Learning Path and Assessment Criteria in the Conception and Development of an e-course based on the PENTHA ID Model

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***Abstract*— The teleology of our research is to propose a solution to the request of "innovative, creative teaching", proposing a methodology to educate creative Students in a society characterized by multiple reference points and hyper dynamic knowledge, continuously subject to reviews and discussions. We apply a multi-prospective Instructional Design Model (PENTHA ID Model), defined and developed by our research group, which adopts a hybrid pedagogical approach, consisting of elements of didactical connectivism intertwined with aspects of social constructivism and enactivism.**

The contribution proposes an e-course structure and approach, applying the theoretical design principles of the above mentioned ID Model, describing methods, techniques, technologies and assessment criteria for the definition of lesson modes in an e-course.

***Index Terms*— Instructional System Design, Intelligent Tutoring Systems, Knowledge Management, Connectivism, Enactivism**

I. Introduction

In our research we apply a multi-prospective Instructional Design model, defined PENTHA ID Model (acronym of *Personalization, Environment, Network, Tutoring, Hypermedia, Activity*), which is inspired by the more universal *complexity theory*: it focuses on dynamic relationships and patterns among subjects ("complex agents") in the learning process, rather than the static properties of isolated objects. The approach is according to a *didactical connectivism* [13], intertwined with aspects of *social constructivism* and *enactivism*

The main crucial elements of the Model are [2] [3] [4]:

a) considering learning as the result of a complex network with numerous typologies of nodes and connections of knowledge, competences, communication, representations, relationships, technologies and multi-paradigms, where:

- the knowledge is dynamic and emerges in a simultaneous and intertwining manner at multiple levels (not only at the individual level), based on reflection, expressive creativity and design, realization of artifacts and projects, dedicated searches, research and analysis in a personalized educational approach
- new and unexpected knowledge is the result of participants interactions from their different points of view: they continuously and actively re-orient their structures in order to maintain coherence in the relation to their worlds
- the student curriculum is a fluid, interactive and unpredictable process, oriented towards the expansion of knowledge spaces mental representations
- the learning design is the result of a co-action between the Student and the Teacher/Tutor

b) considering the perspective to realize an enactive, autopoietic and collaborative learning approach:

- from a teaching centered-, to a Student centered learning approach
- from push mode teaching to pull mode learning
- from a goal oriented -, to a creative approach
- from a problem solving to a problem posing strategy
- from an abstract, symbolic and universal view of the learning process, to a historical and contextualized view
- from a centralized -, to a distributed didactic approach
- from hierarchical to flexible, non linear communication
- from performance based -, to action based learning
- from program regulated -, to strategy regulated teaching

c) a focus on the creation of a **"***Student Relationship Management* "(SRM), where Students:

- are driven and motivated to continuous learning and become protagonists of choices in their learning path (*"fidelity" effect*);
- can behave as learning *stakeholders*, collaborating through pro-active interactions (*personalized learning effect*), to overcome learning difficulties, able to achieve their own cognitive excellence**;**
- can change perspective in their study, present a feedback on their "expectations", generating a relationship between Student and discipline, and research data value (*"Studenting*" *effect*).

This requirement is satisfied by focusing on the Student profile, and guiding the Student to decision making processes about his/her own personalized learning path[1].

d) an *automation* of several aspects of the design process, execution, assessment and tutoring, to interpret and manage the reticular nature of knowledge [10]

e) supplying the Authors of e-Content with *didactical guidelines* for the definition / creation of :

- *parameters* describing the didactical module (extended metadata, profiles etc.)
- *logical action rules*, associated with the didactical module
- *rules for relations* between actions and content
- *rules for adaptation, individualization* and *personalization* of the subject matter (e-course)
- *tutoring rules* for the cognitive tutoring system

f) considering the decision-making itself as a learning process. Choosing what to learn and the meaning of incoming information seen through the lens of a shifting reality [13].

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[1] An important consideration is the measurement of the Student satisfaction per se, but also in relation to the satisfaction level of the "class entity".

g) an attention for different "plans" in the *decisional process* of the Teacher or the involved Student concerning:

- *how* do decision makers (Students or Student Groups, Teacher or Teacher Team) *reason* (descriptive plan) ?
- *how should* they *reason* (prescriptive plan)?
- *what* type of reasoning *motivate* the decisional action in terms of its *efficacy and efficiency* ("social" plan)?
- *what* type of reasoning is *recognizable* (communicative plan) ?
- what are *the conditions* implying a guaranteed "order" in a process, against networking and learning "chaos"?
- how can the Decision Managers/ Students be supported in their *learning choices and "learning path"?*
- *h*ow can Teachers/Authors of an e-course and Tutors be supported in their *decisional choices and "teaching design and teaching path"*?

