The explanatory interaction - history of a research

Abstract. The link between doing and knowing determines the blend between information, help and instruction. The education's instrumentation involves communication, cooperation, sharing and coordination tools. An optimal use of CSCW methods and instruments in instructional systems requires the understanding (modeling) of the explicative interaction. The co-action needs (remote) application sharing facilities and leads to expert-novice-computer triangulations- according to various and flexible "interaction modes" (for a "metamorphic" assistance). The bi-human character of explicative processes limits the simulation (automation) possibilities. To support resource and sense sharing, the computer network can provide "competence matching" services - based on semantic indexation. The procedures' models can be used as instruments for their coordination. I have explored orchestration mechanisms - based on knowledge and supporting its evolution - introducing "functions". I founded systems' physiology on these mechanisms, using them for managing the pedagogical resources "lifecycles" and the "system production cascades".

1 Introduction: between support and explanation

1.1 In order to do/know: communication, instrumentation, sharing, coordination

Throughout my experience as learner/teacher studying/presenting procedural chains (mathematical problems' solving, electronic devices' repair etc), I have perceived the intimate relationship between "doing to learn" and "learning to do"- which governs the experience-based learning. To accelerate this process, the procedures' didactic employs the "double command work": the expert does- demonstrating and the novice learns-doing at his indication (with his help, under his supervision). During many private mathematics lessons, I have experimented ways to climb the "know/do" spiral forming- with my students- expert/novice resolving tandems.

As a vocational trainer coordinating the instructional-informational-support system of a large electronics company (television sets, computers etc), I have noticed another consequence of the indissoluble link between doing and learning: the blending, in the "assistance" concept, of: information, explanation, facilitation, instruction. In some situations, "informing" was enough - to deliver an opportune and intelligible message. When the understanding effort met difficulties- "clarifications" were required. If necessary, the beneficiary was helped to "learn" the information- in order to be able to reuse it anytime. In the place of explicative messages (what is to be done, how, with what instruments)- new tools can be provided ("equipment") or the use of the existent ones can be "facilitated". The advanced "support" systems allow the combination of these possibilities, the choice being adapted to the users' needs.

When I approached the research about instruction instrumentation, I wasn't surprised of the intense use of CSCW methods and tools for the management of the pedagogical activities or for that of the collateral ones (knowledge management, resource production and diffusion, system organization etc.). Like other collective activities, instruction needs tools for message communication (synchronous and asynchronous), resource and sense sharing, cooperation and coordination (in conception, execution or management activities).

The presumption of most CSCW tools is the postural symmetry between the actors using them: two executors of a procedure's plan, two conceivers editing such a plan, two students studying cooperatively that procedure, two managers supervising it. Situations such as: "X makes an object that Y uses" or "X helps (instruct) Y to do a operation" - are rather designated by terms like "assistance" or "interaction" than by "cooperation". They can however be (and often are) modeled (managed, instrumented) as cooperative procedures, involving different "roles". Going into the execution's details for such a procedural chain (workflow)- the operations are distributed (allocated) to the appropriate actors. Refined arrangements allow choosing (tuning) the "floor-control" - that governs the concurrent access for each operation.

In the case of explicative cooperation (interaction) (problem to which I have dedicated a long-standing study), the manner of which every elementary action sharing (between the assisted novice and the assisting expert) is done - constitutes the pedagogical strategy of the respective co-operation, calling for refined and flexible mechanisms of initiative division. At a superior granularity level (of the complete pedagogical procedures' management) we seek the optimal distribution of execution and assistance roles. Finally, even at the global level of the instruction system, specific problems can appear (for instance: "With what strategies and tools should we equip the technologists A and methodologists B, that wish to provide composition and management methods and instruments to a public of authors C and managers D, that organize instructional systems, in which a group of assistants E can instruct a group of learners F so that they obtain an amelioration G of their competences in the knowledge domain H, necessary to reach the performances I in the contexts J- the entire chain being optimized according to criteria K, verifiable by the methods L".)

The optimal application of CSCW methods and tools in instructional systems (approached in CSCL) requires adaptations (specializations), which, in their turn, impose a better understanding (modeling) of the *explicative interaction*. The phenomenon's models can orientate the construction of specialized support tools or highlight the physiology of the existent ones use. Furthermore, some models, properly prepared, can orchestrate the (re)production of the collaborative procedures which they represent, becoming an instrument for the (explicative) cooperation mediation.

1.2 Modeling explanation- the history of a study

I approached the study of educative cooperation in a double hypostasis: as a teacher- trying to understand the strategies of efficient didactics and as engineer- trying to optimize the instruction's instrumentation. After many years of practice, meditation and lab experiences (that I will refer to in chapter 2), I have reached the conclusion that the concept of *explanation* facilitates the fusion between "instruction" and "assistance" and that the foundation of the "instructive-productive procedures' management"- should be a unitary theory of explicative processes- including material and cognitive aspects.

In my PhD thesis [1], I have tried to conceive a model for the (instrumented) explanation phenomena, one that would integrate the multitude of involved aspects, coagulating the observations extracted from a multitude of domains (psychology and cognitive sciences, communication and information sciences, semiotics and multimedia, logics and epistemology, sciences of education, computer telecommunications, theory of negotiation and decision, etc)- each having its own primitives, epistemology, language, paradigms, experience, rituals, models and priorities. The problem complexity forced me to resign myself to elaborate partial models (morphological and physiological), to structure a "map of my perplexity" and to enounce principles that have subsequently guided my research

From those, the observation that "explanation" is based on the cognitive consonance lived by a human pair- is crucial. Synchronous or asynchronous, sonorous, textual or graphical, direct or remote, realized through communication, sharing or co-operation - the explicative relationship between an "expert" and a "novice" is essentially a bipolar phenomenon, based on the collaboration between two decision centers, involved simultaneously, jointly, asymmetrically. The explicative relationship exploits the physical interaction through objects and the innate or cultivated human communication capacities (language etc.)

