Advanced Learning Environments

(workshop at Unicamp)

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- ☞ **Learning**
- ☞ **Major trends in computer-based learning**
- ☞ **Essentials of new wave learning environments**
- ☞ **Other modern, but "light" approaches**
- ☞ **Conclusion: what does "advanced mean"**

1. Introduction: Some remarks about learning
1.1. The dynamics of research

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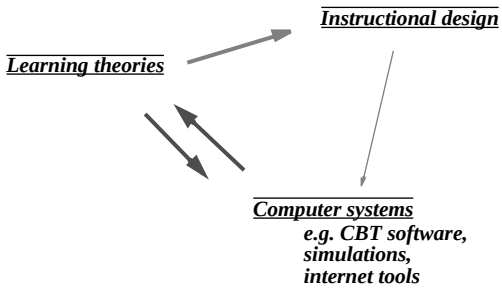

1. Introduction: Some remarks about learning
1.2. Major theoretical approaches

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- ☞ **Behaviorism**
  - **acquisition of behavior by reinforcement**
- ☞ **Constructivism**
  - **construction of action schemas (Piaget)**
  - **learning by doing / active learning (neo-Piaget)**
  - **building objects (Papert)**
- ☞ **Cognitivism**
  - **construction of mental representations**
- ☞ **The socio-cultural approach**
  - **internalization of language**
  - **proximal learning (Vygotsky)**
- ☞ **Situated, shared and distributed cognition**
  - **(see later)**

1. Introduction: Some remarks about learning
1.3. Is there a common denominator ?

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NO, but ..... :

- **One learns by *doing* something (psychology)**
- **One learns by pursuing an *instructional goal* (education)**

Learning as the Psychologists see it:

- **needs *external "conditioning"* (behaviorism);**
- **Is related to active *problem solving*;**
  - involves integration, construction and compilation of new content (cognitivism)
- **is constrained by *human cognitive capacities***
  - (e.g. how much hypertext can we handle?)$

Several kinds of learning:

e.g. Factual information, Concepts, Reasoning, Procedures, Problem Solving,...)

- ☞ **One does not learn by browsing, we need a variety of learning tasks (not just exploration)**
- ☞ **Some pedagogical guidance is needed (either by a teacher or by task/job requirements)**

1.4 The complexity of learning

A: Types of learning (according to Kearsley 1993):

- **Attitudes:**
  - Disposition or tendency to respond positively or negatively ....
- **Factual Information (Memorization):**
  - Processing of factual information and remembering .....
- **Concepts (Discrimination):**
  - Concept learning encompasses learning how to discriminate and categorize things
  - Concept formation is not related to simple recall, it must be constructed.
- **Reasoning (Inference, Deduction):**
  - thinking activities that involve making or testing inferences, closely related to problem-solving and creative behaviors".
- **Procedure Learning:**
  - .... being able to solve a certain task by applying a procedure.
- **Problem solving:**
  - .... involves the identification of subgoals and the use of methods (especially heuristics) to satisfy the subgoals.
- **Learning Strategies:**
  - .... can be learned to some extent only !
- **Sensory-Motor:**

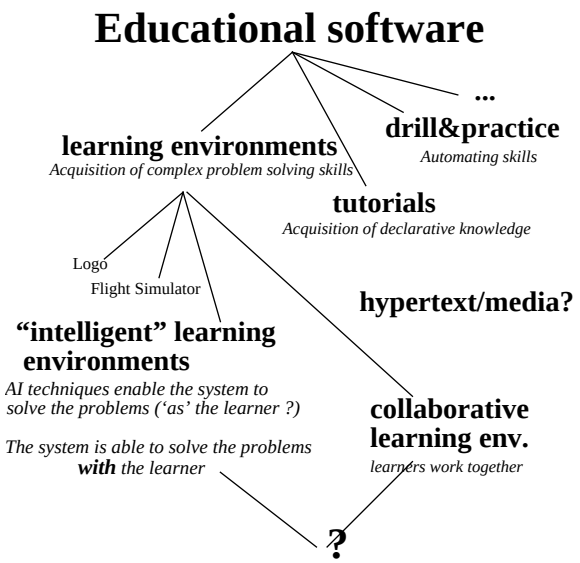
B: Cognitive task behaviors (Kearsley)

