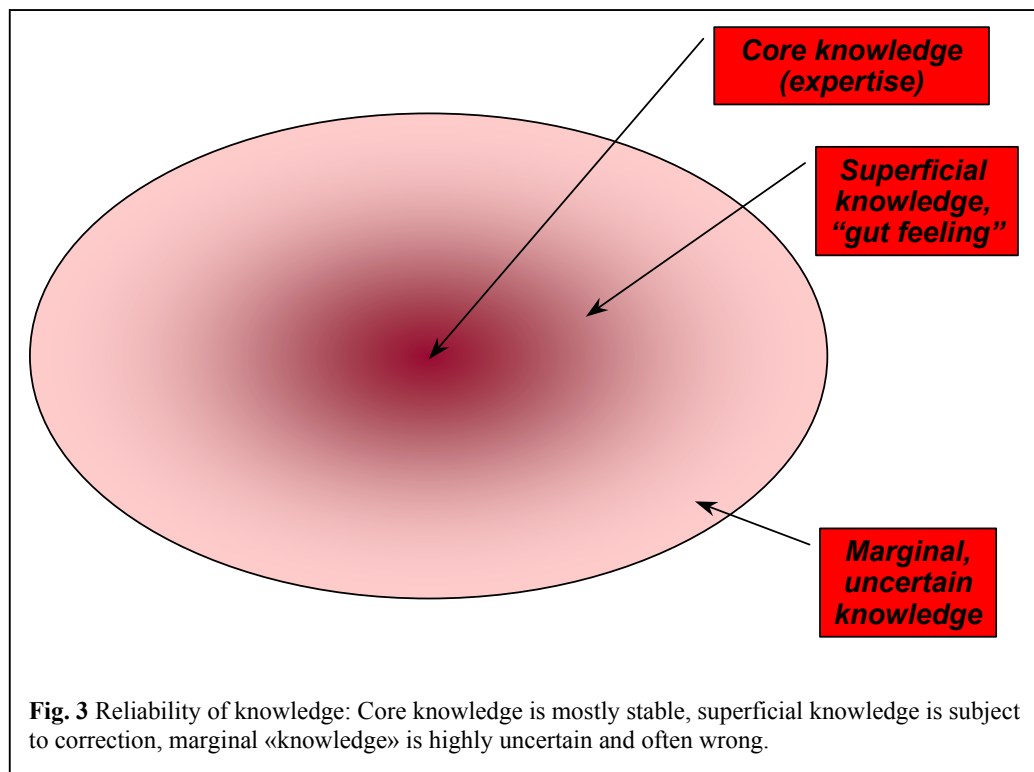
Cognitive flexibility theory focuses on the nature of learning in complex and ill-structured domains. Cognitive flexibility is «the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands...This is a function of both the way knowledge is represented (e.g., along multiple rather single conceptual dimensions) and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval).» (Spiro & Jehng, 1990, p. 165.)

Cognitive flexibility theory is a convenient paradigm to organize the proposed knowledge-elicitation method for fragmented knowledge because:

- One important goal for system dynamics, in general, and our study, in particular, is to promote organizational learning.
- Mental models belong to complex and ‘ill-structured’ knowledge domains.
- The transition from mental model(s) in individuals within the organization to an integrated system dynamics model is in a sense a construction of knowledge.

We will examine whether the proposed group modeling process leads to organizational learning. Organizational learning will be partly measured by the possible realignment of organizational structure following the model-building process.

Quality of Knowledge



Coming back to what kind of challenge is likely to be fruitful for learning theory in the 21st Century I propose that more attention is given to quality of human knowledge, arguably in the sense of how stable or reliable knowledge is with respect to