In the same way a cell's metabolism coexists and interferes with the metabolism of the organism it belongs to, the individual cognitive metabolism is "situated" in that of the community. Communication can be seen as a relationship between two distinct cognitive systems, but also as a manifestation of the cognitive physiology of the human species' system, ensuring knowledge reproduction. Phenomenology reveals the unity of the (observed object / observing subject) pair. We can extend this vision to take into account the shared character of knowledge, including, in a single whole, the represented subject, the representing symbol and the human pair communicating on the subject, through the representation. Thus, we obtain a systemic meaning of "knowledge", realizing that its physiology is based on cooperation.

It is important to observe the dualities: structure/process, existence/transformation, adaptation/evolution, ontogenesis/phylogenesis. The physical and conceptual entities, tied by relationships, create systemic units and determine their behavior (physiology). Conversely, the physical and cognitive processes sediment structures (entities and relations). A complete systemic vision must reveal the existence-becoming duality. The procedures' modeling must express the essence of "structures-in process", decomposing the procedure structurally (in *persons*- the actions' executants and their assistants and *objects*- to be produced or used) and processually (in *operations*- the actions executed or planned). Combining the structural and processual approaches, we obtain the decomposition in interlaced "threads" (roles).

1.3 The modeling of (explicative) procedures as instrument of their reproduction

I have deepened the study of procedure modeling (see par. 3) by analyzing the problem of transforming MOT (an editor for the management of procedural knowledge, pedagogical scenarios and resource diffusion plans [2])- towards a collaborative editor for cooperative procedures' orchestration scenarios. I have proposed initially the ADISA system (Distributed Workbench for Learning Systems Engineering - according to the MISA method- as a compromise for combining the MOT editor with the EXPLORA (a virtual campus management platform) course manager [3]. Then, working on the Explora2, SavoirNet and TELOS architectures [4,5] I compared their pedagogical workflow (learnflow) modeling formulas with similar developments coming from CSCW (or CSCL)- analyzing the inter-operability problem sustained by norms like EML or IMS-LD [6]. In order to deepen the research about the physiology of the ensemble formed by the procedural reality and its orchestrating model, I have piloted the prototypal development of a "function manager" (GEFO- [7]). This instrument was then used and refined in the context of the LORNET project, founding a prototype that has illustrated the behavior proposed for the TELOS system [8].

My approach emphasis on the observation of cycles such as: 1. **Modeling.** A primary procedural phenomenon P is observed (imagined) by designers, which edit its model. 2 **Reproduction.** The phenomenon P is reproduced in a number of secondary phenomena S, through "executions" of the model- which can mean: 2a The model is used as an explicative guide, inspiring the actions' sequencing. 2b The participants declare and produce exploration data, which the model memorizes or uses for reactions (verifications, support etc). 2c The model is used as an interface, for launching and controlling some resources, facilitating their manipulation and their procedural aggregation. 2d In the case of cooperative use, the model mediates the participants' communication and coordination (floor-control, signaling, etc) 2e If it is semantically indexed, the model can provide retrieval, selection and alerting services, sustaining the run-time concretization of the components (matching role) **3 Meta-modeling.** Observing (imagining) the primary process (1) of the model's edition (or the P-1-2-S chain of procedure reproduction), process engineers can edit meta-models, in order to explain or support the modeling process **4 Meta-reproduction.** Using meta-functions (in the a,b,c,d,e sense), the primary process 1 of a model edition can be reproduced (with variations) in secondary editing processes 1S- generating functions, usable in the 2-S chain.

Therefore, when the instructional phenomenon's "model" is used as a cooperation instrument by its participants, the reality and the model form a global system, whose physiology deserve being understood, modeled and optimized. The representation of the meta-process of reproducing procedures by modeling them and using these models to create more or less similar phenomena (procedure "phylogenesis")- is the key of GEFO prototype's use in the management of the TELOS system.

The desire to understand explicative cooperation led me to its modeling. Using the phenomenon's models for its reproduction, I have transformed them, from passive mirrors of cooperation, into instrument of it. The circle was closed, fructuously.

2 Aspects of explicative cooperation

I have accompanied the theoretical efforts of condensing the observations about the explicative particularities of communication, co-working, sharing and coordination with compartmental studies achieved with lab prototypes. I will succinctly expose the goal, the context and the conclusions of these experiences.

2.1 Explicative communication

Becoming aware very early (by my involvement as pupil in experiments and discussions on the modernization of mathematics' initiation), I have been attentive at my "education" process. I have then searched, as teacher, the key to efficient explicative discourses, concentrating my attention on the sense and logic of explanation, interested by its didactical and epistemological dimension. I discovered [1,9] the distinction between "demonstrations" and "explanations"- which include the rhetoric of the communicational act. My PhD studies in education drew my attention to other dimensions - such as learner's psychology- or developmental, cultural and social aspects. But the main goal of the experiences performed, between 1994 and 1996, within GRAEMI and HERON labs framework (the "Metamorphic Multimedia", "Stereo-presentation", "Meta-demonstration", "Triple controlled explanation" projects) was the study of the explicative messages' composition (on various types of media) and of their perception processes (exploration, comprehension)- forming the asynchronous communication chain.

The investigation paths (that determined me to explore domains like human communication, semiotics, cognitive science, diagrammatic reasoning, multimedia, computer mediated-communication, human-computer interface, ergonomics) were: 1 The manifestation of explanation's bipolarity - even in the case of asynchronous or mono-directional communication. 2 The functioning of the serialization-recombining process, allowing the progressive explanation of a conceptual structure, through a discourse. 4 The expressiveness of narrative/graphical/metaphorical representations. 5 The didactics of watching schemes in parallel with the direct observation of the structures and procedures that they model (and with textual and sonorous explanations). 6 Procedures coordination through task graphs. 7 Meta-demonstration management (explaining the behavior of demonstrative chains). 8 The organization of information on multiple tracks- forming a discursive bundle - and the management of the (cooperative) "stereo-explanation's" exploration so that: the windows distribution could be modified at any time without loosing the coherence of the discourse disseminated in them; the directing of the users' attention for optimal reception be facilitated; the synchronicity of the explicative threads be maintained.

