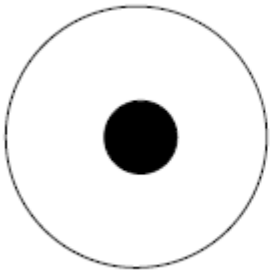

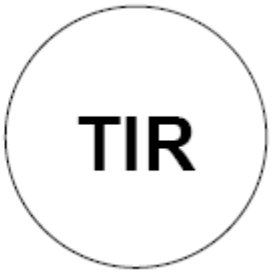

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Table of Contents:

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Results and Impacts of European eLearning in Mathematics

Odd Bringsild

Abstract— 20 years ago the computer algebra system Mathematica was developed by Wolfram Research in the United States. For the first time symbolic mathematics was easy to handle on a computer. Together with the development of markup languages for the Internet this has given us the possibility to develop high-quality digital content for eLearning in mathematics. Many European projects into mathematical eLearning have had especially one main goal: To prevent the number of students in mathematical courses and the number passing the examination reaching a critical low level. To meet this challenge the pedagogics and methods of communicating mathematics will have to undergo an innovative process where new technology is important. However this has turned out to be harder than expected, the main reason being that it requires expertise in several subject matters as well as expertise in several technologies. In the case of mathematics, the required areas of expertise include that of professional mathematicians, software engineers, publishers, and perhaps learning theorists. This article presents an overview of the most important European projects into online learning in mathematics in the context of the Bologna Declaration concerning the tayloring of the structure of the European Higher Education Area (EHEA).

Keywords— Mathematical eLearning, Online Calculations, Pedagogical Value, SciWriter, Semantic Markup, Mathematical Databases, Xmath eBook, Steplets, Multilingual and Multicultural eContent, Mathematical Grammars, OpenMath, TextMath Editor, WebALT Editor, The European Workshop

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1. Introduction

MATHEMATICAL education has traditionally two main goals: to train students in logical and abstract thinking and give students an ability to use mathematical knowledge in fields other than mathematics itself. To achieve especially the last goal will require what we call understanding and the understanding of understanding will be important [1]. We need to let the student feel importance in a wider context than the upcoming examination. The use of eLearning and interactive and event-driven documents may enhance understanding and allow an explorative and personal way of working. These documents are efficient and direct and may combine different kinds of non-linear hypermedia. This is expected to enhance mathematical pedagogics on the Internet and will stimulate activity, independence and collaboration and may also prevent sharp distinctions between boys and girls using ICT. In this way the teacher will be more of an instructor than a professor.

2. The Xmath project

Xmath [2] was the first EU project focusing on mathematical markup in the devolepment of mathematical eLearning resources in 2001. This project, connected to the EU Minerva Action [3], was coordinated by Buskerud University College [4] in Norway and lasted for 2 years (2001-2003).
The objectives of Xmath was first of all to design a framework making it possible to use the markup MathML in mathematical education on the Internet and making it possible to evaluate the pedagogical advantages of netbased education in mathematics. MathML is an application of XML for describing mathematical notation and capturing. It is a recommendation of the World Wide Web Consortium [5] and includes markup for both presentation and content. Using content markup, formulae and expressions may be exported to a computer algebra system.
One of the key elements of netbased pedagogics generally is connected to the communication process student-student and student-teacher over distance (synchronous and asynchronous). The framework then had to include a management system and communication

resources understanding MathML documents. Xmath developed the very first system for e-communication using mathematical symbols, operators and shapes (ScientificTalk). The framework also had to include software making it possible to generate MathML code automatically and to evaluate (calculate) content markup. The system WebMathematica [6] was introduced by Wolfram Research in 2001 and was an important tool in the Xmath project used to develop the Xmath eBook [7].

To demonstrate the use of MathML and to be able to evaluate the pedagogical impact of using it, a pilot course in university mathematics had to be developed [8]. Since MathML was not generally well known because this in 2001 was a brand-new technology or even more important in 2001 the lack of browsers to render it, the project partners had to take responsibility in connection with dessimination of both MathML itself and the envisaged outputs of the project. It was expected that the use and interest for MatmML would be increasing both in education and publishing. The project group had as an objective to create and maintain virtual rooms concerning the use of MathML and WebMathematica in education and publishing.

The most important results of Xmath are the Pilot Course and the Xmath eBook both used and evaluated in practical teaching. Another important result is the European Workshop on MathML and Scientific eContents now in 2008 replacing "MathML" with "Mathematical" [9].