- **Searching for/receiving information (detects, observes, inspects, identifies, reads, surveys)**
- **Processing information (categorizes, calculates, codes, itemizes, tabulates, translates)**
- **Problem-solving (analyzes, formulates, estimates, plans)**
- **Decision-making (examines, chooses, compares, evaluates)**
- **Communication (advises, answers, directs, informs, instructs, requests, transmits)**
- **Sensory-motor processes (activates, adjusts, connects, regulates, tracks)**

☞ **By combining those two kinds of typologies one can imagine the "haystack" Instructional Design theory is faced with when trying to operationalize how to learn what.**

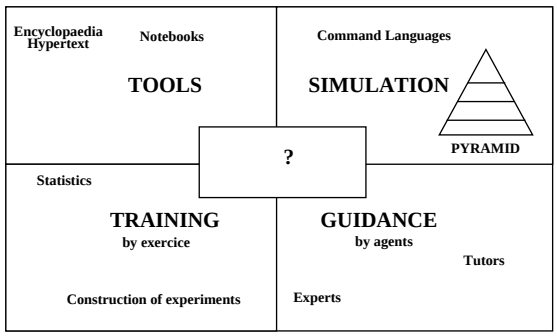
2. Major schools & trends in computer-based learning

2.1 Educational software (overview)

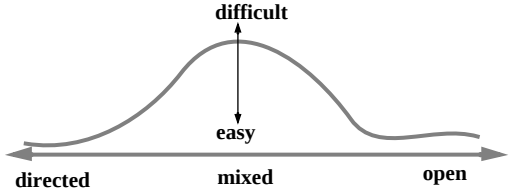


Systematic views:

4 modes of computational training:



3 political styles:

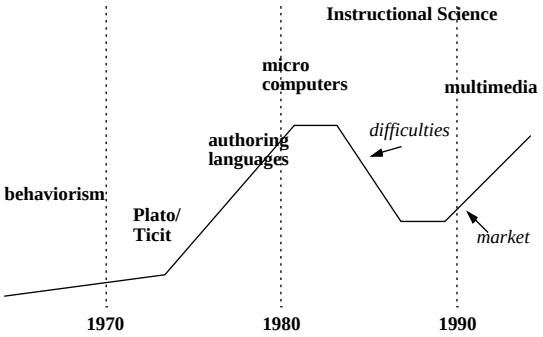


Linking (some) learning theories and systems designs

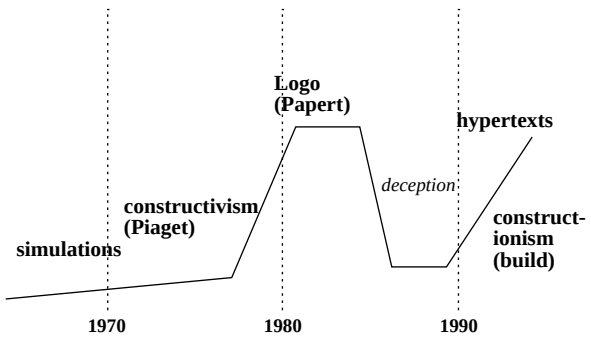
associationism	fractionned knowledge	Programmed instruction
guided learning	Schemas	Tutorials, educational games
constructivism	Schemes	Microworlds
expert - novice	rules, strategies	Intelligent tutors
semantic networks, memory	concepts, graphs	Hyper-documents
Problem solving help	representation and manipulation system	"Software tools"
Situated Learning	implicit and shared knowledge	networking
proximal learning	imitatio, language	CSCW/L tools