I deepened these researches in ulterior projects. In the context of a WEB design course I demonstrated the realization of the same "virtual shop" in six different techniques, using the stereo-explanation formula (the ShopTutor project). The discourse was organized on multiple tracks: P1: the explorable shop, P2: source pages, P3: developers' comments, P4: architecture schemes etc. The advance on the track chosen as "master" (the application-shop, for instance) produced the "slave" tracks' synchronization (the sources involved in the current operation, the corresponding bloc in the schema, the appropriate comments etc). For comparisons, the demonstrated technique could be switched at any time.

Shifting my interest from the semantics of explanation to its semiotics, I was attracted by the understanding of the conceiving/perceiving representations processes. Noting the "learning environments'" aspirations towards "interactivity" and "adaptability", perceiving the difference between: the autonomous use of my prototypes, their presentation by me and their use by someone else with my assistance- I have understood that the problem of facilitating co-operation (central to explanation by co-execution) also shows up in the communicational relationship. Therefore, I have concentrated my attention on it.

2.2 Explicative co-operation

On the occasion of a piloting course for sport (2-seats) airplanes, I passed through the following initiation ritual. At the first flight, the instructor, seated on the front place, flew alone, allowing me to accustom with the sensation. The next flight, he began to explain me his actions, allowing me in the same time to feel the double-command hand levers that equipped the airplane. On the next flights, he asked to me to interpose in handlings' execution. Then he progressively got out of the bi-action, intervening (verbally or gesturally) only to correct me. Finally, I was flying alone. The transfer had taken place. This episode has revealed to me the bipolar essence of explicative consonance, which constitutes the basis of my interest for the computer's use as interface for expert-novice relationship.

2.2.1 Co-action ("pas de deux")

The explanation of a procedure can consist in sharing the action: the expert E does because he knows, the novice N knows progressively- because he is helped to do. It isn't just about concatenating two operations, because the "pas de deux" execution draws its sense from the processes fusion. We can focalize our attention on a "teach process"- correlated with a "learn process" - but the complete phenomenon is a "learnteach". The organic unity of demonstrative cooperation may be noticed thinking to the difference between the following situations: 1 E executes; N observes (spies), knowing that E does not know that he is observed. 2 E executes; N spies, thinking that he is not observed, but E knows he is observed and consequently adopts a strategy (acts as usual, acts better to facilitate comprehension or make a good impression, falsifies, etc). 3 E executes, knowing that N observes, but not knowing that this one has realized he is observed. 4 E executes, knowing that N, that observes him, is aware that E knows that he is observed. 5 E presents a procedure, after an agreement with N on the role and mechanism of its demonstration.

Trying to formalize these nuances, I have obtained sophisticated formulas (models)- even after having operated many simplifications. In the model exposed in figure 1a, I have represented the interfering sub-systems of the procedures executed by the novice N and by the expert E. The novice operator (N) establishes an evolutionary semantic connection with a subject (S), by manipulating a target object

(C) through the interfaces (In and Ic) and the link (Lnc), having a direct relationship (reception (3), emission (1) or bi-directional (2)) with his assistant E or collaborating with him through a support tool O. His interface (In) connects him with the other components. He can discuss with his assistant, consult the documentation (when O is a support document), work on a secondary target (when O is a simulation tool), follow E's demonstrative movements towards the target C or the support tool O.

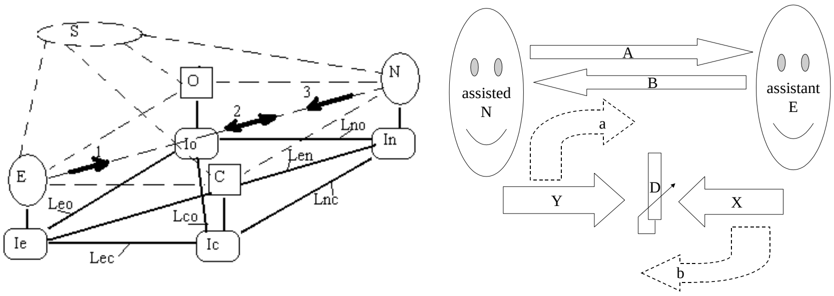

Figure 1 a: A model for co-action; b: Decisional modes

In order to support the "computer supported cooperative explanation", the "shared application" type tools should be enriched, so that the two partners split the same task, in a bundled way and with the best reciprocal visibility. The consequences of explicative bipolarity are manifested even in the case of asynchronous cooperation. Maneuvering the demonstrative object prepared by an author, the user devirtualizes the explanation incorporated in it, in the limits of the conceiver's mandate. Combining asynchronous co-operation (using a simulator) with synchronous co-operation (with a coach, working in tandem with the novice or assisting the simulator's use)- the explicative possibilities are amplified. Such behaviors require rich communication structures and a fine control sharing of the application for which we explain the operation. The immersion in the other's adventure requires the observation of his external gestures and of his reasoning- exposed on explicative tracks, correlated with the principal one (of the cooperative work). The flexible management of these "discursive threads" requires mechanisms for negotiating the handlings, the initiatives and the communication modalities.

2.2.2 Interaction mode and metamorphosis

In the "Metamorphic multimedia" and "Meta-demonstration" projects, I have concentrated my attention on the "interaction mode" between the partners of a co-demonstration. I was searching for a structural characterization of the prepared demonstration, as well as a behavioral characterization of its actual progress. In the theoretical model of the computer-assisted demonstration [1], I have joined in the "explicative mode" the elements determining the cooperation's physiology (communication channels and forms, floor control rules, resource sharing and initiative negotiation protocols) - separating them from the explanation semantics. A "mode" shows up at a certain time during an explanation, or can be planned for one of its stages. I wanted to establish an "alphabet" of possible rituals for elementary actions/decisions, in order to be able to define, on its base, cooperation formulaspropagated throughout the demonstration (homogenously used modes) and protocols for their change. (I have called " metamorphosis"- the transition form one assistance formula to another, without leaving the ongoing operations' chain).