The Pilot Course was designed using MathML presentation markup and evaluated in distance education at Sogndal University College [10]. The Pilot Course covers number theory, functions, analysis and calculus divided into 3-4 levels and is supposed to be a supplement to a common textbook. Most students agreed about good relevance to the mathematics courses and on a good structure of the book. Online eBooks have several advantages: dynamic content, easy navigation and links to other resources on the semantic web, e.g. using an online mathematics course in one window and your favorite mathematics workplace in a second.

The Xmath eBook is composed of what we call Steplets [11]. A Steplet is a routine for solving arbitrary mathematical problems into specific fields step-by-step using webMathematica. The Steplet algorithms developed in Xmath have been praised by the students and are especially important in distance edication where the teacher is absent. As stated by a student at Buskerud University College in a compulsory project report: "*Steplets are moving focus from detailed calculating techniques to understanding mathematics*".

The European Workshop on Mathematical and Scientific eContents has been arranged 4 times and the 5th workshop already planned for Salamanca in Spain in 2010. The workshop focuses on the didactics and technologies related to web-based interactive mathematics, math typesetting, eLearning and scientific communication. Topics of interest include mathematical and scientific eLearning, learning management systems, markup languages, e.g. MathML and SVG [12], online mathematics, computer algebra systems (CAS) and dynamic geometry systems (DGS), technologies for eContent

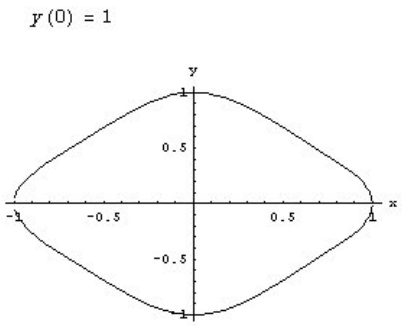

Figure 1. Graphics, Steplet for exact step-by-step solution of the differnetial equation $x^3+3y^2x+(y^3+3x^2y)y'=0$

development, integration of communities and transdisciplinary research, methodology and educational research design, software development standards and user studies.

The workshop in 2008 focuses on mathematical and scientific eContent in the educational sector with the aim of bringing together experts in technologies, mathematics and science education, practitioners and providers of tools and content. About 50 papers are accepted for talks and hands-on sessions. The 4th JEM Workshop and the 1st GeoGebra Day will be satellite events.

3. THE DMATH PROJECT

The dMath [13] project is a follow up from Xmath and was also coodinated by Buskerud University College. It was connected to the EU Leonardo Action [14] and lasted for 3 years (2003-2006). The main purpose was to build a European Database of Mathematical eLearning Modules. The database content consists of reusable learning objects (RLO) using MathML and Steplets. The system is divided into four main parts:

1. The General Authoring Suite to be used by editors.
2. dMathArchive, the repository for RLO's
3. Downloading facilities to a LMS (learning management system) for publishers
4. The Xmath eBook

The modules are organized according to standard textbook levels and a module is divided into different independent objects for downloading by a publisher. The publisher may freely use these objects in a web-based course in mathematics. The main target groups are schools on different levels and industrial companies wanting to give employees further education. This database may be used as a mathematical dictionary as well and is evolutionary in the sense that people may put own objects into the database (subjected to review). The Xmath eBook is online and may be used for supporting mathematical calculations connected to the database modules.

The editor SciWriter [15] for authoring scientific articles and mathematical or technical eLearning content was developed in dMath (LaTEX, XML/MathML, HTML, PDF).

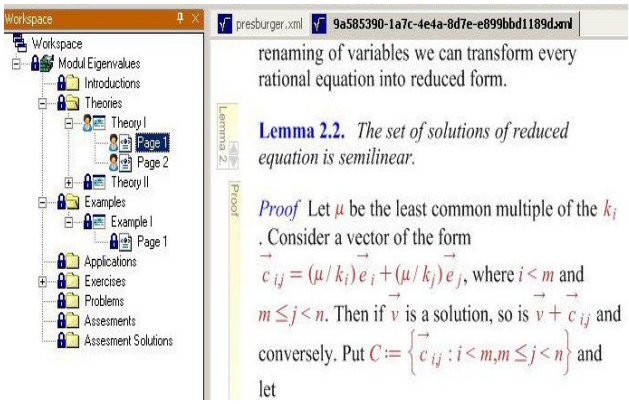

Figure 2 dMath Database, Module Eigenvalues in client workspace

Many of the participants in the dMath project are either from engineering universities or technical companies. The selection of modules is then dominated by technical and engineering studies and applications.