The Model considers that a paradigm shift from Teacher-centered to Student-centered learning requests a complex didactical screenplay (scenario): a macro project (about operation modes), a micro project (about e-content and e-tivity [2] types) and scripts of activity sequences (Fig.1).

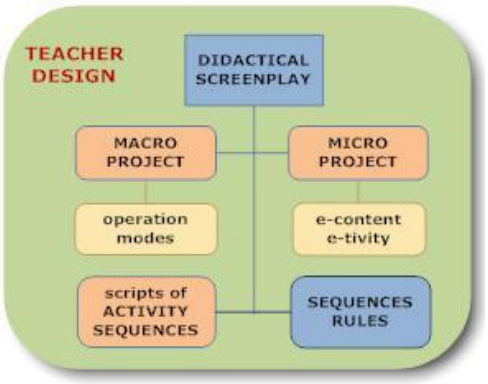

Figure 1 – The Teacher Design

In the PENTHA Model perspective, the need for an automation of several aspects of the design process, execution, assessment and tutoring, can interpret and manage the reticular nature of knowledge [10].

Following we describe the proposed didactical planning, several specific lesson modes, assessment factors and criteria for an e-course according to the concept. This allows to define the main tools, roles and functions to structure a Dynamic Intelligent Learning Environment.

II. The Didactical Planning

In the PENTHA concept, the planning can be defined as hybrid, versatile and re-designable. It suggests to start from the context and "logical sense" for the Student ("integrated background principle"), to amplify the known perspectives with new problematic questions or situations. Subsequently it would branch and at same time allow the realization of a spiral paths, using, in a fractal mode, a holistic vision and "knowledge blocks" (curriculum, course units and modules, learning episodes) in a network of actions and meanings.

In particular, we suggest the following "gradual" *didactical steps* :

1° step: *Direct instruction* - Teacher-focused. It includes methods such as lecture, didactical questioning, explicit teaching, practice, drill, and demonstrations. It is effective for providing initial basic information.

2° step: *Indirect instruction* - Primarily learner-centred. Using an interpretive method, it requests the Students to determine the significance of the information presented. Inquiry, induction, problem solving, decision making, collaborative/ competitive actions and discovery are key terms. The role of the teacher shifts from lecturer / leader to facilitator, supporter, and resource person.

3° step: *Experiential learning* - Inductive, learner-centred, and activity oriented. Personalized reflections about an experience and the formulation of plans to apply learning to other contexts are critical factors in effective experiential learning. The emphasis on experiential learning is on the process of learning, and not on the content.

4° step: *Independent learning and actions* - Independent study encourages Students to take responsibility for planning and pacing their own learning path. Has implications for responsible decision-making, as individuals are expected to analyze problems, reflect, make decisions and take focused actions. During this step, free shared knowledge actions are empowered.

The duration of each mentioned step depends on the pedagogic or andragogic level (instruction, competences, expertise, autonomy, etc.) and the personal didactical approach of the Teacher.

III. Standard Lesson Modes according to the PENTHA ID Model

This section explains some of the standard lesson modes, which, in PENTHA Model perspective, would guarantee the application of a hybrid approach, intended as a combination of connectivism, socio-constructivism and enactivism (see Fig. 2).

For the general evaluation criteria see the section IV.

A. Community online session

It debates on specific topics of study materials to consult and study before starting the learning session, provided by the Teacher (enriched or extended by the Student during the course). Mediation is realized by the Teacher, with possible external Subject Matter Experts. In these sessions, brainstorming (for comparison, creativity and collective problem posing) and social discussions (for the problem posing and comparison of opinions and perspectives) are activated.

B. Community Tutoring

During this session, a Learning Entity can request e-tutoring at any time, posing questions (about content, methodology, instructions, etc.) where the answer is valid and available for everybody. In this context *cooperation / collaboration modes* (for mutual support and sharing of resources) are activated.

[2] "E-tivity" is a framework to create an online *active learning* and i*nteractive*.

