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A Context-Aware Learning System based on generic scenarios and the theory in didactic anthropology of knowledge

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Abstract

Nowadays, technology-enhanced learning systems must have the ability to reuse .learning resources from distributed repositories, to take into account the context and to allow dynamic adaptation to different learners based on substantial advances in pedagogical theories and knowledge models. We focus on learning systems using a problem-based learning approach represented by scenarios. In our framework, the goal of scenarios is to describe the learning and tutoring activities to acquire some knowledge domain (for instance physics) and know-how to solve a particular problem. The main issue is to design a generic scenario which can deal with most of learning situations for problem-based learning science curriculum. From a generic scenario, the learning system will compute on the fly a particular scenario dedicated to the current learner and its learning situation. The main contribution of this paper is a semantic and didactic-based model of scenarios for designing an adaptive and context-aware learning System. The scenario model is acquired from: i) the know-how and real practices of teachers ii) the theory in didactic anthropology of knowledge of Chevallard [1]; iii) a hierarchical task model.

1. Introduction

Nowadays, technology-enhanced learning systems must have the ability to reuse learning resources (learning objects, tools and services) from large repositories, to take into account the context and to allow dynamic adaptation to different learners based on substantial advances in pedagogical theories and knowledge models [2]. The context is one of the key issues for dynamic adaptation. The design and engineering of learning systems must be considered as an interdisciplinary problem requiring the integration of different scientific approaches from computer science, pedagogical and/or didactical theories, education, etc. The design process leads to an artifact - the learning system - based on different scientific approaches which are related to different theories – for instance, activity theory [3], theory of didactic situations [4], computer-based theories, etc. Consequently, it is crucial to establish the relationships between theories, models and artifacts to ensure the traceability and the interpretation of phenomena related to the use of artifacts [5].

Research on the learning scenario models leads to the standardization of pedagogical approaches - IMS LD [6]. The goal of scenarios is to describe the learning and tutoring activities to acquire knowledge. A scenario is defined by the following characteristics: the structure, coordination and typology of activities, the activity distribution among learners, teachers and computers and their roles. Now, we analyze how IMS LD scenarios are or are not context-aware and adaptive according to different learners, pedagogical/didactical theories and knowledge models. In other words, the main question is: how is it possible to adapt an IMS LD scenario according to these parameters?

R. Koper and B. Olivier argue that there are hundreds of different pedagogical models and then developing tools to support it would be an inefficient path to follow. IMS LD provides a more abstract notation that is sufficiently general to represent the common structures found in different pedagogical models [7]. These kinds of models enable authors/teachers to produce generic and standard models which are neutral on a pedagogical and/or didactical point of view [8]. Moreover, the teaching-learning process is modeled using the metaphor of a theatrical play (plays, acts, and activities). Such a process could be not natural for authors and very different from their community of practices. IMS LD manages the following scenario dimensions: the learners, the teachers, the classrooms type, services (for instance, CITT tools), face to face or at distance and learning objects. IMS LD manages adaptation in a limited way: only activities, associated to roles, can be selected dynamically by means of If-Then-Else rules according the learner features, progression data and results of tests. If-Then-Else rules can not select plays and acts according to the previous features. Resources, associated to activities, are defined a priori. In other words, it is not possible to change and/or to select some resources according to some dimensions. The learning domain – or domain knowledge – is not managed in scenarios. Consequently, it is not possible to manage learner know-how and knowledge level. On the contrary, MISA has a domain model and a pedagogical model [9-11]. In conclusion, IMS LD has a limited adaptation mechanism because a scenario does not depend on resources, learning domain and pedagogical/didactical approaches; that is to say IMS LD scenarios are neutral on these dimensions.

We claim that a scenario is defined from the following dimensions: the learning domain (course topic), the learner, the learner know-how and knowledge levels, the tutor/teacher, the resources (documents, communication tools, technical tools, etc.), the pedagogical and /or didactical model, the learning “procedures” according to a particular school/institution/ university, classroom type, face to face or at distance, CITT[1] tools, etc. [12]. In other words, the structure, typology and coordination of activities, the activity distribution among actors and the resources have to change according to above-mentioned dimensions. Consequently, it is necessary to adapt dynamically the delivered scenario to these dimensions; scenarios have to be contextualized.

1 Communication and Information Technologies for Teaching

We are interested in technology-enhanced learning systems using a problem-based learning approach, represented by scenarios. The goal of scenarios is to describe the learning and tutoring activities to acquire some knowledge domain and know-how to solve a particular problem. Our assumptions are different to IMS LD approach: we aimed at designing generic scenarios to deal with the broadest range of learning situations for problem-based learning science curriculum. Generic scenarios are context-aware and based on a particular teacher community of practices. The delivered scenario is computed on the fly according to the resources, the domain, the learner knowledge and know-how, the pedagogical and/or didactical model, the learning "procedures" according to a particular school/institution/ university, classroom type, face to face or at distance, CITT[2] tools. The explicit knowledge and know-how of the community of practices is acquired to design the scenario model. The scenario model should be more natural for teachers because we are using their knowledge and know-how to establish the scenario model instead of an "external" metaphor.