2.2 Trends

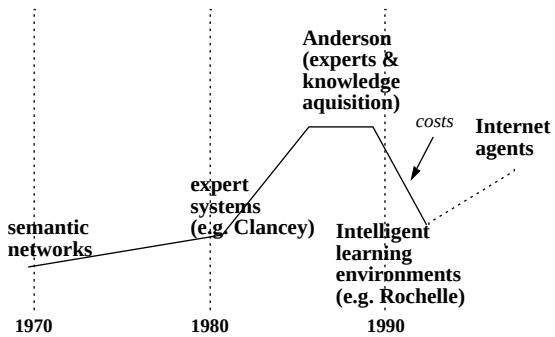
A: Computer-based training



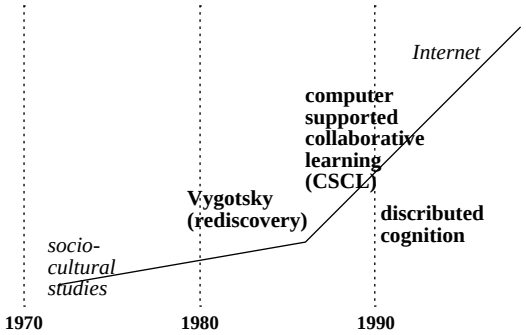
B: Micro-Worlds



C: Intelligent Tutoring Systems



D: Collaboration



3. The essential ingredients of "new wave" learning environments

3.1 The situated, shared and distributed cognition approaches

☞ **reacts against the "rational view" of cognitive sciences**
- **less planning, more opportunism (Suchman, Steels)**

☞ **reacts against the "mentalist vision" of cognitive sciences**
- **not everything is in the brain (Lave, Pea)**
- **mental representations do no exist (Clancey)**

☞ **insists that the environment is important**
- **addresses the transfer problem**
- **knowledge is contextual**

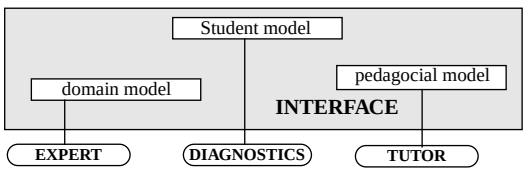
☞ **gives importance the social and cultural dimension**
- **learning = integration into a "community of practise" (Lave)**
- **several agents form a single "distributed cognitive system" (Hutchins)**

☞ **Supporting environments are being built on the Internet.**

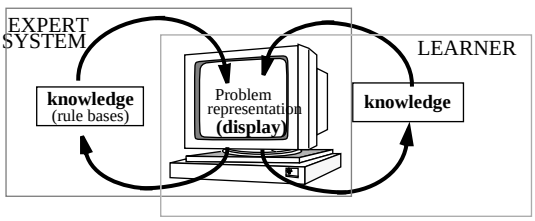
3.2 Intelligent Tutoring Systems and Environments

A: Intelligent Tutoring Systems

The "classical" ingredients:

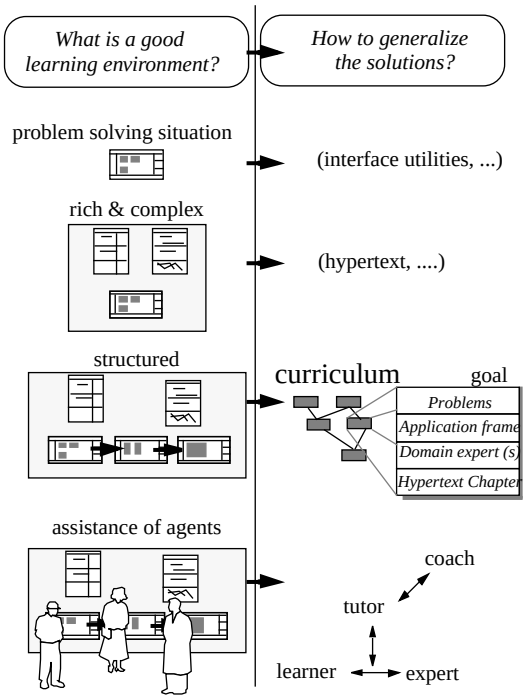


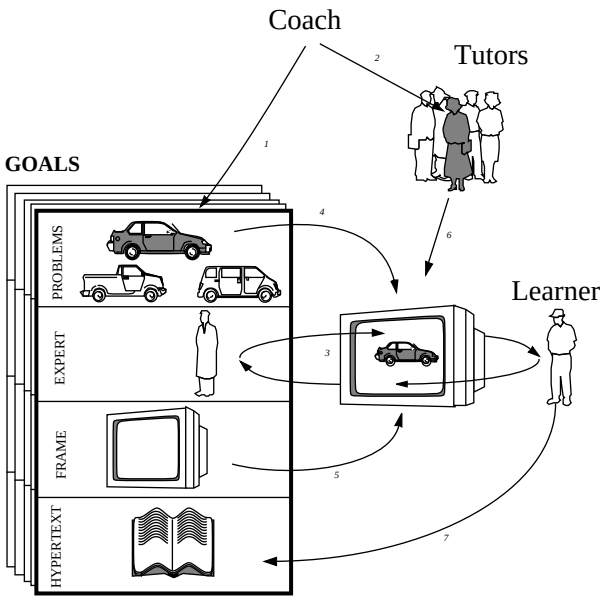
The typical ingredients of a simple learner-centered system:



The learner and the expert system share the problem:
IF the problem-state-display has feature X
THEN apply operator Y on problem-state-display

B: A more complex example: The ETOILE architecture





C: Where was the problem ?

- Intelligence is knowledge
- One can separate knowledge layers
  - knowledge / metaknowledge
  - deep / shallow
  - domain specific / domain independent ????
- An ILE needs a lot of domain knowledge
- It is difficult to encode explicit pedagogical knowledge
- Diagnose knowledge (modelling), not factors
- Student modelling is difficult
- Learner control does not often work
- An ILE needs multiple equivalent knowledge sets
  - domain viewpoints
  - teaching styles

D: Intelligent Learning Environments in simple talk:

The Learner must be active
- (again and always: people don't learn by browsing hypertext and by answering questions!)

A learning environment should be designed to be as powerful dedicated working environments.
- It must be rich and complex reflecting the essential properties of what has to be learned.

The environment must be structured.
- If the richness of a learning environment is a quality, its complexity may reduce learning.
- It must provide optimal learning conditions as a function of the learner's stage of knowledge.

Learning environments should be designed as hierarchical knowledge base generators
- ... tools for thinking !

Learning environments should present knowledge as a communication system.
- A learner must interact with agents, tutors, co-learners (real or artificial)

☞ **Such environments do not exist on Internet (yet)**
- The "artificial intelligence" part will be much less important than in traditional ITS systems

4. "Light" approaches of interest to Internet providers/users

4.1 Instructional Design

A: Example: Gagné's Theory

(1) Gain attention
- e.g. present a good problem, a new situation, use a multimedia advertisement.

(2) Describe the goal:
- e.g. describe the goal of a lesson (task,...), state what students will be able to accomplish and how they will be able to use the knowledge, give a demonstration if appropriate.

(3) Stimulate recall of prior knowledge
- e.g. remind the student of prior knowledge relevant to the current lesson (facts, rules, procedures or skills). Show how knowledge is connected, provide the student with a framework that helps learning and remembering. Tests can be included.

(4) Present the material to be learned
- e.g. text, graphics, simulations, figures, pictures, sound, etc. e.g. follow a consistent presentation style, chunking of information (avoid memory overload, recall information)

(5) Provide guidance for learning
- e.g. presentation of content is different from instructions on how to learn. Should be simpler and easier that content. Use of different channel.

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4.1. Instructional Design

(6) Elicit performance "practice"
- let the learner do something with the newly acquired behavior, practice skills or apply knowledge

(7) Provide informative feedback
- show correctness of the trainee's response, analyze learner's behavior (or let him do it), maybe present a good (step-by-step) solution of the problem

(8) Assess performance
- test if the lesson has been learned. also give sometimes general progress information

(9) Enhance retention and transfer:
- inform the learner about similar problem situations, provide additional practice. Put the learner in a transfer situation. Maybe let the learner review the lesson.