The modeling proved to be difficult, because the decisions shared in teacher-learner or instrument-learner pairs (that I joined in the "assistant-assisted" syntagm) can have multiple forms of manifestation, even in the case of an elementary action, like pressing a button! In figure 1b, I have signaled the elements that can influence the equilibrium of a decision D: X and Y- represent the two direct intervention lines on the adjustment forming the decision's object; A and B- the explicit messages changed in the decision taking (modification requests, proposals, questions or answers); a and b- information obtained through the observation of the other's actions.

We can find cases like: **1 D=X.** The assistant (expert E) decides the continuation by following the logics of his discourse without taking into account the assisted's (novice N) opinion **2 D=X(a).** The assistant decides, observing the learner (his last gestures, his global evolution). **3 D=X(A).** The decision is preceded by a request explicitly formulated by the assisted. **4 D=X(a,A).** The assistant decides, considering his observations and his partner's requests. **5 D=X(A(B)).** The assistant decides, taking into consideration his partner's suggestion (A), that responds to his question (B)- signaling the need for a decision. **6 D=X(A(B(a)), a).** The dialogue on the intervention is produced and accompanied by the observation of the assisted. **7 D=Y or D=Y(b).** The assisted decides the change according to his needs and observations. **8 D=Y (B) or D=Y(B, b) or D=Y(B(a)).** The assisted decides (eventually observing E actions (b)) after having received a change proposition B(a)- eventually produced by the observation of E **9 D=Y(B(A)) or D=Y(B(A, a)) or D=Y(B(A),b).** The assisted's initiative (A) (eventually followed by the observation a of his actions) produces the assistant's reaction (B,b) that helps the assisted to take decisions. The dialog preceding the intervention can pass by several loops. **10. D=[X Y].** The two partners can co-participate in exclusive manner (any one of them, the intervention being irreversible), sequentially (one at a time, but one's action being modifiable by the other) or simultaneously (the "stronger" decides, or the result is a compromise). **11. D=XY (a,b); D=XY(A); D=XY (B); D=XY(A(B)); D=XY(A,B) etc.**

The facility / facilitation of mode changes (management) depends on the flexibility of the demonstrative system's topology. When the two partners directly cooperate and synchronize themselves simultaneously, the change of the "initiative formula" is done fluidly, the expert-novice couple being able to continuously negotiate the interventions, respecting or changing the cooperation protocol agreed initially. If the two actors do not work simultaneously (together), the synchronization of decisions gets harder, even when a computer is used as intermediary. The author must embed a participation mandate in the demonstrative object, for the negotiation of the initiative during the object use, which seriously complicates the composition.

2.2.3 Triangulation (through the computer)

The multi-actor explicative relationship can intervene in situations like: cooperation between users learning a collaborative procedure, assistants recommending or facilitating the use of certain "pedagogical resources", relation between the conceivers of an interactive application, the computer "agents" representing them towards the users and support persons that intervene when the agents can't face to the assistance task. These interesting solutions raise redoubtable modeling, management and instrumentation problems. (The analysis of the "polygonal" interaction modes, decision protocols and metamorphic processes has led me to veritable combinational labyrinths...). The exploitation of the educative potential of co-driving a car or combining the principal, second and automatic plane's pilots interventions- requires a better collaboration between the domains studying the "microscopy" of the (co)action, decision and initiative (CSCW, DSS, negotiation theory, AI) and those viewing "macroscopically" the systems behavior or the pedagogical relationship.

In the "Triple controlled explanation" project, I took advantage of the distance control facilities (in an "AppleTalk" network) of certain applications ("HyperCard" among others) with the support of "AppleScript". The commands to the computer A were able to produce orders, sent to the computer B- that executed the consequent actions. Inspiring myself from the literature on the "awareness" in "shared windows", I have tested various stratagems for communicating the demonstrative gestures. By using, on my coupled interfaces, personages representing actors (the "avatars" technique- widely used in games and cooperative virtual reality), I succeeded in offering a common image of the shared world to the partners of the demonstration replicated between two computers. The expert, the novice and the agents mandated by the author could indicate and press buttons, communicate, make annotations, modify the presentation windows' structure and negotiate intervention rights. They had a broad area of possibilities (see also par. 2.2.2) for sharing decisions as: Who decides the transition towards a new action/step? Who observes, get information, remembers, thinks and deduces what should be done? Who enounces and explains the proposed action? Who intervenes to validate or contradict it? Who has the right to make the executing gesture? Who has the right to validate or reject it? Who can make comments, during or after the action? It was not easy to extract, from all the possible combinations, those significant for a usable ritual or used at a precise point of the demonstration, structuring spaces of situations like: "the teacher decides the continuation; the computer makes suggestions; the learner acts; the teacher validates and comments"; "the learner asks for the continuation; the computer recommends; the learner solicits expert mediation, this one being unavailable, the computer memorize the question", etc...

Technical complications augmented the methodological and principle problems. Despite of the remarkable developments accomplished in application and component sharing and remote control (DCOM, CORBA etc) - we do not dispose yet of a computer networked infrastructure *dedicated to bi-action*. To allow the combination of (distributed) asynchronous and synchronous collaboration in the explanation of computer applications I have proposed [10] a universal "glass window" (transparent)- placed between the applications and their users. This intermediate layer (wrapping, interface) would allow the interception of the user actions trough the application, the gathering of the message to transmit to the partner, the mix of your own commands and annotations with the tele-commands and messages coming from the other- in conformity with the current communication and co-action protocols.

The interfaces' variability (organization, dimension, resolutions etc), the delays and losses due to network congestion make "bitmap sharing" solutions harder to apply.

Portability limitations between platforms reduce reproducibility (application range) and increase the costs of "replicated architecture" solutions. Pushed to compromises and particularizations in my projects (for instance, the cooperative browsing solution adopted in TaxiNet was confronted to problems characteristic to the sharing of client-server applications- like the different addresses and accounts of the involved partners- and was based on the particularities of the http protocol), I have deplored the absence of "bi-computers" (systems conceived to be manipulated in double- command by co-localized or distributed pairs), specifying a virtual instrument called "NOVEX" (allusion to the NOVice - EXpert couple to which it would be dedicated) [1].