Adaptive technology-enhanced learning systems compute on the fly the delivered courses from distributed data resources, according to the current context and the learner's needs. The resource reusability has to rely on resource interoperability at syntactic and semantic level. At semantic level, resources are described by semantic metadata and their corresponding ontologies. These ontologies can be used to formalize at knowledge level the different required models of learning systems: learner and teacher models, domain model, context model, scenario models, pedagogical and/or didactical models, adaptation models and rules, etc. New software architectures are necessary to use learning system models based on ontologies and to support dynamic adaptation and context awareness. We designed a flexible and adaptive composition engine, called SCARCE - SemantiC and Adaptive Retrieval and Composition Engine – to design such technology-enhanced learning systems [13]. Our adaptive and context-aware learning system is based on SCARCE.

The main contribution of this paper is an adaptive and context-aware model of scenarios based on a interdisciplinary approach (didactics, physics and its epistemology, computer science and education) and a particular teacher community of practices. To ensure traceability, a co-design process is used to study of the different theories and their concepts. The co-design process enables us to establish relationships between a didactic theory, computer-based models, teacher practices and physics. It can be viewed as a swirl model having iterative loops which leads to cooperation between computer scientists, didacticians, physicists and expert teachers by means of repetitive interactions. Our model of scenarios is able to deal with all dimensions above-mentioned. The different scenario dimensions are acquired from: i) the know-how and real practices of teachers in a problem-based learning approach in a particular framework: an institution IUFM[3], different categories of probationary teachers, a course about "the air as gas in its static and dynamic aspects: properties, theory and applications"; ii) the theory in didactic anthropology of knowledge of Chevallard [1]; iii) a hierarchical task model. The Chevallard theory provides a reusable overall structure of scenarios, types of tasks and tasks/techniques systems, a task typology and the key issues for modeling the learner knowledge and know-how levels and the corresponding adaptation strategies. The hierarchical task model enables us to define the learning and

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[2] Communication and Information Technologies for Teaching

[3] IUFM : Institut Universitaire de Formation des Maîtres (Teacher Training Institut)

tutoring activities, the activity distribution among learners, teachers and computers and also to transpose the main concepts of the Chevallard theory. The learning system is based on four different models: a scenario model, a domain model, a learner model and a context model to deal with the different scenario dimensions. The context model implement the concept of didactical environment acquired from the Chevallard theory.

First of all, we briefly present the main features of the SCARCE environment and more particularly, how our scenario model is used in the environment. Secondly, we present the co-design methodology for acquiring the problem-based learning scenarios from teacher real practices and the Chevallard theory in didactic anthropology of knowledge. Thirdly, the computer-based model of scenarios is detailed. The transposition of the main concepts of Chevallard theory and the typology of learning and tutoring activities is explained. Finally, the conclusion highlights the main results of this study. We also point out the next research issues.

2. The SCARCE Environment

The adaptive learning system can be viewed as an adaptive virtual document. It will use a flexible composition engine, called SCARCE - SemantiC and Adaptive Retrieval and Composition Engine based on a semantic web approach [13, 14]. SCARCE is the core of ICCARS[4], CANDLE[5] and KMP[6] projects. In our framework - the MODALES project (Modeling Didactic-based Active Learning Environment in Sciences)-, a learning system consists of a set of resources, their metadata and the corresponding ontologies and **an adaptive composition engine** which is able to **select** the relevant resources, to **organize** and to **assemble** them by **adapting** the delivered course to the learner needs and the current learning situation. To provide flexibility, selection, organization and adaptation are parameters of the composition engine and lead to a specification.

In Figure 1, the composition engine uses four loosely coupled ontologies which are: metadata ontology at the information level which describes the indexing structure of resources, some index values are taken in the domain and scenario ontologies; domain ontology representing knowledge in a specific area – physics, didactic, epistemology; scenario ontology consisting of a scenario model - organization and selection - and an adaptation model. The scenario model defines the core concepts of the organization which is a directed graph. Thus, it defines the different types of nodes and links and the different sub-types of nodes and links which depend on the application. In our framework, it is respectively the main concepts of a hierarchical task model and the didactical concepts and their features. The scenario and adaptation model leads to a scenario ontology based on a hierarchical task model and an adaptation model based on the adaptation policies required by the MODALES[7] Project; a learner and teacher ontology which defines different stereotypes - categories of probationary teachers and teachers - and individual features. Metadata schema, ontologies and specifications are based on the explicit common knowledge shared by all community members. In other words, scenarios are key issue to design the scenario ontology, adaptation ontology and

[4] ICCARS : **I**ntegrated and **C**ollaborative **C**omputer **A**ssisted **R**eporting **S**ystem
[5] CANDLE : **C**ollaborative **A**nd **N**etwork **D**istributed **L**earning **E**nvironment
[6] KMP: **K**nowledge **M**anagement **P**ortal, RNRT Project
[7] Modeling Didactic-based Active Learning Environment in Sciences

specifications. At present, SCARCE is not context-aware. It does not manage context ontology – formalizing a context model.