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C. Personal Tutoring

A Learning Entity can request e-tutoring at any time, posing personal questions (about the personal learning path, any other course related question)

The PENTHA Model suggests to apply the following Tutoring Modes [2]:

- *Modelling*, where the Teacher demonstrates how to perform a task
- *Coaching*, where the Teacher actively supports the Students, while teaching, motivating, analyzing the Students performance, provide feedback, reflection concerning assignments to stimulate discussion about the method adopted
- *Scaffolding*, which favours the adaptation of the learning path taken, a reflection on the actions developed by the Student stimulated by the Teacher
- *Fading*, a method for adjusting and adapting the learning path according to the achievements of the Student until the proof of his positive capability in full autonomy
- *Narrating*, for teaching- and learning aspects: a) the basic idea of the teaching aspect is to introduce a topic to attract the attention of Students, the appreciation of different learning styles and different forms of intelligence; b) the basic idea of the learning aspect is to encourage the Students to verbalize their experiences
- *Reflecting*, pushing the Students to compare own difficulties with an Expert / Tutor and encourages them to perform pull actions. Reflection is the vehicle for critical analysis, problem-solving, synthesizing of opposing ideas, evaluation, identifying patterns and creating meanings
- *Exploring*, which force the Students to solve problems with new or alternative solutions. The construction of knowledge occurs through the observation and the transformation of experience.

The PENTHA Model is in accordance with Tuckman's Model, which defines a guide for teachers, to provide a connectivist environment by concentrating on the network rather than on the content.

It identify four main topics:

- *forming* (topic introduction)
- *storming* (effective communication, conflict resolution)
- *norming* (high performing, effective behaviors)
- *performing* (motivation and attitude)

It is conceptually similar to the idea of Wenger's Community of Practice, except that connectivism provide a more unbounded, distributed and chaotic structure (the debate between connective and collectives). It is conceptually similar to the idea of Wenger's Community of Practice, except that connectivism provide a more unbounded, distributed and chaotic structure (the debate between connective and collectives). Among other modes, guided problem solving should be activated.

D. Cognitive Tutoring

The expert system and the associated Knowledge base should suggest links, knowledge contents (through predefined reusable learning objects), monitor and supervise the learning behaviors, suggest actions to be taken (through established rules) [9]. In summary, an e-Tutor, on today's state of research, should be able to [3], [10]:

- recognize and update the profile of the Student and domain specifications
- monitor the status of each Student's knowledge in real time and tailor course material for each Student, based on continuous assessments
- provide immediate feedback on errors, associating suggestions to the Student (just-in-time, automatic hint-/help or upon the Learner's request) and has the ability to propose an adaptation of the actual learning path (based on optional selected didactical nodes)
- suggest interventions to the human Tutor and suggests "re-designing" actions to the Teacher/Author
- suggest a personalized learning path based on the learning session selected considering the corresponding prerequisites. Therefore, Learners will not miss any fundamental sections for the targets of the learning activity selected
- guide the Student towards the achievement of objective tests, based on the structure of problem solving (*reification action*)
- divides the problems in primary and secondary targets, active actions of scaffolding and reasoning
- allows Teachers to monitor the Students' progress and select suitable learning materials/topics in the Learning Object Repository (LOR) accordingly
- streamline the process of content management and course development, allowing Teachers to spend more time on the pedagogical design/-issues of the course

The Cognitive Tutor should be able to suggest a diversification of the learning path on the base of the student profile evolution and necessities.

The collaboration with an ID Knowledge Specialist is an essential strategy to obtain technical and methodology support a) in adapting the course design, b) in the formulation of the necessary didactical rules and logical relations for the Rule Engine of the Cognitive Tutor [4].

E. Community Laboratory

In this activity, the users share their experience, information and resources about the subject of the course, in a network of communication.

F. Group Laboratory

The groups receive instructions containing a research- / activity path (like a "treasure hunt"), with the objective to make a "learning product" (subject matter depending). It consists in the activation of collaborative and competitive behaviors. "Collaborative situations" are divided in: cooperation (situation in which several Students work together to perform some global tasks that cannot be achieved by a single Student); coordination (cooperation in which the actions performed by each Student take into account the actions executed by other Students in such a way that the result ends up being a coherent and high-performance operation); communication (sharing the same language and tools).