2.2.4 Limits in simulating the intelligent initiative

As co-action and communication partner, the human assistant (appropriate, available and good-willed) has intrinsic qualities - difficult to mechanize. The posture of information "emitter" is multipliable (through the diffusion of the conceiver's "message"), but that of the learner "listener" or interactive partner- much harder. The assistants' "artificialisation" is problematic - practically and ethically. The trainer art is to drive the learner on the "royal ways" of comprehension. Establishing the presentation order - is the finest part of the didactical expertise. The teacher (author) continuously takes refined decisions to engender his discourse. It is difficult (impossible?) to program an algorithm for taking these decisions. We should not be interested by letting combinatorial hazard establish the educational sequence... Mechanical concatenation of "modules" in "courses" and "programs"- pretending being adapted to the user- can not compete with the quality of discourses- that intensely rely on explicative relationships between the message parts. The "reproductive" realizations, seeking "efficiency" - can lower the quality of education and must be used circumspectly and with good reasons.

That is why I have delimitate myself from the orientation of the SAFARI project, in which I had involved myself (with the "Meta-demonstrator" project)- to deepen the issue of managing initiative between human and artificial agents. Noticing that the project was aiming at equipping computers with teachers more than equipping teachers with computers, I exposed my reserves towards the omission of the teachers (the tendency to substitute them). I reiterated these observations through my interventions to the ITS'96 congress- that has determined me to quit the research of pedagogical artificial intelligence for exploring the computer's potential as human assistant in the intelligent management of explicative processes.

For the efficient adaptation of explanation, following rather the developments in "parallel processing", "distributed systems", "situated action", "social cognition", "intelligent agents" than the ITS paradigms (in vogue at that time), I orientated myself towards the distribution of intelligence between human and artificial agents. Instead of degrading the explicative dipole, the synaptic infrastructure based on the computer network can provide contact, contract and management services. Activity coordination systems elaborated in CSCW (CSCL), could be enriched with matching facilities so that they facilitate the retrieval and the selection of the participants which can perform (optimize) the ongoing operations' chain.

2.3 Resource and knowledge sharing

Explicative cooperation can consist in sharing documentary resources (and, implicitly, the meanings that these documents clarify). The organization of the information (knowledge) bases is an approach complementary to the discursive act. A knowledge structure has an explicative potential that each exploration materializes. Information search is an interrogative discourse, alternating with lecture stages, to compose an exploration phenomenon. I have approached, between 1996 and 1999, in the TaxiNet project, the problems of organizing documentary systems, studying the indexation and reference processes and the physiology of information transactions through the Internet. The TaxiNet "dispatchers" should facilitate immediate or programmed connection between Internet guides and their clients, based of various mechanisms for treating (matching) support requests and offers. Afterwards, they should sustain cooperative navigation sessions or chains of asynchronous documentary cooperation.

My participation (between 1999 and 2003) in projects as: ADISA [3], Explora [4], MOT [2], ION (a distributed resource controller and aggregator), Edusource (an inter-operation system for pedagogical resource repositories) has allowed me to continue my study of the composition and use of pedagogical resources. Additionally, in these projects, I was confronted to the organization of production and diffusion processes [2] and with the management of resource repositories based on metadata records, respecting inter-operability norms.

I was able to fructify the preoccupations mentioned in this research story, about the semantics and physiology of explanation, as conceptual architect of TELOS (tele-learning operating system). The LORNET project: "learning object repository network" (launched in 2003 and lasting until 2008) seeks the technical and semantic inter-operation between Canadian educational service sources and resource repositories accessible through the Internet. I have defined TELOS' conceptual architecture [5] so that it sustains the modeling and management of distributed instruction activities: from the emergent ones (searching human and material support resources and chaining operations freely) to the orchestrated ones (through rigid or adaptable scenarios).

With this aim, I provided the "indexation" of all elements: potential participants P (persons, groups, categories, agents), documentary resources D, generic actors A and instruments I specified in the activity scenarios- relative to "knowledge domains" K, used as reference systems [11]. The various forms of knowledge's representations and consequently of the indexing and retrieval processes (classification, relational structures, dictionaries, hypertexts, declarative languages, graphs etc) have, all, their qualities. The best potential of automatic inference (assistance) is obtained when the reference system is organized according to a "computer-comprehensible" logic - hence the interest for ontologies.

In a support (instruction) system, the evolution of the subjects' understanding and the contributions to this evolution must be observed. We can use "*competences*" C (qualitative and quantitative descriptions of someone's position relative to knowledge): "mastering levels"- measured on a scale M or "abilities" *(knowledge/ comprehension/ application / analysis/ synthesis / evaluation)*. In order to observe the competence equilibrium around pedagogical operations, I have introduced [12] the "postures": (*knowK, aimK, explainK(x,y), describeK(x,y), evaluateK(x,y), recommendK(x,y)*)- where the parenthesis show a predicate depending on the detained (x) or aimed (y) "mastering level" of the person (learner etc) to which the expert could explain (describe in a document, evaluate, recommend) the knowledge k.

When users prefer the freedom to order (emergently) the operation sequence (resource conception, adaptation, retrieval, use etc), the system offers them retrieval instruments for finding the appropriate resources (support tools and persons, previously "published" in the resources repositories): semantically pertinent, administratively available, and technically operable. But in other situations, instead of loosing time to find resources and chain operations, users can rely on "aggregates" edited by an author at a previous stage [13]: "collections" (sets of resources, equipped with management interfaces, "fusions"- unitary systems composed from interdependent components, "operations"- aggregating an action, its executor, support actors and support or target resources, "functions"- procedural aggregations, with resources declared or connected to the operations decomposing the modeled activity.

2.4 Explicative orchestration

Thus, I have reached the form of explicative cooperation that reunites communication, co-action, sense and resource sharing: the collaborative procedure coordination (orchestration). I will present (as coherent solution to the bundle of problems approached throughout the research related in this paper) the way in which the "functions", managed with the GEFO prototype [7] can serve for procedure modeling, orchestration and reproduction (see also par 1.3).