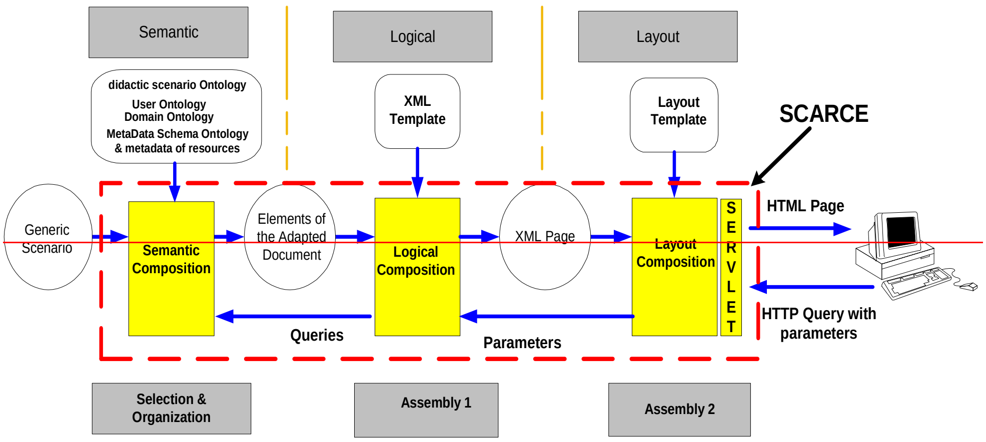

Figure 1. Composition Engine Architecture

The specification is called a generic scenario (see Figure 1). It has to deal with the broadest range of learning situations. From a generic scenario, the learning system will compute on the fly a specific scenario dedicated to the current learner and his/her learning situation. The generic scenario acts as scaffolding in the learning system. Acquiring the scenario model is not an easy task because it is necessary to make explicit knowledge, know-how and real practices of teachers and to establish the relationships between theories, models and artifacts. After a short introduction of the MODALES Project, the outcome of the acquisition of teacher practices and know-how is presented.

3. The MODALES Project

MODALES project is aimed at designing an adaptive learning system for probationary teachers, based on real practices. The course topic is about "the air as gas in its static and dynamic aspects: properties, theory and applications" for different categories of probationary teachers – called learners. In our framework, scenarios may change according to the following features: i) the category of learners having intra and inter category variability; ii) the available resources from different domains - physics, didactic and epistemology - which can be determined by teachers iii) distance or face-to-face activity according to learner needs and learning policy iv) the sharing of activities between teachers, learners and computers according to learner needs and learning policies. These features are key issues for adaptation policies in the learning system. The main issue is to design a generic scenario which can deal with the broadest range of learning situations (from a computer science viewpoint).

In our framework, the co-design process can be viewed as a swirl model having iterative loops which leads to cooperation between computer scientists and expert teachers by means of repetitive interactions – similar to proposal made by Akrich et al 1988 [15]. In such an approach, several models, artifacts are achieved. Several theories will be used to acquire teacher practices and to determine the benefits and the limits of each one in this co-design process. These theories are: activity theory [3], the theory of didactic situations [4] and the theory in didactic anthropology of knowledge [1, 16]. At present, the co-design of scenarios is only based on teacher real practices acquired by means of the theory in didactic anthropology of knowledge and is formalized in a hierarchical task model [17-19]. Teachers belong to a community of practices: they share and build a common knowledge to work together [20]. Scenarios are based on the explicit community knowledge and are a key issue to design the e-learning system and to adapt the delivered course to learners.

4. Acquisition of teacher practices and know-how

The schema of the didactic transposition of Perrenoud [21] sums up our methodology to design and to model the learning situations: i) to discover and describe finely the practices and the know-how of teachers and learners, ii) to identify the competences at work (of teachers and learners), iii) to analyze the cognitive resources (knowledge, etc.) used by teachers and learners, iv) to make assumptions about the genesis of competences during learning situations; v) to elaborate devices, situations, planned contents of the curriculum (a formal curriculum vitae) and to implement them (a real curriculum vitae). At present, the co-design has been done in three main stages: 1) design of an initial version of the scenarios by expert teachers; 2) acquisition of the refined scenarios using the theory in didactic anthropology of knowledge [1, 16]; 3) formalization in a hierarchical task model [17-19]. The first stage has been done to initiate the swirl model and the cooperation between computer scientists, didacticians, physicists and expert teachers. The stages two and three lead to iterative loops investigating theory, models and artifacts in depth. This paragraph is organized as follows: first of all, we describe the first version of scenarios designed by expert teachers; secondly, we introduce the Chevallard theory and the corresponding refinement of scenarios and thirdly we present the main features for scenario adaptation. The Chevallard theory enable us to acquire a reusable overall structure of scenarios, types of tasks and their corresponding tasks/techniques systems, a task typology and the main adaptation features.