"Competitive situations" consist in specific didactical games in search of new solutions, appropriate behaviours and effective control strategies, activating cooperative game mechanisms in the learning groups. They suggest a fundamental didactical *problem-driven* strategy, to pose and solve a practical problem or simulation. Furthermore, they

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aim to reward the expertise and creativity of the Students, expressed through:

- the search of new ("original") solutions
- the ability to design and build complex "work tools" or methods to perform the learning activity
- the study of appropriate behavior and effective control strategies
- the synergy of multidisciplinary knowledge
- the activation of cooperative game mechanisms, allowing other Students to share "game" knowledge

The goal is an experience of enactive and "deliberative" thinking.

The evaluation focuses on: 1) Showed social-, organizational-, communicative skills and knowledge management capabilities; 2) collaborative activity inside the group and behavior during the laboratory; 3) story-authoring and story-participation actions; 4) individual-, collective problem solving and adductive activities; 5) created communication networks ; 6) the final product of the research

G. Report

It is an area where the Students summarize all events of the week. Everyone can add content/information. It actives the propositional thought (which translates the experience into knowledge semantics), the construction of mental images (which can recognize and identify the information retained), the activation of the narrative thoughts (that interprets own experience, comparing it with the experience of others)

H. e-Portfolio

It involves the user (Student or Teacher) in self-reflection and "critical thinking", recognizing the profile of own learning/teaching and selecting the necessary information with the perspective of factual choices in their personal path *in progress*. In particular, the Student e-portfolio contains the student curriculum, acquired competences, personal grade book, personal repository of documents, graphical or multimedia elements, selected websites, or other personal items.

IV. Assessment Factors and Criteria

The interpretation of the PENTHA ID Model concerning a connectivist logic foresees seven interconnected assessment factors and criteria (see Tab. 1).

A. Profiling

The Profiling assessment factor consists in the analysis of the change (possible evolution) of the personal characteristics of Students, satisfaction of their own needs.

EVALUATION CRITERIA - The PENTHA Model adapts the Learning Orientation Model [8], which identifies four types of learner (transforming, performing, conforming, resistant). The cognitive state, learning style and preferences, are obtained: a) by confronting the test results at the end of the assessment activities with previous test results; b) by observing the used didactical material, the acquired knowledge and skills, in order to determine the degree of receptivity (retention) of the Student to various types of issues/subjects. Some leading frameworks of learning styles definitions are: Gardner's Multiple Intelligences, Felder-Silverman Index of Learning Styles (ILS), Fleming & Mills' VARK, Kolb's Learning Styles Model and Experiential Learning Theory (ELT), Myers Briggs Type Indicator (MBTI) - Jung

B. Behaviour Recording

The Behaviour Recording assessment factor consists in the analysis of Student behaviours during the learning cycle in real time, including collaborative activities and participation in group assignments

EVALUATION CRITERIA - In the learning process the learner navigates through the individual graph by following its sequence. The individual content and behavior graph serves as input for a set of sequence rules. The resulting sequence is the *learning path*, a personalized navigation structure of sections and sub-sections, activity types/modes, tutoring interactions etc.

C. Presenting

The Presenting assessment factor consists in the evaluation of the structuring capacity, visualization, storytelling modes, logical- graphic simulations, exercises, brainstorming and developing ideas

EVALUATION CRITERIA - The PENTHA Model adapts the Concept Didactic and the Guilford Taxonomy (*by operations:* memory skill, convergent or divergent productions, decisional and judicial skills, etc.; *by contents:* figurative, symbolic, semantic, behavioural; *by products:* units, classes, relationships, systems, transformations, implications)

D. Planning

The Planning assessment factor consists in enabling content management at a high level of abstraction through ontology, maintained in accordance with common standards for knowledge representation, semantic analysis of concept maps for Tutors, and production of flowcharts for Students

EVALUATION CRITERIA - The PENTHA Model adapts the Semantic Analysis, Guilford Taxonomy and also Gagnè's Taxonomy (which proposes diversified learning: signal learning, Stimulus-Responsive learning, principles learning, problem posing and solving, etc).

E. Scanning

The Scanning assessment factor consists in the analysis of activities, associated to social- and knowledge networks, availability and control of multiple resources and the type of user interactions

EVALUATION CRITERIA - The PENTHA Model is in accordance with the Self-Regulated Learning (SRL) indicators, which identify a evaluation grid, composed from the Student's interactions, personal planning, monitored execution and evaluation with cognitive / meta-cognitive and motivational / emotive levels.