The tailoring of the structure of different university studies to the European Higher Education Area (EHEA), an objective forthcoming from the Bologna Declaration, is the major task outstanding in Europe's different university systems. The reform affects not only the structure of university studies, but furthermore leads to European-wide reflection on the suitability of the syllabuses in mathematics subjects and, of greater importance, on the manner in which mathematics is taught. It is now no longer possible to uphold the same approach to teaching mathematics as fifty years ago and classrooms should reflect the technological revolution that has occurred in recent decades.

In view of the characteristics of the EHEA and the aforementioned demands on teachers, certain changes, at times of a drastic nature, are required in our traditional approach to teaching. The changes required does not only affect syllabuses, stemming from weaker initial grounding, but in general affect the knowledge of mathematics acquired in the stages leading up to a university education. This is highlighted by different European-wide reports, such as the PISA report, and there is also a need to embrace a methodological change that which will allow for addressing the students' new learning needs. The use of the entire potential provided by new technologies applied to teaching may lead to reconsideration of the organisation of different teaching groups, adapting their size to the possibilities of the different computer rooms.

The Bologna declaration has started a necessary revision of the contents and of the teaching techniques to use in the teaching of mathematics at the different University levels. In this sense, the new demands created by the necessary European harmonisation and the need to have available tools that may make it possible a continuous mathematical formation in diverse learning situations, demand a new strategic response. In order to begin to give an answer to these new challenges the dMath project has been developed.

4. THE EVLM PROJECT

EVLM [16] is the European Virtual Laboratory of Mathematics. The project is a EU Leonardo project lasting from 2006-2008 and is coordinated by The Slovak Technical University [17]. The aim of EVLM is to promote better understanding and utilisation of mathematical knowledge in a range of other disciplines that are underpinned by mathematics.

Each National Centre will host a portal (in the respective national language) providing a virtual database of mathematical resources and eLearning materials available from the partner institutions and other sources (such as previously EU funded projects).

The project will promote eLearning in Mathematics, and provide solutions for different target groups and help for teachers and trainers to enhance their skill in using the most advanced educational tools and environments. It will develop an authorative catalogue of available educational materials in mathematics and establish a central database providing

information on the availability of and links to the above resources.

Further the project will privide expert consultancy on the use of these materials and increase the dissemination and utilization of these resources through translation into relevant languages (multilingual and multicultural). The opportunity for educational institutions to share special educational materials developed for their own specific purposes (frequently with funding from European programmes) with other European institutions is important.

The primary target groups are students from secondary school up to PhD, secondary school teachers, trainers, university lecturers, researchers or scientists who need to improve their knowledge and understanding of mathematics, or need expert consultancy in solving their mathematical problems. Targeted sectors are educational institutions from secondary schools to universities.

Secondary target groups are any interested party from the non-academic sphere, from industry or research and development, who need a deeper knowledge of mathematics - including the latest results and details of available information - or who need help with the solution of specific mathematical problems. Targeted sectors are research and training organisations, university enterprise training partners, research centres and scientific institutes.
A third group of potential users of the project´s results may be any training organisations, schools and university training organisations providing continuous education and distance learning or life-long learning. Potential final users are also private individuals as home self-learners, interested in self-education who, for personal reasons, may not normally engage with formal education including disabled people and people perceiving discrimination due to social and gender stereotypes.

5. THE WEBALT PROJECT

The WebAlt project [18], Web Advanced Learning Technologies, was a EU eContent project coordinated by the University of Helsinki [19] lasting from 2005 to 2007.

Under the heading of “OpenMath”, the EU has supported the development of both OpenMath [20] and MathML, the current standards for communicating semantically rich mathematics via XML. These standards are now supported by commercial software packages such as Word and PowerPoint together with MathType, and web browsers such as Internet Explorer and Mozilla. Hence MathML and OpenMath are now ready for their prime time.

The WebALT project showcases a significant application that combines existing standards for representing mathematics and existing linguistic technologies in order to enable the creation of language-independent mathematical content for multilingual and multicultural localization.