4.1 The first version of scenarios designed by expert teachers

A common learning scenario P*o* (whose variables are learners, the expert teacher and the available resources) was built (cf. Tables 1). It shows two phases: 1) construction of professional references for teaching, 2) development of a training sequence implemented in classrooms. A phase consists of a sequence of activities. Scenarios for PE and PLC in earth/biology sciences and physics were established according to the same procedure: each expert teacher (according to his domain) built a scenario from the common plan Po. He associates to an activity of the two phases a series of information: 1) activation of the phase (if it exists in the scenario); 2) distance or face to face; 3) a description of the available resources and their type (physics, didactic, epistemological / historic); 4) an activity description for learners and teachers. Activities Tij can be refined according to the learner, its group, the didactic situation and some others constraints given by the teacher.

Table 1. Common learning scenario Po

Phase 1: construction of professional references for teaching	Phase 2: construction of a learning sequence
T1. define the problem	T1. define the scientific problem
T2. read the resources	T2. scientific goals
T3. explain the approach	T4. method and know-how goals
T4. intermediate report	T5. Description of the didactic problem solving method
T5. achieve the approach	T6. describe necessary activities to solve the problem
T6. write the final report	T7. Compare the different approaches
T7. Compare all the reports	T8. Synthesis

The first stage enables expert teachers to explicit common knowledge, but also to build new one. The Chevallard theory has been used to deal with the refinement of scenarios, the acquisition of new common knowledge.

4.2 Scenario refinement using the Chevallard Theory

The praxeology system ($T/\tau/\theta/\Theta$) of the Chevallard theory enables us to refine and to structure the scenario model and the didactical environment. According to Chevallard, teacher and learner activities can be described in terms of types of task*s* T_c achieved by techniques τ which may be recursively achieved by subtasks $T_{c'}$. A Task/Technique system (T/τ) has a hierarchical structure. For a given technique, a task can be decomposed into sub-tasks which are achieved according to specified operators. At present, three different operators are used: sequence, alternative and parallel. This hierarchical structure (T/τ) defines a know-how that leans on an environment composed of a technology θ (discourse that justifies and explains techniques) and a theory Θ justifying and highlighting the technology.

4.3 Structure of a complete scenario

A complete scenario has two phases composed of a sequence of activities, temporally organized by moments. In a phase, we can observe six different moments in the didactical organization: i) the first encounter with the type of tasks T_c (moment M1); ii) the exploration of the type of tasks T_c and the construction of techniques τ (moment M2); iii) the technique work that improves the technique and makes it more efficient (moment M3); iv); the evaluation (moment M4) v) the construction of a Technology/Theory related to technique τ (moment M5); vi) the institutionalization of the system ($T/\tau/\theta/\Theta$) by the teacher (moment M6) (cf. Figure 2). The types of tasks T1 and T2 include the moments M1 to M4. These types of tasks incorporate

Task/Technique systems corresponding to the moments M1, M2, M3 and M4. The didactical organization provides a temporal sequence of the different moments.

We analyzed the two parts of scenarios by means of ($T/t/\theta/\Theta$) systems and the different phases of the educational organization: each part has the same structure: a) a problem solving proposal (in tasks T1 or T2), b) a construction by learners of the Task/Technique system for solving the problem (moments M1 or M2 or M3 in tasks T1 or T2), c) evaluation (moment M4 in tasks T1 or T2), d) construction of a critical discourse on the Task/Technique system (the technology construction), e) institutionalization by the teacher which brings a theoretical discourse validating the technology (moment M6).

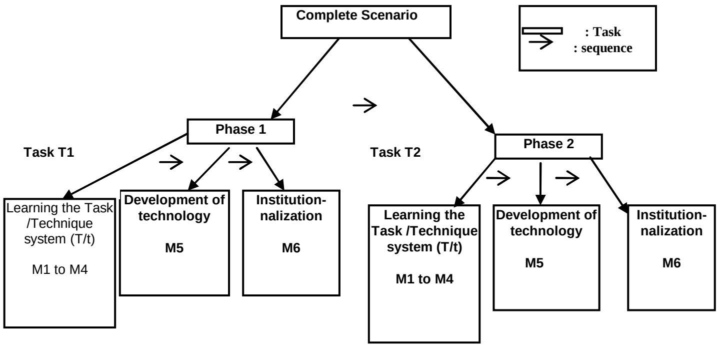

Figure 2. A complete scenario

This scenario structure can be reused in sciences. It has been used for different course topics, for instance astronomy and earth/biology. The scenario analysis shows different categories of learning and tutoring tasks, organized at different levels of the task hierarchy: scenario, phase, moment, learning task, routine task and tutoring task. All these types do not appear in the figure 1 which mainly highlights the decomposition of tasks into subtasks.