... other models exist

4. "Light" approaches of interest to Internet providers/

4.1. Instructional Design

B: A general "Courseware" view for Internet-based teaching:

Topics are:

- **Courseware = *optimize access* to edu "information"**
  - via an appropriate interface and structuring of the material
- **implementation of *instructional strategies*,**
  - i.e. sequencing of teaching materials
- **implementation of *instructional tactics*, e.g.:**
  - giving examples
  - multiple choice questions
  - asking the student to perform a task, etc.
  - telling what learning strategy to adopt with some material
- **Learning material contains *what has to be learned* in a very broad sense (e.g. knowing what, knowing how).**
  - It can be computational in various ways (exploratory hypertext, lesson & task oriented hypertext, simulation software, task solving environments, etc.)

☞ **Web potential: For teachers, the focus shifts from *"information transfer"* to *"organization of information access"* + *"organization of collaboration"*.**

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4.2. Resource based, active learning put simply:

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A constructionist approach (Kafai & Resnick)

Constructionism is both:
- a theory of learning and a strategy for education.
- Built on the "constructivist" theories of Jean Piaget

Central ideas:
- Knowledge is not simply transmitted from teacher to student, but actively constructed by the mind of the learner.
- Children don't get ideas; they make ideas.
- Constructionism suggests that learners are particularly likely to make new ideas when they are actively engaged:
  ==> in making some type of external artifact
  (a robot, a Lego tower a computer program...)
  ==> which they can reflect upon and share with others.

constructionism involves two intertwined types of construction:
- (1) the construction of knowledge
- (2) in the context of building personally and socially meaningful artifacts.

5. So what does "advanced" mean ?

5.1. At technological and conceptual levels (up to you

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5.1 At technological and conceptual levels (up to you !)

Fancy multimedia (Animation and 3D) instead of pictures

Interaction instead of presentation

Well structured presentation instead of simple manuals

Simulation instead of description of processes

Electronic tutors instead of simple feedback

Micro-worlds instead of simple exercises

Integration into practise instead of abstract learning

Authenticity ("anchored instruction")

Evaluation (make sure that transfer works, context)

Cognitive Tool

Design for conversation

Cognitive apprenticeship

Lifelong learning

Participatory design

.....

5. So what does "advanced" mean ?

5.2. Make sure that learners learn and can transfer !

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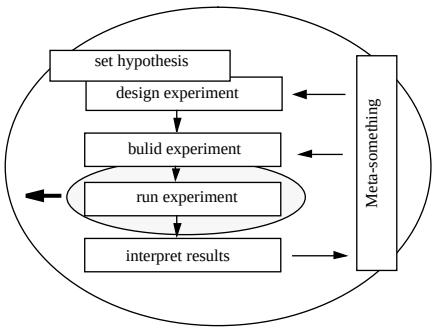
For example in simulations:

- Extend interaction to the whole process:

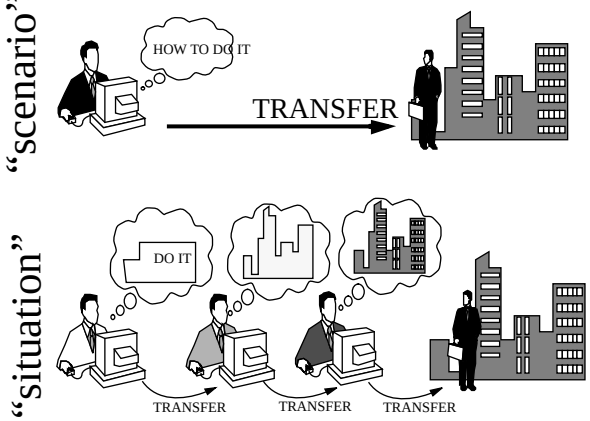


- Providing support may deteriorate learning (avoid the "video game effect")

5. So what does "advanced" mean ?

5.2. Make sure that learners learn and can transfer !

With a picture:



... involves among other things:

1. **Identification of problem's categories**
2. **Construction of specific contextual knowledge**
3. **Identification of new goals**
4. **Modification of view points on a situation**
5. **Extraction of general and abstract knowledge**

6. Advanced Learning Environments over the Internet

6.1. Case 1: Interactive multi-user learning

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6.1 Case 1: Interactive multi-user learning environments

More in the workshop on educational multi-user environments

6.2 Case 2: 3D Interactive Multimedia (VRML 2.0)

If you want I can teach you this !