The core deliverable of WebALT is the the WebALT grammar for mathematics. Mathematical text conforming to the WebALT grammar can be automatically generated in many European languages. This means that valuable educational content can be easily located and used across Europe. Authors in Norway can now write educational content that is immediately usable in Spain, and vice versa, without labour intensive manual translation. This will supprort the Bologna process and makes it possible for educational institutions across Europe to use, for example, the same test banks.

The highlights of deliverables also includes the TextMathEditor [21] for authoring mathematical text conforming to the WebALT grammars, the WebALT eRepository (WALTER), the WebALT Editor (WExEd) [22] supporting the creation of language independent problems in mathematics, the WebALT Maple T.A FireFox plug-in and multilingual mathematics laboratories for calculus.

6. THE JEM PROJECT

The JEM project [23], Joining Educational Mathematics, is an ongoing EU eContent project coordinated by the University of Helsinki lasting from 2006 to 2009. JEM is a thematic network.
The network intends to bring together the markup technologies developer community with the user community and in particular with the authors of eLearning content in mathematics. Developers of mathematical markup standards and tools will obtain feedback from key users of the technologies and vise versa. Users of state-of-the-art web languages will have access to in-depth training and be able to influence future developments.

The overall goal of the network is to become a focal reference point for all mathematical eContent stakeholders. Further to foster and extend the multicultural and multilingual use of semantic markup for mathematics within the European eLearning community, to monitor the development of learning technologies so that

mathematical content can be integrated and delivered by state-of-the-art and learning systems and finally to structure, coordinate and support the user and authoring community of eLearning content in mathematics

7. CONCLUSIONS

Mathematical content is one of the corner stones of the information society, for education just as much as for science, technology and business. Advances by European projects in representing mathematics on the web enable content actors to create and deliver quality mathematical content to users across Europe, who need it in their work, studies or at home.

Mathematics is a particularly suitable area for electronic learning. With present day information technology it is possible to create interactive learning tools which themselves know an impressive amount of mathematics. This is to a large extent due to the exact and a priori nature of mathematical knowledge. Many areas of the exact sciences rely heavily on basic mathematical knowledge.

European projects and technology have played a fundamental role in the development of the world wide web and mathematical eLearning. The same has been true for enabling semantically rich representations of mathematical content on the web. Mathematical eLearning will also have great pedagogical advantages compared to traditional learning methods.

The real challenge of eLearning is to produce content that brings a general improvement in the way students learn and the way teachers teach. But the design and production of high-quality digital content has turned out to be harder than expected, the main reason being that it requires the convergence of many kinds of experts in parallel to the convergence of the several technologies involved. In the case of mathematics, the least amount of expertise asks for the presence of professional mathematicians, software engineers and perhaps learning theorists that can productively talk to each other. To channel this expertise in order to enhance the quality of eContent in mathematics is the main goal of the further effort.

8. ACKNOWLEDGMENT

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Representing Variants Including Quality Attributes

Clotilde Rohleder

Abstract. Developers must seriously address Non-Functional Requirements (Quality of Service) in the production of software families that include variants for different customers. Most prior research in this area deals with design and implementation aspects such as mechanisms that help implement the variability in software architecture. Few researchers have addressed how to represent variability in Non-Functional Requirements. This paper proposes a goal driven approach that captures the variability at both Functional and Non-Functional Requirements level. We use a goal driven formalism to represent the feature variability including the quality attributes through relationships. Our approach provides a global view of variants having different quality attributes and facilitates matching between the requirements and the product. It exposes the user to the choices that are relevant to the satisfaction of user goals. To identify the impact of Non-Functional Requirements on variants, we represent the Non-Functional Requirements by goals according to several decomposition methods. We capture the variability through requirements analysis and represent the variants through a goal-driven modeling formalism called "map." Each variant has its own quality attributes.

Keywords: Software variability, Quality of Service, Non-Functional Requirements.

1 Introduction

Developing any system, even one for a single customer, requires addressing the customer's Functional and Non-Functional Requirements (Quality of Service). Unfortunately, as mentioned in [4] and [5], most prior researchers have neglected the representation of the variability of requirements and have not addressed the impact of Non-Functional Requirements on variants [2], [3], [9], [10], [15].

We propose treating the variability from a Functional and Non-Functional Requirements perspective. To identify the impact of Non-Functional Requirements on variants, we propose to represent the Non-Functional Requirements by goals [6], [7], [8],[14] according to the decomposition methods of [1], [6], [7], [8] and [14], and to capture the variability through requirements analysis and to represent the variants through a goal-driven modeling formalism called "map" [12], [13], [4] and [5].