For a given problem, several Task/Technique pairs can be observed according to the teacher role: i) a routine pair: there is no teacher interaction and he did not plan to intervene (for instance, learners are able to read and write). Nevertheless, he could check whether the task is completed on time and could do it on line. The routine pair does not have any learning interest. ii) a problematic pair: the teacher is acting in the learning situation after a period $\Delta\tau$. The value of $\Delta\tau$ gives us a relevant features to analyze different learning situations. More does the teacher intervene quickly in the didactic situation (i.e. $\Delta\tau$ is small), more the Task/Technique pair is considered as problematic. The learner does not have a routine at all to solve the problem. It is a learning task in comparison with the previous pair (routine). Thus, we can show several - didactic situations with such a pair: 1) the first meeting with the problem and the first Task/Technique system able to solve the problem (moment M1). The Task/Technique system has to be more detailed and is composed of several sub-tasks which are problematic. Maybe, some of them could be a routine; 2) the work on a problematic Task/Technique system after the first meeting (moment M2). The Task/Technique system has to be less detailed than previously and is also composed of several sub-tasks which are problematic; 3) the work on a new Task/Technique system to be more efficient, but which is always problematic (moment M3). There is no routine to solve the corresponding problem. To design a scenario, it is important to know whether a Task/Technique pair is a routine or a problematic one. Problematic tasks are called learning tasks. One issue is to manage the transitions between the moments M1, M2 and M3, for managing adaptation. Adaptation does not manage routine tasks because it is not a learning issue.

4.4 Adaptation

The adaptation of scenarios leads to choose the relevant technique according to the learner needs and the didactical environment. In other words, it is equivalent to choose the relevant moment for a given type of tasks: M1 or M2 or M3 because the relevant technique is achieved by one of these moments. According to the Task/Technique system, the choice can be done by the computer, the learner or the teacher. The selection of the relevant technique depends on the following properties: the Task/Technique system, the learner category (PE: PE1 fresher, PE1 Minor: minor in physics, PE1 Major: major in physics, PE2 sophomore, PLC 1 fresher, PLC2 sophomore, etc.), the learner knowledge and know-how levels and the didactical environment. The didactical environment consists of the type of classrooms (virtual classroom, scientific laboratory with or without computers and/or with or without internet access, associated CITT tools (chat, email, forum, etc.), technical instruments (thermometer, barometer, etc.), resources (documents, experiments, etc.) and face to face or at distance.

At the top level of abstraction, scenarios vary according to the learner category and curriculum. In figure 3, a complete scenario shows the presence or absence of the different phases for different category of learners.

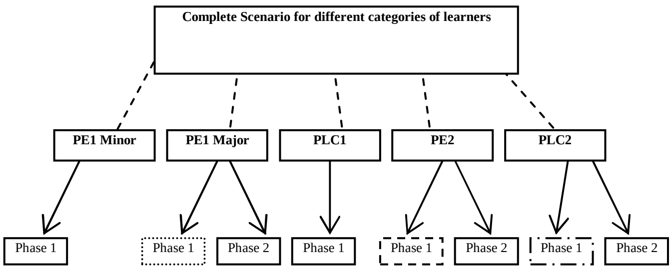

Figure 3. Complete scenarios for different learners

For PE1 Minor and PLC1 learners, the main goal is to study the professional references for teaching in physics. The scenario is reduced to the phase 1. For others, the scenario has two phases, but the phase 1 is mainly a reminder. The corresponding Task/Technique system is simplified compared to the same phase for PE1 Minor and PLC1 learners.

First of all, we explain how the learner and the technique properties are used to choose the relevant technique in a given didactical environment. Secondly, we detail the different roles of the didactical environment features. To illustrate the Chevallard's theory and its concepts, we choose a particular case study: a PE1 Minor learner in which we detail the task "phase 1" composed of several sub-tasks. Some of them have alternative techniques.

The course topic is about "the air as gas in its static and dynamic aspects: properties, theory and applications". In the Chevallard framework, the considered theory is thermodynamics. In physics, theories can be "evaluated" by means of different laws. In our case, it is the Boyle-Mariotte law which is represented as follows ($PV/T = K$) for PE Learners and ($PV = nRT$) for PLC learners. The knowledge domain is composed of the thermodynamic theory, the corresponding laws, the related concepts (Pressure P, Volume V, and Temperature T) and their relationships. To deal with the learner knowledge and know-how levels, the knowledge domain entities (theories, laws, concepts and relationships) and the type of tasks may have three different states: "not acquired", "in progress", "acquired". In figure 4, we assume the learner states for the concepts "P", "V" and "T" are "acquired" (otherwise more techniques must be added and consist of sub-tasks dedicated to the acquisition of the corresponding knowledge). For a given type of tasks, the state "not acquired", correspond to the moment M1 and the states "in progress" and "acquired" correspond respectively to the moment M2 and M3. After a successful evaluation task, a teacher or the computer can update the learner know-how and knowledge levels for some domain entities and for a task: from "in progress" to "acquired" if the corresponding know-how is considered as acquired.