2.4.1 Function use in procedure orchestration

The model of a procedure uses representations for the components reflected in its "mirror": actors (hexagons) - which can designate generic participant categories or specified persons, instruments (rectangles) - which can designate concrete resources or generic classes, operations (ovals) - designating particular or generic processes, realized or to be realized. Some procedures are dedicated to a single actor, their purpose being to order actions and connect resources; others can negotiate the "flow-control" between the elements that intervene concurrently in an operation; others can manage complex scores for "man-machine orchestras"- combining connection, ordering and coordination.

To assist, present or teach a procedure - the simple model of the operation chain can be useful. The participant consulting the model can look for appropriate support resources and persons, the assistance having not been planned in the model. The involved support persons can assist him in using the model. The *pedagogical management of a procedure* is a flexible solution, but it can create organization difficulties (finding support etc). *The management of pedagogical procedures* supposes the explicit representation in the procedure model of the support actors and instruments, reducing the freedom of choosing them, but assuring the conformance to the didactical intentions of the model's author. Leaving certain concretization choices, this one can specify the knowledge required by the operation, the competence profiles required for the actors, the "competence leap" covered by the support document.

Some models can represent *resource lifecycle chains*: the edition of a new type (class) of resource - by an author, the concretization of resource instances, adapted to different contexts- by an administrator, the retrieval and use- by various participants, the analysis of use data- by observers making recommendations and launching feed-back reactions. The composition cycle can continue, aggregating more and more complex objects. The models of the procedures can support their binding (aggregation) in "*production cascades*".

2.4.2 Lifecycle mode and its management

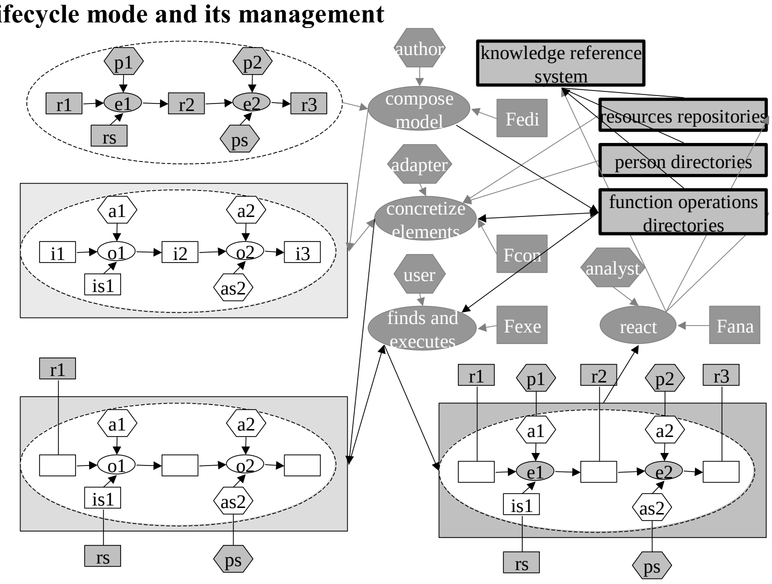

Figure 2 Function lifecycle

1 Edition. A real procedure is observed by an author, that conceives a model based on it, using a "function editor". The operations and elements (actors and instruments) are declared abstractly, allowing liberties for further concretizations, in the limits specified by the author. **2 Concretization.** The administrators can choose the appropriate components from the system repositories (indexed on a knowledge reference system) or just restrict the selection criteria for the connectable elements An arborescence of increasingly particular "derivate" models can be obtained this way, leading eventually to "contracts" (allowing only the liberty of changing the potential users) or even to a "scheduling model" (fixing all participants). **3 Retrieval** The functions are indexed and published in a repository, becoming retrievable- as any resource **4 Execution.** Is accomplished (taking advantage of the assistance facilities incorporated: guiding, supervising, manipulating, coordinating, matching etc) according to the scheduling, or after free function instance retrieval. In the case of

adaptable instances, the participants can still concretize support elements at run-time, just before the operations' execution. The execution's results (data, annotations, traces, produced resources)- are put aside. **5 Reaction.** Is based on the result analysis and can include the modification of competence profiles and resource's indexation or even the re-organization of the knowledge reference system.
The meta-procedure exposed above can also be treated in GEFO- as a metafunction. That offers us the possibility to define and manage the "life mode" of a function. We can, for instance, establish (observe, coordinate) modes as: the editor only fixes the topology of the implied operations, leaving the right to fix resources to the administrator, and to find support partners- to the executor. Or: the editor fixes the support resources; the administrator allocates participants to an instance etc.

2.4.3 Matching for adapting components concretization

Throughout the functions' lifecycle - according to the "life mode"- the components' concretization may be piloted by the observation of the "competence conditions".
Actors' and instruments' concretization and selection. The executor actors E, the assistant actors A and the generic documentary instruments D) that appear in the operations' models have competence pair characterizations (c1-detained, c2-to obtain), analogue to those of the participants e/a (or documentary resources d), that will concretize them. That allows the use of selection criteria as c1(e,k)>=c1(E,k) (the sense of the order relationship depending on the chosen competence structure).
Orchestrated operations and global procedure indexing If all the elements of an operation have been specified (connected) – with the exception of its "executor" e– we are dealing with an assistance "contract", placed in the "prepared activities" directory, waiting for its client. The global indexation of such an aggregate is similar to that used for other support resources: the competence levels required (C1) and obtained (C2) for/through the execution of the activity "O" are signaled. But the concrete users e having the level c1 (instead of C1) and the intentions c2, the actual execution "o" transform them cognitively (trough e' states), acting like an operator changing the c1 level in L(c1) (witch can differ from C2 and c2 , the presumptions about the lesson's effect having only a statistical value).
Internal indexation of operations and progressive concretization. We can optimize (assist) the selection for the connected persons and documents, in any phase of the concretization chain- if we watch the operation's internal competence equilibrium. These facilities are created by the use of the same knowledge reference systems for the indexation of actors (persons), operations (activities) and instruments (documents) and by the definition of competences by postures (see 2.3). The rules (equations) that intervene depend on: the procedure's "topology" (Toeda – operation, executer, support document, assistant, Toea, Toed, Toe, etc.), the concretization order (for instance: first d(o), then a(o,d) and finally e(o,a,d)) and the assistance strategy. As we can see in figure 3, each concretization modifies the maneuver space of the subsequent particularizations, as in a state machine.
For example [14], for an operation O requiring a competence level C, instantiated in an execution o by a learner having a competence c, with the support of an assistant capable to sustain (c1, c2) leaps and by a document capable to sustain (c3, c4)

evolutions, we can observe situations as: *(c1<=c<C<=c2* or *c3<=c<C<=c4*)- any support component is sufficient or (*c1<c<c3<c2<C<=c4)* – the assistant can lead the executor in the document's efficiency range