F. Selection of Right/Wrong Actions

This assessment typology is necessary to detect misconceptions and so called "knowledge holes" for an advanced AI based tutoring system.

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EVALUATION CRITERIA - They are connected on the specific subject matter pedagogical pattern, the Model assigns a particular value to the support of the fuzzy logic principles in the identification of gradual boundaries of the individual learning graph, and to the risk parameters of the interpretation between objective and subjective dimension of the didactical decisional process.

G. Technical Tests

The Technical Tests consist in entry tests, learning tasks, assigned actions, required performances, acquired knowhow, the use tools, through posing of open/closed questions, true/false tests, multiple choice test, Subject matter tests etc . EVALUATION CRITERIA - objective criteria (like Bloom Taxonomy, mainly in the cognitive and affective area)

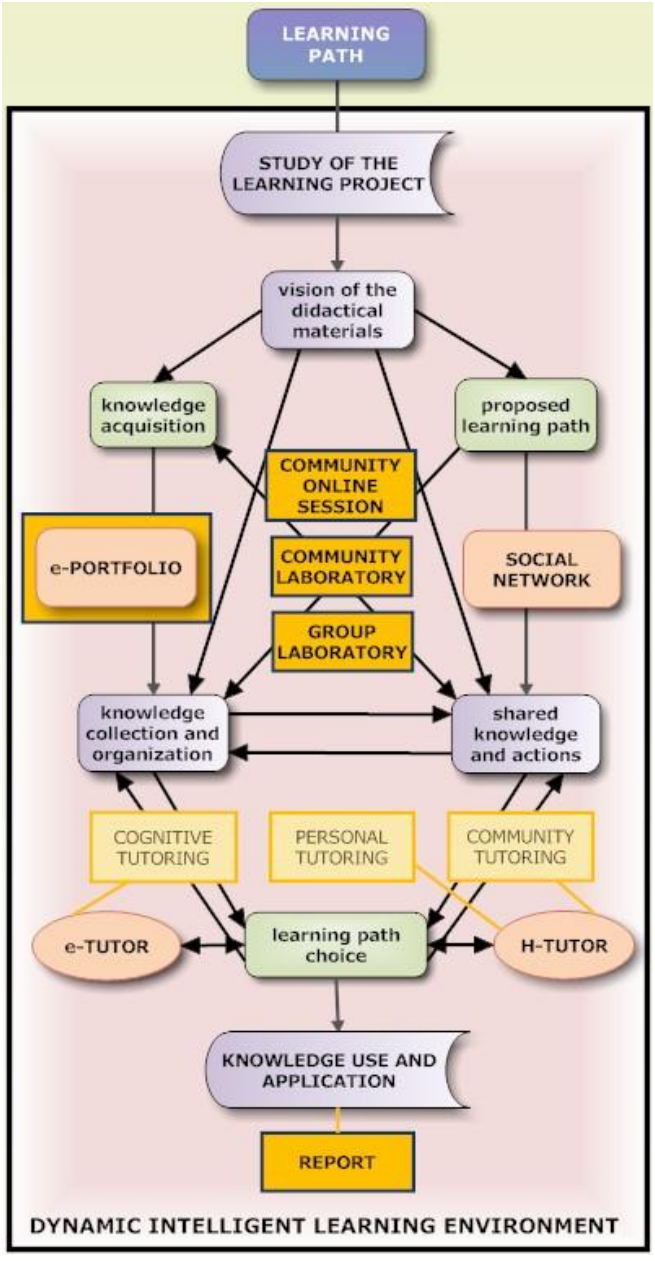

Figure 2: Learning Path

V. Didactical Suggestion for a Dynamic Intelligent Learning Environment

On the basis of the present conceptual essay, a Dynamic Learning Environment should support the following tools for the specific teaching/learning functions:

- to fulfill the proposed TEACHING DESIGN:

Active Syllabus Area, Teacher Portfolio, e-Content Editor, User/Group Management, Cognitive Tutoring Interface, Tests Authoring Tools

- to realize COMMUNITY ONLINE SESSIONS:

*Video-conferencing System (*synchronous mode)

- to realize the COMMUNITY TUTORING FUNCTION:

Forum (asynchronous mode)

- to realize the PERSONAL TUTORING FUNCTION:

Private Messaging (asynchronous mode) and *Instant Messaging* (synchronous mode) *Subsystems*

- to fulfill the COMMUNITY LABORATORY FUNCTION:

Social Networks Access, Workflow Engines, Community Repositories internal and external (documents, video clips, power point presentations,...)