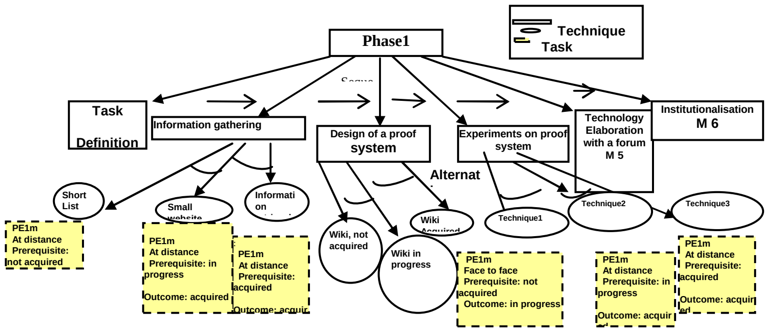

Figure 4. Description of the phase 1 for a PE learner.

In Figure 4, several techniques are annotated with the knowledge and know-how levels: the prerequisite and outcome states of the learner. When it is the first encounter of the type of task "experiments on proof system", the corresponding learner state is "not acquired". Thus, the relevant technique is "Technique 1". After a successful evaluation sub-task, his outcome state will be "in progress" for the task. When the learner state for the type of task "experiments on proof system" is "in progress", the relevant technique is "Technique 2". After a successful evaluation sub-task, his outcome state will be "acquired" for the task. If the evaluation task fails, a remediation task is used (not described in figure 1). The type of task "experiments on proof system" can be worked several times a year in different modules about astronomy, thermodynamic, etc. in physics. Thus, the relevant technique may change according to the moment at which the type of task "experiments on proof system" is worked in a particular module. Thus, several alternatives are provided for a given type of task.

From the didactical environment, we firstly explain the role of the technical instruments. An historical and epistemological analysis of several historical and didactical situations shows that laws in physics are tested by means of technical instruments; For instance, the technical instruments could be a thermometer and a barometer or a simulation tool. Thus, the learners must have or acquire know-how to use these technical instruments to solve the problem related to the task "phase 1". Whether the learner state for these tasks "temperature and pressure measurements" are "not acquired" or "in progress", the relevant technique must have the corresponding prerequisite states and must consist of sub-tasks dedicated to the acquisition of the corresponding know-how.

The "face to face" or "at distance" feature change the Task/Technique system and the activity distribution among learners, teachers and computers. It is the same for the type of classrooms and the CITT tools. Moreover, some specific know-how may be assumed (internet access and information gathering, forum, chat, etc.) to achieve communication tasks or information retrieval tasks. Thus, such know-how must be routine tasks or at least acquired. Otherwise, it is necessary to have sub-tasks to acquire such know-how.

In conclusion, we show that, it is necessary to describe the different techniques according to the learner and the didactical environment features to choose the relevant technique. The relevant technique is achieved by one of the moments M1, M2 or M3. Scenario parts, described in figure 2, 3 and 4, should be reusable in different course topics (astronomy, physics, electricity, and electronics). Such model of scenarios is used to analyze face to face recorded courses in different sub-domain of physics to evaluate it. It is also applied in different course topics by teachers in IUFM. As far as we investigate this model, it seems to be accurate in sciences. Building such a model leads to the creation of new practices and new common and explicit knowledge among expert teachers. One of the main issues is to have a computer-based model able to transpose the different concepts of the Chevallard theory in preserving their meanings. Thus, it is necessary to analyze in depth the transposition process.

5. Adaptive and context-aware model of scenarios

From the acquisition of teacher real practices by means of the Chevallard theory, the didactic-based scenario model is transposed into a computer-based hierarchical task model. Firstly, we describe and justify the transposition of the Task/Technique systems and their hierarchical structure. Secondly, we analyze the representation of the typology of learning and tutoring activities. Finally, we show how the adaptation is formalized according to parameters describing the learner, the context.

Teaching and learning activities of scenarios have been described in terms of type of tasks T_c and techniques τ. The type of tasks T_c describes the teaching and learning activities, while techniques τ describe a way of achieving the types of task T_c. We transpose the resulting Task/Technique system (T_c/τ) in the task/method paradigm of a hierarchical task model. Therefore, we can represent in these model, the Task/Technique system (T_c/τ) of Chevallard fitted with its hierarchical structure and didactics properties describing scenarios while we preserve its initial properties and semantics.

5.1 The task/technique system transposition

Several research studies in artificial intelligence focus on the hierarchical task model using the task/method paradigm [17-19]. In learning environment, hierarchical task models were also used for designing, for instance, authoring tools [22], learning systems [23-25] and recommender systems [26]. The mechanism of hierarchical and recursive decomposition of a problem into sub-problems is one of the basic characteristics of the hierarchical task model [17-19].

We need to analyze the concepts of ***task*** (denoted in italic bold to distinguish them from the tasks in the didactic anthropological theory of the knowledge denoted T_c), method, abstract ***task***, elementary ***task***, control structure of ***tasks*** and sub-***tasks***, inheritance and composition graph of ***tasks***.