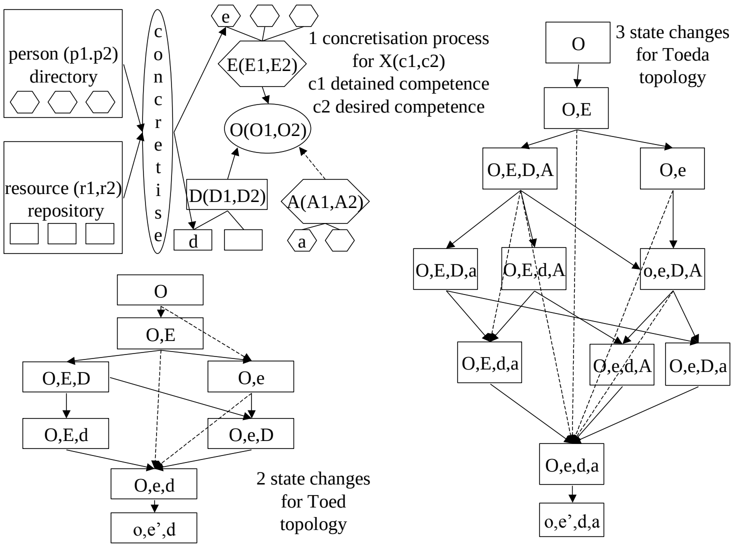

Figure 3 Progressive concretization state machine

Semantic services for an adaptable model. The mechanisms suggested above are useful in the model preparation phase. They can also intervene in the execution phase, if concretization liberties have been allowed. "Semantic services" are realized by optimization agents supporting at run-time the selection of connectable resources and persons, launching useful alerts, matching automatically etc.

3 Conclusion: from support to meta-support

I have applied the functions technique of modeling and coordinating the resource lifecycles for the description, demonstration, and management of the system operations forming the global TELOS physiology (main production cascade): 1. The construction of an authoring system (LKMS - learning and knowledge management system) with the instrument toolkit available in the TELOS core 2 Its particularization for various beneficiaries 3 Its use in the construction of application scenarios (LKMA - learning and knowledge management application) 4 The instructional use of these LKMA, producing living-knowledge modification (learning), the change of a knowledge representation, and eventually some objects (LKMP- learning and knowledge management products). Furthermore, the cooperative research in LORNET was described and could have been managed through specific functions.

The observation of the interaction between the model of a cooperative procedure (used as an instrument in an actual procedure execution) and the involved actors- with the help of metafunctions- can have multiple applications: theoretical (understanding the global physiology of knowledge based systems, the combination between planning and emergence, the behavior of complex support systems) and practical (facilitating the engineering of facilitation systems).

I am tempted to refine some projects (Internet use assistance centers, infrastructure for "free-wave knowledge propagation " etc) or to attack others, like the organization of a development environment that would combine work cooperation with instruction of the trainees involved in a project, facilitating the recovery of the development process - as an emancipate form of reengineering). But before opening new tracks, I will have to return to the passion of synthesizing a satisfactory model for the explanation process.

References

1. Rosca, I.: Towards a systemic vision of the explanation process; the story of a research on integrating pedagogy, engineering and modeling- PhD thesis, http://www.ioanrosca.com/educatie/these, (1999)
2. Paquette,G., Rosca, I: Modeling the delivery physiology of distributed learning systems. Technology, Instruction, Cognition and Learning (TICL), v1, No2, (2003)
3. Paquette, G., Rosca, I., De la Teja,I., Léonard, M., Lundgren-Cayrol, K.: Web-based Support for the Instructional Engineering of E-learning Systems, Proceedings of WebNet'2001, Orlando FL, October, W. Fowler, J. Hasebrook (eds.) pp. 981-987.(2001)
4. Paquette,G, Rosca, I: EXPLORA2, An open educational operating system for managing learning objects repositories CANARIE Workshop, Deuxième Atelier national canadien sur le cyberapprentissage, Montréal, 25-26 février (2002)
5. Rosca, I., Paquette, G., Mihaila, S., Masmoudi, A.: "TELOS, a service-oriented framework to support learning and knowledge Management" E-Learning Networked Environments and Architectures: a Knowledge Processing Perspective, S. Pierre (Ed), Springer (2006- in press)
6. Marino,O., Paquette,G., Rosca, I., De la Teja, I., Leonard, M., Contamine,J. Rogozan,D., *Pedagogical* modeling languages: a bridge between educational engineering and online information systems. 72e congress AGFAS, (2004)
7. Rosca, I., Rosca, V., GEFO- demonstration of pedagogical orchestration principles, Research reports, published at www.ioanrosca.com/education/gefo (2003)
8. Rosca, I., Paquette, G.: TELOS research progress, LOR'04 Towards the educational semantic web, Vo1, No4, Dec, http://www.lornet.org/eng/infolornet_vol1_no4.htm#a35 (2004)
9 Rosca I, Observations about mathematical teaching in Romania, license thesis, (1990)
10 Rosca I, A. Morin, *May we rediscover the dialog between teacher and learner in the processes of computer based instruction?*, Acfas congress, Montreal,(1996)
11 Paquette,G , Rosca, I: An Ontology-based Referencing of Actors, Operations and Resources in eLearning Systems SW-EL, (2004)
12 Rosca, I.: Semantic indexation and knowledge propagation, Hermes, (2006- in press)
13 Rosca, I., Paquette, G.: Organic Aggregation of Knowledge Objects in Educational Systems, Canadian Journal of Learning Technologies, Volume 28-3, pp. 11-26 (2002)
14 Rosca, I.: Knowledge management instrumentation for a community of practice on the semantic Web, http://pedagogie.ac-montpellier.fr/Disciplines/maths/REF_2005/REF-Rosca.pdf Symposium REF-2005, Montpellier (2005)

Note: My paper exposes the story of more than 20 years of research. Due to the interdisciplinary and long-lasting character of this research a usual bibliography would take to much space. The annexed page attached above is an example of a pertinent partial bibliography (to which I could have referred to in my text)- extracted from the vast bibliography structured and commented in my PhD thesis about the explanatory cooperation.