confrontation with new facts. Figure 3 is an admittedly very simplified metaphor of reliability of knowledge, or rather of reliability of mental information stored in individuals. Knowledge in members (employees) in an organization is continuously challenged by ongoing experiences. Core or expert knowledge is stable in the sense that it mostly proves useful to handle new challenges (but it grows and expands through learning). More superficial knowledge is much less stable – overturning of superficial knowledge by refuting facts is a prerequisite for the replacement of faulty knowledge by correct one, and ultimately for creation of expert knowledge. At the end of this continuum there is highly marginal and uncertain knowledge (i.e. mental contents that are likely to be disproved when confronted with facts). Improved quality of knowledge is, accordingly, the outcome of a scientific or quasi-scientific discovery learning. It is expected that organizational learning relates to improved quality of knowledge in that feedback from experience leads to better match between the individuals' knowledge and their functional role in the organization. Assuming that organizational learning to a large extent implies increased quality of preliminary knowledge might reconcile the clash between the tacit and implicit nature of the learning goals in the 'modeling as learning approach' (Lane, 1992) with Gagné's claim (1985) of the general need for explicitly stated learning goals and mechanisms to facilitate progress towards those goals. In other words, a possible explanation might be that employees in organizations have stable professional goals that act as learning goals (even if the learning objectives as such are implicit). Such stable professional goals would act as an 'enterprise' in the sense of Gagné & Merrill (1990).

Conclusions

We conclude that learning theory (and with it, instructional technology) can greatly benefit from impulses coming from organizational learning, and vice versa. The time seems propitious since organizational learning has got large momentum and popularity in private and public enterprises during the last decade.

As fruitful issues for research at the dawn of a new century we propose a closer study of the fragmentation and incompleteness of knowledge in organizations in relation to learning processes, arguably the growth in quality or reliability of individual knowledge and (quasi-)scientific discovery processes.

Finally, given that an essential part of individual learning is intended for professional life (i.e. for performance in some private or public organization) it is legitimate to ask to what extent content of school curricula, learning theory (or theories) and implementations thereof conform with such ultimate goal. Spector (2000b) argues that an identifiable landscape (context, perspectives, issues, methods, and values) is associated with instructional design. Key features of that landscape include assumptions about the nature of being a person and living in society. We suggest adding assumptions about ultimately becoming part of an organization and participating with one's fragmented knowledge together with others' fragmented knowledge in organizational learning.

References

Argyris, C. & Schön, D. (1978). *Organizational Learning*. Reading, MA: Addison-Wesley.

- Argyris, C.** (1982). *Reasoning, Learning and Action: Individual and Organizational*. San Francisco: Jossey-Bass.
- Argyris, C.** (1985). *Strategy, Change and Defensive Routines*. Boston, MA: Pitman.
- Breuer, K., Hillen, S. & Berences, K.** (2000). Readability of Glass-Box Models As Part of Learning Environments In Vocational And Economics Education. In P.I. Davidsen, D.N. Ford. & A.N. Mashayekhi (Eds), *Proceedings of the 18th International Conference of the System Dynamics Society*. Cambridge, MA: System Dynamics Society.
- Coyle, R.C.** (1996). *System Dynamics Modelling – A Practical Approach*. London: Chapman & Hall.
- Cyert, R.M. & March, J.G.** (1963). *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice Hall.
- Davidsen, P. I., & Spector, J. M.** (1997). Cognitive complexity in system dynamics based learning environments. In Y. Barlas, V. G. Diker, & S. Polat (Eds.), *Systems dynamics proceedings: Systems approach to learning and education in the 21st Century*. (Vol 2), 757-760. Istanbul: Bogaziçi University.
- de Geus, A.** (1997). *The Living Company*. Harvard Business School Press: Boston, MA.
- Dodgson, M.** (1991). Technology, Learning, Technology Strategy and Competitive Pressures. *British Journal of Management*, 2/3, 132-149.
- Dörner, D.** (1989). *Die Logik des Mißlingens*. Reinbek: Rowohlt.
- Dörner, D.** (1996). *The Logic Of Failure: Why Things Go Wrong And What We Can Do To Make Them Right*. 1st American ed. New York: Metropolitan Books.
- Dörner, D.** (1997). *The Logic of Failure*. 2nd American ed. Addison-Wesley..
- Fiol, C.M. & Lyles, M.** (1985). Organizational Learning. *Academy of Management Review*, 10:4, 803-813.
- Forrester, J.W.** (1971). *Principles of Systems*. Williston, VT: Pegasus Communications Inc.
- Gagné, R. M.** (1985). *The Conditions of Learning* (4th ed.). New York: Holt, Rinehart, and Winston.
- Gagné, R. M. & Merrill, D.M.** (1990). Integrative Goals for Instructional Design. *Educational Technology Research and Development*, 38(1), 23-40.
- Gonzalez, J.J. & Sawicka, A.** (2000). Fragmented Knowledge and Group Model Building. In P.I. Davidsen, D.N. Ford. & A.N. Mashayekhi (Eds), *Proceedings of the 18th International Conference of the System Dynamics Society*. Cambridge, MA: System Dynamics Society.
- Greenberger, M., Crenson, M.A. and Crissey, B.L.** (1976). *Models in the Policy Process: Public Decision Making in the Computer Era*. New York: Russell Sage Foundation.
- Hayek, F. A.** (1973). *Law, Legislation and Liberty. Vol. I. Rules and Order*. 1st ed. London: Routledge & Kegan.
- Lane, D.C.** (1992). *Modelling as Learning: A Consultancy Methodology for Enhancing Learning in Managements Teams*. In **Morecroft, J. D.W. and Sterman, J. D. Eds.** (1994). *Modeling for Learning Organizations*. Portland, OR: Productivity Press.
- Levinthal, D.A. & March, J.G.** (1988). A Model for Adaptive Organizational Search. In March, J.G. (ed.): *Decisions and Organizations*. Oxford: Blackwell, 187-218.
- Levinthal, D.A. & March, J.G.** (1993). The Myopia of Learning. *Strategic Management Journal*, 14, 95-112.