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Each identified variant will have its own quality attributes.

The remainder of this paper is structured as follows. Section 2 introduces the Quality Variation Model, including the variant formalism using map, and the Non-Functional representation using NFR decomposition. This section shows with an example how to represent variability including Non-Functional Requirements. Finally, we summarize our work and conclude with plans for future work

2 Quality Variation Model QVaM

2.1 Overview of our model

In moving to the target systems, we consider design techniques of map to achieve Functional Requirements represented as goals and strategies. Functional Requirements are represented as variants. A variant is a representation at requirements level of a cohesive bundle of system functionalities according the user's point of view. In the variant representation, we include the Non-Functional Requirements and translate the impact of Non-Functional Requirements on Variants as quality attributes. During variants selection one can apply the impact rules of the represented Non-Functional Requirements on variants. This variants selection shows consequences at design level by the selection, implementation or configuration of system functionalities

2.2 Variants

Variants are based on the map model [12], [13], [4], [5]. Map is a process model expressed in a goal driven perspective. It provides a system representation based on a non-deterministic ordering of goals and strategies. Map features have four kinds of relationships, namely *multi-thread*, *bundle*, *path* and *multi-path*. These relationships show the possible combination of features from which the user can select the appropriate ones according to user needs. We map these combinations of features to variants. A **variant** is a representation at requirements level of a cohesive bundle of system functionalities according the user's point of view. We define different variant types corresponding to the different relationship types inside the map: *atomic*, *simple* and *composite* variant.

Textual notation of variants

We describe variants with codes (Table 1). Additionally we need the variant name, the

Source goal, the Target goal, the Manner and Application Rules [4], [5]. For all variant types, the *name* of the multi-path composite variant is the target goal. The *source and target goals* are source goal (which has the code *a*) and a target goal (which has the code *b*). The *manner* is expressed by a strategic path. Table 1 shows all variant codes and strategic path (*Q* is the intermediate goals bundle).

Variant types	Variant Code	Strategic path
Atomic Variant	ab_k	ab_k
Simple Variant with Alternate Choice	SVa_{ab}	$\otimes(ab_1, ab_2, .., ab_n)$
Simple Variant with Multiple Choice	SVm_{ab}	$\vee(ab_1, ab_2, ..., ab_n)$
Path Composite Variant	$CVp_{a,Q,b}$	$.(V_i, ..., V_n)$
Multi-Path Composite Variant	$CVm_{a,Qi,...,Qn,b}$	$\cup(V_i, ...V_n)$

Table 1. Textual representation of variants

2.3 Integration of Non-Functional Requirements

NFRs are rarely "satisfied" in a particular clear-cut sense [6], [7]. Instead they affect decisions to contribute to, or hinder that a particular goal. Therefore, we used goals satisficing to suggest that generated software is expected to satisfice NFRs within acceptable limits, rather than absolutely. To concretely analyze and understand the impact of each NFR on variants, we have to decompose the NFRs into quality softgoals [1], [6], [7], [8] and [14]. Figure 1 shows the graphical and textual representation of Non-Functional Requirements. Graphically the NFR is represented by a circle. The NFR circle is named by the identified NFR and its decomposed NFR goal within brackets. For the textual representation of the NFRs goals, we need a *code,* a *name,* a *subject goal, satisficing data,* and a *coefficient*.

Graphical representation	Textual representation
NFR Code [NFR subject goal]	Code: <NFR Code> Name: <NFR name> Subject Goal: <NFR subject goal> Satisficing Data: <absolute satisficing result, relative satisficing result> Coefficient: <Importance weight of NFR>

Figure 1. Representation Non-Functional Requirements

2.4 Representation of NFR Impact on different types of variant

After having captured, defined and represented the variants and the NFRs, we research the impact of NFRs on variants. To consider the impact of Non-functional Requirements on variants, we use a catalogue of interrelationships that describe contributions of Non-Functional Requirements toward meeting goals/variants. We use satisficing links whose five values are recorded in Table 2.

NFR Impact on Variants	Very positive impact	Positive impact	Neutral impact	Negative impact	Very negative impact
Symbol	++	+	?	-	--

Table 2. Different NFR impact values on variants.

2.4.1 Atomic variants are not decomposable into other variants. They are linked directly to system functionalities. An atomic variant describes how to reach *directly* the target situation (concretized by the target goal satisfaction) from a initial situation (that has been reached after the source goal has been realized). The atomic variants are linked with each other to build variants with bigger granularity (simple or composite).