Annexe: Extract from the bibliography of my thesis about explanatory cooperation

"Bernsen, N.; Dybkjaer, H.; Dybkjaer, L., Cooperativity in human-machine and human-human spoken dialogue, *Discourse Processes*. 21(2), 213-236, 1996.[] Borden, G. A., *Human communication systems*, 2 ed., American Press, Boston, Massachusetts.[] Cawsey, A., *Explanation and Interaction: The Computer Generation of explanatory dialogues*, The MIT Press, Cambridge, Massachusetts, p232, 1992.[] Dalal, N. P., The design of joint cognitive systems: the effect of cognitive coupling on performance, *Int. J. Human-Computer Studies*, 40, 677-702, 1994. [] Green, A. K., Interacting cognitive subsystems: a framework for considering the relationships between performance and knowledge representations, *Interacting with Computers*, 6 (1), 61-85. 1994. []Knapp, M. ed., *Handbook of intrepersonal communication*, second edition, SAGE Publications,1993. [] Petrilli, S., Dialogism and interpretation in the study of signs, *Semiotica*, 103-116, 1993. [] Raver, C. C.; Leadbeater, B. J., The problem of the other in research on theory of mind and social development, *Human Development*, 36, 350-362, 1993. [] Smith, R. B., What You See Is What I Think You See, *Sigcue Outlook*, 21 (3), 18-23, 1992. [] Stewart.J, *Language as articulate contact – toward a post-semiotic philosophy of communication* , State University of New York Press, 1995.[] Walther, J.,Computer-mediated communication- impersonal, interpersonal, and perpersonal interaction,. *Communication Research*, 23(1), 3-43, 1996.[] Wilmot, W. W., *Dyadic communication*, Addison-Wesley publishing coompany , second edition [] Zhang, J.; Norman, D. A., Representations in distributed cognitive tasks, *Cognitive Science*, 18, 87-122, 1994.[] Batson, T., Finding value in CSCL, *Sigcue Outlook*, 21 (3), 26-29, 1992. [] Berlage, T.; Genau, A., A framework for shared applications with a replicated architecture in *ACM* '93, Proceedings of UIST '93, 249-257, 1993. [] Bowers, J.; Rodden, T., Exploding the interface: experiences of a CSCW Network in *INTERCHI* '93, 255-262, 1993.[] Carver, N.; Lesser, V., Evolution of blackboard control architectures, *Expert Systems With Applications,* 7, 1-30, 1994. [] Dommel, H. P.; Garcia-Luna-Aceves, J. J., Floor control for multimedia conferencing and collaboration, *MultiMedia*, 5 (1), 23-38, 1997. [] Dourish, P.; Bellotti, V., Awareness and coordination in shared workspaces in *CSCW* '92, 107-114, 1992.[] Hatcher, M., A tool kit for multimedia supported group/organizational decision systems (MSGDS), *Decision Support Systems,* 15, 211-217, 1995. [] McKinlay, A.; Procter, R.; Masting, O.; Woodburn, R.; Arnott, J., Studies of turn-taking in computer-mediated communications, *Interacting with Computers*, 6 (2), 151-171, 1994.[] Nyerges, T.; Moore, T.; Montejano, R.; Compton , M., Developing and using interaction coding systems for studying groupware use, *Human-Computer Interaction*. 13(2), 127-165, 1998.[]Ponta, D.; Scapolla, A.., Tematics for Education: the Design of a Distributed Computer-Based Collaborative Learning System, in Educational Telecommunications '96, P. Carlson (eds), AACE, Boston, 252-257 1996 []Ramsay, J.; Barabesi, A.; Preece, J., Informal communication is about sharing objects in media, *Interacting with Computers*, 8 (3), 277-283, 1996. [] Riexinger, D.; Fehr, C., Applications sharing based on bitmap exchange in *IEEE* '95, 76-85, 1995. [] Rodden, T.; Blair, G. S., Distributed systems support for computer supported cooperative work, *Computer Communications*, 15 (8), 527-537, 1992. [] Miyahara, K. ; Okamoto, T., Collaborative information filtering in cooperative communities, *Journal of Computer Assisted Learning,* 14(2), 100-109, 1998 [] Rose DE.; Bornstein JJ., Information rendezvous, *Interacting with computers,*10(2),213,1998.[] Tiffeneau, D., *La sémantique de l'action*, Editions du Centre National de la Recherche Scientifique, Paris, p136, 1977. [] Twidale, M.; Nichols, D., Designing interfaces to support collaboration in information retrieval, *Interacting with computers,*10(2),177-193,1998.[] Wellman MP.; Durfee EH.; Birmingham WP., The digital library as a comunity of information agents, *IEEE Intelligent Systems & Their Applications,*11(3), 10-11, Jun 1996.[] Frick, T., Artificial tutoring systems – what computers can and can know, *Journal of Educational Computing Research*, 16(2),107-124, 1997.[] Gaiti, D., Introducing intelligence in distributed systems management, *Computer Communications*, 17 (10), 729-737, 1994.[] Petrie, C. J., Agent-based enineering, the web, and intelligence, *IEEE Intelligent Systems & Their Applications*, 11(6), 24-29, 1996. []Terveen, L.; Hill, W.; Amento, B.; McDonald, D., A system for sharing recommendations,*Communications of the ACM*, 40 (3), 59-62,1997.[]"