- Levitt, B. & March, J.G.** (1988). Organizational Learning. *Annual Review of Sociology*, 14, 319-340.
- March, J.G. & Olsen, J.P.** (1975). The Uncertainty of the Past: Organizational Learning under Ambiguity. *European Journal of Political Research*, 3, 147-171.
- Meadows, D.H. & Robinson, J.M.** (1985). *The Electronic Oracle: Computer Models and Social Decisions*. Chichester, UK: Wiley.
- Myrtveit, M.** (2000). Object Oriented Extensions to System Dynamics. *Proceedings of the International System Dynamics Society*. Cambridge, MA: System Dynamics Society.
- Read, L.E.** (1958). I, Pencil. *The Freeman*, 12, 33-37.
- Richardson G.P. & Pugh III, A.L.** (1981). *Introduction to System Dynamics Modeling*. Williston, VT: Pegasus Communications Inc.
- Senge, P.M.** (1990). The Leader's New Work: Building Learning Organizations. *Sloan Management Review*, Fall, 7-23.
- Senge, P. M.** (1992). *The Fifth Discipline – The Art & Practice of The Learning Organization*. (1st ed. 1990, New York, NY: Currency/Doubleday). London: Century Business.
- Spector, J. M.** (2000a). System Dynamics and Interactive Learning Environments: Lessons Learned and Implications for the Future. *Simulation and Gaming*, 31(3), 457-464.
- Spector, J. M.** (2000b). A Philosophy of Instructional Design for the 21st Century? *Journal of Structural Learning*, x, xxx-xxx. (in press)
- Spector, J. M. & Davidsen, P. I.** (1997). Creating engaging courseware using system dynamics. *Computers in Human Behavior*, 13(2), 127-155.
- Spector, J. M. & Davidsen, P. I.** (1998). Constructing learning environments using system dynamics. *Journal of Courseware Engineering*, 1, 5-12.
- Spector, J. M. & Davidsen, P. I.** (2000a). Cognitive Complexity in Decision Making and Policy Formulation: A System Dynamics Perspective. In R. Sanchez & A. Henee, *Selected Papers from the 4th International Conference on Competency Based Management*. (in press)
- Spector, J. M. & Davidsen, P. I.** (2000b). Designing Technology Enhanced Learning Environments. In B. Abbey (Ed.), *Instructional and Cognitive Impacts of Web-Based Education* (pp. 241-260). Hershey, PA: Idea Group Publ. (in press)
- Spiro, R.J. & Jehng, J.** (1990). Cognitive Flexibility and Hypertext: Theory and Technology for the Non-linear and Multidimensional Traversal of Complex Subject Matter. In D. Nix & R. Spiro (eds.), *Cognition, Education, and Multimedia*. Hillsdale, NJ: Erlbaum.
- Sterman, J. D.** (1988). *People express management flight simulator*. Cambridge, MA: Sloan School of Management.
- Sterman, J. D.** (1994). Learning in and about Complex Systems. *System Dynamics Review*, 10(2-3), 291-330.
- Sterman, J. D.** (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston, MA: Irwin McGraw-Hill.
- Vennix, J.A.M.** (1996). *Group Model Building: Facilitating Team Learning Using System Dynamics*. Chichester, UK: Wiley.