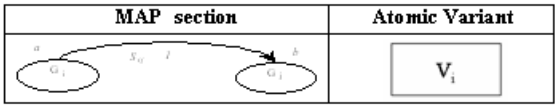

Figure 2 Example of map section and representation of its corresponding Atomic Variant.

These links associate the NFRs with variants and they describe which NFR gives which impact on which variant. The information concerning the NFR impact on each variant will be considered as a quality attribute for this variant. We will first deal with the graphical representation and then the textual representation of NFR impact on variants. The representation of NFRs'impact on variants requires satisficing links. We start the satisficing link from the NFR decomposed goal to the variant represented by a circle. The end of the link does not touch the variant circle to avoid confusion with the decomposition process explained by [6], [7], [8] and [14]. The link is completed by the satisficing NFR impact results. **Figure 3** is an example of representing some Atomic Variants with quality attributes.

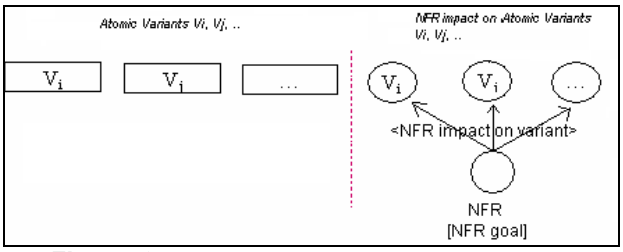

Figure 3. NFR Impact on Atomic Variants

2.4.2 Simple variants represent requirement variability by grouping the atomic variants that are linked either by an *alternate choice link* (Simple Variant with Alternate Choice) or by a multiple choice link (Simple Variant with Multiple Choice). In the first case, the atomic variants are mutually exclusive. This link expresses an exclusive choice between all atomic variants. Only one variant can be selected among several. Each atomic variant represents a manner or a

distinct strategy in order to reach the variant target goal from its source goal. In the second case at least one atomic variant must be selected. The atomic variants are complementary. The satisfaction of target goal is done through the selection of one or more among those variants.

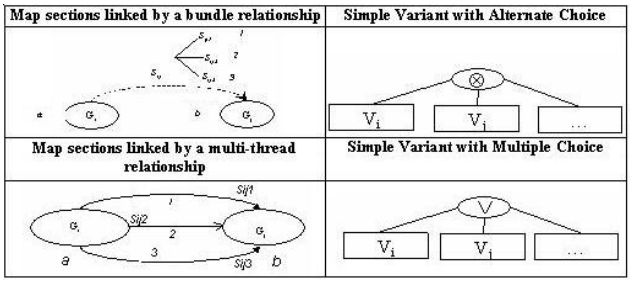

Figure 4. Map sections linked by a bundle or multi-thread relationship and Simple Variant with Alternate or Multiple Choice.

In order to implement the NFR Impact of Simple and/or Composite Variants without losing the understandability of the graphical representation, we have developed a NFR impact hierarchy. The main architecture principles are defined as follows. The NFR impact architecture implements the different variation types in assigning a NFR impact layer to each variant of our model. In choosing to perform the NFR impact for each atomic variant separately, we can then get the NFR impact of a bundle of atomic variants that are linked by an alternative or a multiple choice, on a higher layer. **Figure** 5 is an example of graphical representation of Simple Variants including quality attributes.