Within the framework of the Task/Method paradigm of the hierarchical models of tasks, ***tasks*** define activities and sub-activities managed by a knowledge-based system. There exist two types of ***tasks***: abstract ***task*** and elementary ***task***. An abstract ***task*** represents a high level activity which is composed of sub-***tasks***. Sub-***tasks*** can be abstract or elementary ***tasks***. An elementary ***task*** is not composed of sub-***tasks***. It can be achieved by a simple procedure – for instance, an information retrieval process, a particular human computer interaction, etc. Thus, an abstract ***task*** can be broken down recursively into sub ***tasks*** until having elementary ***tasks***. A method describes how a particular ***task*** can be achieved. Methods define the control structure which allows the recursive decomposition of ***tasks*** into sub-***tasks*** and the control structure defines sub-***task*** order at runtime. For a given ***task***, several methods can be used for achieving it. In this case, a mechanism must select dynamically the relevant method for achieving the task according to the current problem solving context. Moreover, ***tasks*** are also organized in an inheritance graph which enables us to refine the ***tasks*** definition in one (or several) more specific ***tasks***.

A comparison of the concepts (and their properties) of the Chevallard theory applied to the scenarios and those of the hierarchical models of ***tasks*** shows semantic similarities between them. Indeed, according to theirs respective interpretations and properties, we can establish the following connections:

– Type of Tasks T_c of the Chevallard theory, can be represented by the concept of ***task*** in the hierarchical model of ***tasks***.

– Techniques which are a way of achieving a task T_c can be represented by the concept of method describes above.

– Amongst types of tasks T_c of the Chevallard theory, we can distinguish « learning » tasks (call LT task, corresponding to a problematic pair) and tasks without learning interest (call NLT task, corresponding to a routine pair); such as the first one can be broken down recursively into LT and NLT tasks and the second one cannot be decomposed into LT tasks. With this, we can represent a composition graph of LT task, in which, LT tasks are seen as abstract ***tasks*** and NLT tasks as elementary ***tasks*** since they cannot be decomposed into LT tasks.

– The decomposition of a task T_c into sub-task T_c by a technique can be represented by the decomposition mechanism of a ***task*** by a method in the hierarchical model of ***tasks***.

– The *Problematic/Routine* Category of a task T_c for a given learner can be represented by two different categories of **tasks**: **learning tasks** and **routine tasks**.

These connections show that it is possible to transpose the T_c/τ_c structure of the Chevallard organization of learner and teacher into a hierarchical model of ***tasks***. A hierarchical models of tasks enables us to transpose the hierarchical structure T_c/τ_c of

Chevallard theory and their properties into a computer-based model. But, it also enables us to share activities among actors.

The **task**/method paradigm has respectively a semantic and a hierarchical structure similar to those of the Task/Technique systems (T_c/τ) of Chevallard. Moreover, we have to refine the task and method concepts of our model (specialization) to take into account adaptation and sharing of activities.

5.2 Transposition of the task type typology

The typology of tasks of our computer-based model identifies the various types of tasks Tc which compose the scenarios described and represented in paragraph 4: scenario, phase, moment, learning tasks, routine tasks, tutoring tasks.

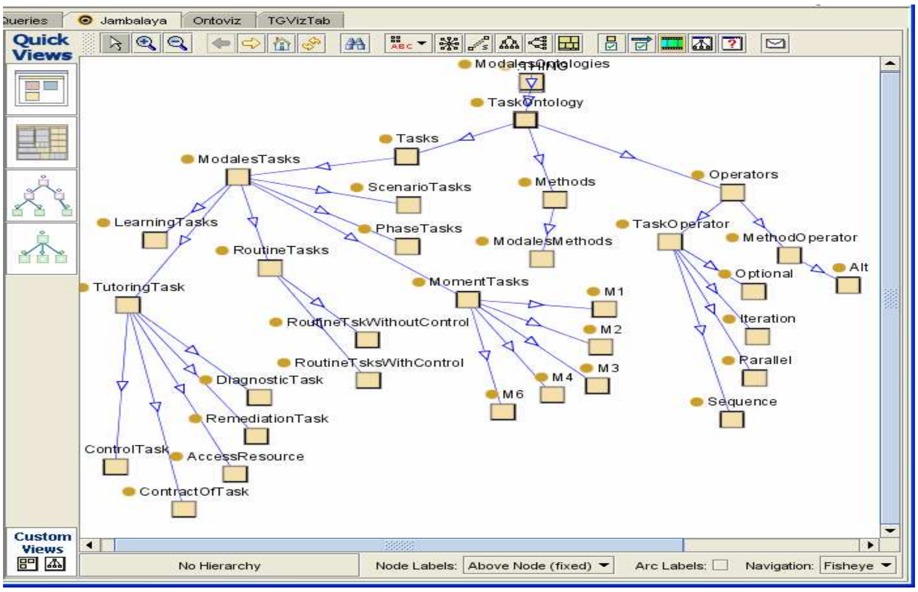

Figure 5. Typology of tasks of the computer-based model.

One of the main criteria of the formalization of tasks represented in figure 5 is their elementary character or not - respectively abstract or not. The **tasks** «ScenarioTasks», «PhaseTasks», «MomentTasks» are represented by **abstract tasks** since a scenario consists of two phases which are broken down into moments while each moment consists of learning tasks, routine tasks, and/or tutoring tasks. Tasks «LearningTasks» are also represented as **abstract tasks**, because they represent a Task/Technique system which can be broken down into others sub Task/Technique systems. On the other hand, the **task** «RoutineTasks» without control, called «RoutineTask WithoutControl», is only composed of elementary **tasks**. The **tasks** «TutoringTask» are elementary **tasks**. They correspond to tutoring activities of the teacher or the computer. In both cases, these **tasks** are seen as “simple procedures”.