6.3 Case 3: Intelligent Agents (again)

Next time !

7. Bibliography

6.3. Case 3: Intelligent Agents (again)

7. Bibliography

A: "Traditional CBT"

Merrill M.D & Li Z. (1989) An instructional Design Expert System. Journal of Computer-Based Instruction, Vol. 16, 3, pp. 95-101.

B: Intelligent tutoring systems and advanced learning environments

Anderson, J., Boyle, C., Farrell, R. & Reiser, B. (1987). "Cognitive principles in the design of computer tutors", in P. Morris (ed.), Modeling Cognition. NY: John Wiley.

Anderson, J.R (1984) Cognitive Psychology and Intelligent Tutoring. *Proceedings of the Cognitive Science Society Conference*, Boulder, Colorado, pp. 37-43.

Burton, R.T. (1982) Diagnosing bugs in a simple procedural skill. In Sleeman, D.H. and Brown J.S. (Eds) Intelligent Tutoring Systems. Academic Press, London

Clancey, W.J (1993) Guidon-Manage Revisited: A Socio-Technical Systems Approach. Journal of Artificial Intelligence in Education, vol. 4,1, pp. 5-30.

Collins, A and Brown, J. S. (1988) The Computer as a Tool for Learning through Reflection. in H. Mandl and A. Lesgold (Eds), Learning Issues for Intelligent Tutoring Systems. (pp. 1-18). New York: Springer Verlag.

Roschelle, J. (1990) Designing for Conversations. Paper presented at the AAAI Syymposium on Knowledge-Based Environments for Learning and Teaching, Standford,CA, March 90.

Roschelle, J. & Teasley S.D. (1995) The construction of shared knowledge in collaborative problem solving. In C.E. O'Malley (Ed), Computer-Supported Collaborative Learning. (pp. 69-197). Berlin: Springer-Verlag

Self, J.A. (1989) The case for formalising student models (and intelligent tutoring systems generally). Paper given at the 4th Conference on Artificial Intelligence and Education, Amsterdam, The Netherlands.

Terveen, L.G.. Wroblewski, D.A. & Tighe S.N. (1991) Intelligent Assistance through Collaborative Manipulation. Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI-91). pp. 9-14. Sidney, Australia.

C: Collaboration, communication and virtual environments, Situated action, shared and distributed cognition

Ackermann Edith (1994), "Direct and Mediated Experience: Their Role in Learning", in R. Lewis and P. Mendelsohn (eds.) Lessons from Learning, Amsterdam: North-Holland, (IFIP TC3/WG3.3 Working Conference 1993), 13-22.

Ackermann, Mark, S. (1994b). Augmenting the Organizational Memory: A Field Study of Answer

Garden. In Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW'94), pages 243-252

Bruckman, A. et Resnick, M. (1993). Virtual Professional Community: Results from the MediaMOO Project. In Third Internation Conference on Cyberspace, Austin, Texas

Clark, H.H., & Marshall, C.R. (1981) Definite reference and mutual understanding. in A.K. Joshi, B. L. Webber & I.A. Sag (Eds) Elements of discourse understanding (pp. 10-63). Cambridge: Cambridge University Press.

Clark, H.H., & Brennan S.E. (1991) Grounding in Communication. In L. Resnick, J. Levine & S. Teasley (Eds.), Perspectives on Socially Shared Cognition (127-149). Hyattsville, MD: American Psychological Association.

Dillenbourg, P., & Self, J.A. (1992) A computational approach to socially distributed cognition. European Journal of Psychology of Education, 3 (4), 353-372.

Dillenbourg, P., Mendelsohn P & Schneider D. (1994) The distribution of pedagogical roles in an intelligent learning environment. In B. Lewis and P. Mendelsohn (Eds) Lessons From Learning (pp. 199-216). Amsterdam: North-Holland (IFIP)

Dillenbourg, P. (to appear) Distributing cognition over brains and machines. In S.Vosniadou, E. De Corte, B. Glaser & H. Mandl (Eds), International Perspectives on the Psychological Foundations of Technology-Based Learning Environments. Hamburg: Springer-Verlag.