- to fulfill the GROUP LABORATORY FUNCTION:

Video-conferencing tool, Collaborative Chat and Scribe functionality, Private Drop Box, Conceptual Map Software, Educational Role-Play, Wiki (for the final report)

- to fulfill the REPORT lesson mode:

Wiki, Digital Narrative Learning Environments and Conceptual Map Software

- a comprehensive *Student e-Portfolio*
- Several *Technical testing tools*
- *e-Assessment Tools*
- a *Cognitive Tutoring System*

The specific didactical prerequisites of a Dynamic Learning Environment, to be defined "Intelligent", is the ability to monitor and supervise every learning step and the individual/group learning path. The resulting network of acquired logging and tracking data has to permit a dynamic, context sensitive hint management function during the teaching and learning process in real time.

Only LMS platforms supported by an AI based, tracking and tutoring system are able to trace the Students step-by-step in their problem posing/solving approach, supporting the Teacher to reflect on course activity structure and re-design, develop study resources, enable the control of the learning path and monitor the Students activities through the analysis of specific activity logs.

From a didactical perspective, the Author of an e-course should provide several type of Tags and Meta data, logical parameters and didactical rules to realize the intelligent learning process.

Today, known AI tutoring and adaptation implementations require among other, a "Subject Matter" profile and a set of section related variables, used to evaluate the work done by the Student and detect possible "knowledge deficiencies".

In summary, in addition to the *Teacher/Author of an e-course***,** that designs, manages the course and evaluates the results of the learning, the PENTHA ID model requires the following significant roles and functions to interface with Artificial Intelligence Sub system:

- the *Learning Entity*: is a single Student or a Learning Group
- the *Learning Leader***:** is a significant figure in a learning class, able to lead initiatives, starting from a personal pro-active approach

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- the *(didactical) Human Tutor***:** is a teacher (or a group of teachers) that provide a feedback on each detected problem, recognizably correct actions are acknowledged, where erroneous actions are flagged. It gives the Student the opportunity to reason about the current problem state, assisting his/her approach
- the *e-Tutor (or Cognitive Tutor):* is an expert system able to support the teacher/tutor in his actions, guide Students to complete their courses on the base of their performance, optimize the progress and style of learning, towards the realization of "self-directed" and personalized learning processes [9], [7] [3: *use cases*] .
- *ID Knowledge Manager***:** is an essential role to provide technical and methodology support a) in adapting the course design, b) in the formulation of the necessary didactical rules and logical relations for the Rule Engine of the Cognitive Tutor [4]. He is a very human "catalytic agent".

In a Dynamic Intelligent Learning Environment the Didactical Relationship is another focus point in the PENTHA approach. According to the Complexity Theory, in this dynamic context, dominated by many variables, the following range of interactions are available:

- between Learning Entities
- between the Learning Entity and the Human Tutor: prototypically tutors will give the student the maximum opportunity to reason about the current problem state, monitoring and assisting his/her approach
- between e-Tutor and the Learning Entity: the e-Tutor traces every Student or Group step-by-step in their problem solving and offers a context specific hint support
- between e-Tutor and Teacher/Author: the e-Tutor supports the Teacher/Author to reflect on the effectiveness of course activities (re-design). This interaction is useful to go on the common "muddling through science", also adopted by expert Teachers, to optimization the teaching path control
- between e-Tutor and Human Tutor

Every protagonist will evolve to a real decisional Actor (included the Expert System), that operate mutual adjustments, developing decision-making skills.

VI. Conclusion

The focus of the PENTHA ID Model is explaining the complex scenario of a "diversified" e-learning environment (dynamically adaptive, individualized and personalized), based on a tutoring system with "intelligent" decisional support.

In the ID Model perspective, the Teacher/Author is a real decisional manager, able to reflect on didactical actions. Students can also evolve to real decision managers, able to recognize the elements of a problem, and select the necessary information with the perspective of factual choices in their personal learning path.

According to this perspective and approach, in this contribution we propose lesson modes and assessment criteria for an e-course, intended to solve the key questions how to define and maintain an active Student profile.

On the basis of this analysis, our research team developed a new intelligent dynamic e-learning environment, called Opus 2 [10] which allows to apply the above explained didactical approach.

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