5.2 Adaptation of scenarios

From a computer-based viewpoint, the adaptation process can be viewed as the selection of the relevant method which represents the Chevallard concept of techniques. It aims at a dynamic selection of the relevant methods according to the context and the current learner. The know-how and knowledge levels of the learner are represented by an overlay model associated to the learner model.

The context model represents the didactic environment as described in the paragraph 4. It is described by the type of classroom in which the learning activities will take place, the associated CITT tools and devices, a list of technical instruments which are a subset of those in the domain, "face-to-face" or "at distance". The domain model consists of the thermodynamic theory, the corresponding laws, the related concepts and their relationships. The learner is described by his curriculum, his category (PE, PLC, type of PLC, etc.) and his knowledge and know-how levels (an overlay model): a set of states ("not_acquired", "in_progress", "acquired") for some domain entities and know-how (tasks). These states are assigned to the learner and are updated.

The context, learner and domain models are represented by means of ontologies within SCARCE (SemantiC and Adaptive Retrieval and Composition Engine) environment. The adaptation process in SCARCE consists of two stages: firstly, resources are evaluated and classified in one equivalence class according to class membership rules. In this paper, we only need two equivalence classes ("good" and "bad"); secondly, one adaptation technique is chosen for the current learner (annotation, hiding, sorting, direct guidance, etc.). All methods, belonging to the class "good", are selected for the learner. The membership rules define necessary and sufficient conditions to belong to an equivalence class. Rules are declarative predicates using context, learner and method features (which are binary relationships).

Thus, let T_a be a task, Ci be a context, L be a learner, SL the current set of states describing the knowledge and know-how levels of L. The adaptation process is as follows: 1) If SL does not have a state for the task T_a, the corresponding state is added to SL with value: SL.T_a = "not acquired" (the task T_a does not be worked). 2) Membership rules: all methods of T_a for which the context and the learner features match up to the corresponding method features (or "belong to" for multiple-valued features) belong to the class "good" and others belong to the class "bad". 3) If the class "good" is empty, it is considered as a problematic situation and required a teacher action to remediate or to provide a new method and context adapted to the learner and the task T_a. Otherwise, all methods, belonging to the class "good", can be provided to the learner.

6. Conclusion

Technology-enhanced learning systems have to reuse learning resources (learning objects, tools and services) from large repositories, to take into account the context and to allow dynamic adaptation to different learners based on substantial advances in pedagogical theories and knowledge models.

We proposed an adaptive and context-aware model of scenarios based on the theory in didactic anthropology of knowledge of Chevallard, the teacher real practices and know-how and a hierarchical task model. The latter enables us to define the learning and tutoring activities, the activity distribution among learners, teachers and computers and also to transpose the main concepts of the Chevallard theory. The scenario model is closely related to the domain model, the learner model and the context model. The latter represents the didactical environment acquired from the Chevallard theory and the teacher know-how and real practices. The Chevallard theory provides at least a task typology (phase, moment, learning task, routine tasks, etc.), task/technique systems represented in task/method paradigm, the representation of the learner knowledge and know-how levels corresponding to the moment M1, M2 and M3 by means of an overlay model having three states (“not_acquired”, “in_progress”, “acquired”).

A deep analysis of the phase 1 (for a PE learner, cf. Figure 4) shows that the design of a proof system task is defined from and depends on an inquiry-based science teaching, the learning domain (physics) and the domain epistemology. The technology elaboration and institutionalization tasks depend on the Chevallard theory, the learning domain and the teacher know-how and practices. These tasks have to change if you have to deal with another institution (the teacher practices and know-how), another learning domain and another didactical theory. On the contrary, IMS LD scenarios are neutral on these dimensions. In conclusion, IMS LD is unable to deal with such type of scenarios.

We implemented the scenario model in SCARCE. Nevertheless, the model is not complete. We need to investigate the two other categories of adaptation: evaluation and remediation tasks and information retrieval tasks. In other word, we need to continue the co-design process to precise the other adaptation categories and to refine the different models. We also implemented an authoring tool based on this scenario model. A user-centered approach has been used to design the authoring tool for teachers to ensure its usability. It is based on a web server and database system having a schema conform to the scenario model. It enables the teachers to create scenarios and later on to evaluate the model.

This scenario model seems to be reusable and accurate for different course topics: astronomy, physics, electricity, and electronics (as far as we investigate it). We analyzed successfully face to face recorded courses in different sub-domain of physics. It is also applied in different course topics by teachers of IUFM to create scenarios. It seems to be accurate in this institution. We plan to use in another institutions. Building such a model leads also to the creation of new practices and new common and explicit knowledge among expert teachers which will be easier to convey to other teachers or new teachers.

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