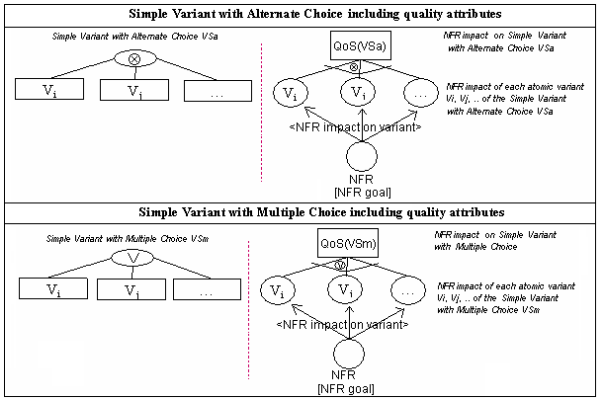

Figure 5. Simple Variants including quality attributes

2.4.3 Composite Variant

The Path Composite Variant consists of a *simple composition link* which links atomic variants, simple variants and/or composite variant, under a plan form which defines the order in which the variants must be realized. In a general way, a path composite variant is grouping all possible variants combinations between a source and a target goal through the satisfaction of an intermediate goals bundle. Each combination goes through the same intermediate goals bundle. The variations are in the manners that lead to satisfy each goal of the intermediate goals bundle. A Multi-Path Composite Variant expresses a variation in the selection of the intermediate goals which lead to satisfy the target goal from a source goal. Each possible combination of intermediate goal builds a distinct way. The satisfaction of the target goal implies the selection of distinct intermediate goals. Structurally, a Multi-Path Composite Variant (Figure 6) consists of a *multiple composition link* between variants. The Multi-Path Composite Variant must consist of at least one Composite or Simple Variant. Each sub variant is a possible variant combination which constitutes a possible way between source and target goal.

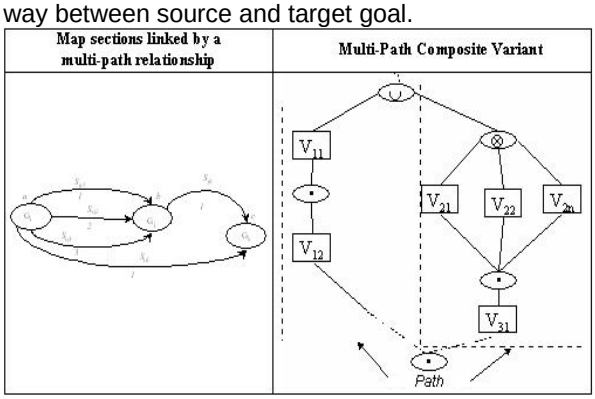

Figure 6. Map sections linked by a multi-path relationship and Multi-Path Composite Variant

In applying the same approach with variants which are linked with each other by a simple composition link, we get the NFR Impact of Path and Multi-Path Composite Variant in setting the NFR impact of each path. The NFR impact of the root variant is computed by the NFR impact of the sub variants. The NFR impact of the sub variant can be self computed by another NFR impact if the variant is self composed by sub-paths. So, the representation of the NFR impact of a composite variant consists of a hierarchy of NFR impacts which are linked by composition. **Figure** 7 represents the NFR impact of a Composite Variants.

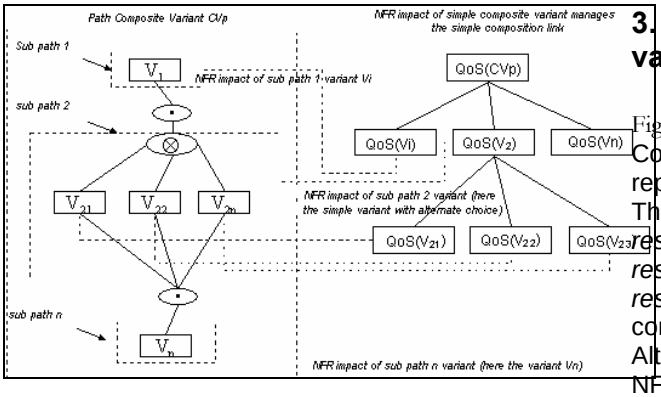

Figure 7. Composite Variants including quality attributes

The textual representation of NFR Impact on Variants completes the textual representation of variants [4], [5] using the NFR dimension that is considered as a quality attribute for this variant. The notation of the quality attribute inside the textual representation of variant Vi is QoS(Vi), which means Quality of Service of variant Vi. The quality attributes of the variant Vi is written as follows:

QoS(<Vi>*)*= <Vi>.NFR1[goal$_{NFR1}$].<ImpactValue>…<Vi>.NFR$_n$.[goal$_{NFRn}$].<ImpactValue>

3. Example of representing the variants with quality attributes

Figure 8 is the representation of the Path Composite Variant CVp$_{a\{b\}c}$. This variant represents the cancellation of a paid reservation. The letter *a* is the code of the goal *To make a reservation*, *b* is the code of goal *To pay for a reservation* and *c* is the code of goal *To cancel a reservation*. *SVa$_{ab}$* and *bc$_1$* are the corresponding codes of the Simple Variant with Alternate Choice and the Atomic Variant. The NFR Impact of CVp$_{a\{b\}c}$ will consider the quality attribute of *SVa$_{ab}$* and *bc$_1$*. The NFR impact on atomic variants *ab$_1$*, *ab$_2$* and *ab$_3$*, which build the quality attribute of Simple Variant with Alternate Choice S*Va$_{ab}$* are represented through circles linked by the symbol of alternate choice link «⊗». The NFR impact of atomic variant *bc$_1$* is attached to the other NFR impact by the sequence link symbol «.».