Farmer, F. R., Morningstar, C., et Crockford, D. (1994). From Habitat to Global Cyberspace. In Proceedings from CompCon '94. IEEE Computer Society.

Gay, G. et Lentini, M. (1995). Use of Communication Resources in a Networked Collaborative Design Environment. Journal of Computer-Mediated Communication, 1(1)

Harasim Linda, Hiltz, S.R., Teles, L., & Turoff, M. (1994), *Learning Networks: A Field Guide*. Cambridge: MIT Press.

Harasim Linda (1993), "Collaborating in Cyberspace: Using Computer Conferences as a Group Learning Environment", *Interactive Learning Environments*, 3, 119-130.

Hiltz, S.R. (1993), The Virtual Classroom, *Norwood*, NJ: Ablex.

Kafai, Yasmin & Resnick, Mitchel (1995). eds. Constructionism in Practice: Designing, Learning and Thiniking in a Digital World, Erlbaum.

Moyse, R. & Elsom-Cook, M. (1992) Knowledge Negotiation. London: Academic Press

Pea, R.D. (1993a) Learning scientific concepts throuhg material and social activities: conversational analysis meets conceptual change. Educational psychologist, 28 (3), pp. 265-277.

Pea, R.D. (1993b) Practices of distributed intelligence and designs for education. In G. Salomon (Ed) Distributed Cognition. Cambridge University Press, New York.

Resnick, L.B. (1991) Shared Cognition: Thinking as Social Practice. In L. Resnick, J. Levine and S. Teasley. Perspectives on Socially Shared Cognition (pp. 1-22). Hyattsville, MD: American Psychological Association.

Suchman L.A. (1987) Plans and Situated Actions. The problem of human-machine communication. Cambridge University Press. Cambridge.

D: Learning Theories and Instructional Design

Aronson, Dennis T., & Leslie J.Briggs, (1983). "Contributions of Gagné and Briggs to a Prescriptive Model of Instruction", in Reigeluth, C.M. (1983) (e.d). Instructional Design Theories and Models: An Overview of their Current Status. Hillsdale, NJ: Prentice-Hall.

Ausubel, D. (1963). The Psychology of Meaningful Verbal Learning. New York: Grune & Stratton.

Ausubel, D. (1968). Educational Psychology: A Cognitive View. New York: Holt, Rinehart & Winston.

Bruner, J. (1966). Toward a Theory of Instruction. Cambridge, MA: Harvard University Press

Butterworth, G. (1982) A brief account of the conflict between the individual & the social in models of cognitive growth. In G. Butterworth & P. Light (Eds) Social Cognition (pp. 3-16). Brighton, Sussex: Harvester Press.

Doise, W. & Mugny, G. (1984) The social development of the intellect. Oxford: Pergamon Press.

Gagné, R.M. (1987) (ed.) Instructional Technology: Foundations, Hillsdale: Lawrence Erlbaum.

Kearsley, G., Seidel, R. & Park, D.K. (1993). Theory Into Practice. A hypertext Database for Learning and Instruction, US Army Research Institute.

Merril, M.D. Richards, L (1983). "Component Display Theory", in Reigeluth, C.M. (1983) (e.d). Instructional Design Theories and Models: An Overview of their Current Status. Hillsdale, NJ: Prentice-Hall.

Sandberg, Jacobijn A., (1994) "Educational paradigms: issues and trends", in R. Lewis and P. Mendelsohn (eds.) Lessons from Learning, Amsterdam: North-Holland, (IFIP TC3/WG3.3 Working Conference 1993), 13-22.

Vygotsky, L.S. (1962) Thought and Language. Cambridge, Massachusetts: MIT Press.

Vygotsky, L.S. (1978) The Development of Higher Psychological Processes (edited by M.Cole, V. John-Steiner, S.Cribner and E. Souberman). Harvard University Press. Cambridge. Mass.

Wertsch, J. (1985) Adult-Child Interaction as a Source of Self-Regulation in Children. In R. Yussen (Ed). The growth of Reflection in Children (pp. 69-97). New York: Academic Press.

http://tecfa.unige.ch/tecfa/research/CMC/brazil97/intro.html