For example, the quality attribute of Atomic Variant *ab$_1$* is QoS(ab$_1$) = ab$_1$.Performance[PerfGoal].++, ab$_1$.Security[SecurGoal].++. The quality attribute of Simple Variant with Alternate Choice *SVa$_{ab}$* is QoS(*SVa$_{ab}$*)) ⊗ [QoS(ab$_1$), QoS(ab$_2$), QoS(ab$_3$)]. The quality attribute of Path Composite Variant CVp$_{a\{b\}c}$ is QoS(CVp$_{a\{b\}c}$) = .[(QoS(SVa$_{ab}$)), (bc$_1$.Informativeness[InformGoal].+)].

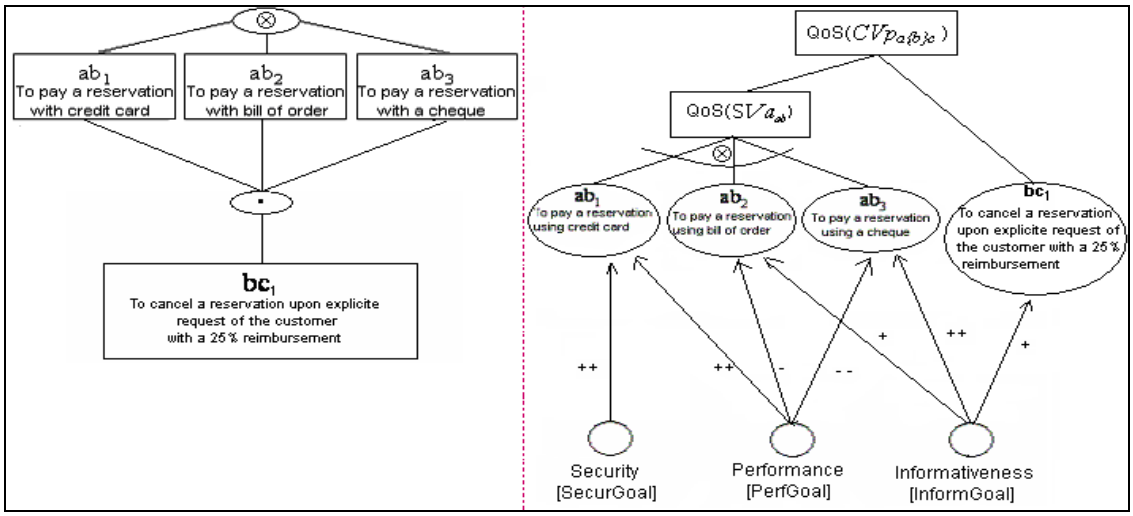

Figure 8. Graphical representation of NFR impact on Path Composite Variant CVp$_{a\{b\}c}$

4 Conclusion

This paper proposes a new way to express quality feature variability. We use a goal driven formalism to represent the feature variability including the quality attributes through relationships. Through our approach, the customer gets a global view of variants having different quality attributes without being lost in technical details. A representation of the variants at the Functional and Non-Functional Requirements level facilitates the matching between his requirements and the product. However, our proposal is a work in progress. In further work we will consider the task of building the correct derived product for different companies.

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Sequential Structure of Objective Knowledge with an Application to Learning System

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***Abstract*—**We deal with knowledge structure of (operation) sequences, where the operation may contain information on acquisition of objective knowledge. A sequence of operations makes a performance of procedure causing situation transitions, where the system based on formation of operation sequences has characters such that: (1) the operations are regarded as media for objective knowledge, which may denote not only objects but also primitive procedures, (2) the situation is referred to by name, and (3) the organization of operation sequences may be automated. We apply such knowledge structure to implementation of a learning system such that it is mainly constructed to take formation of operation sequences for exercise practice in programming language.

Index Terms—*Knowledge structure*

1. INTRODUCTION

This paper deals with a model for a method of how to organize an automated process of learning. The conceived theory is concerned with a system for sequential structure of objective knowledge. As regards the proposed system, some artificial intelligence frameworks may be relevant.

(1) There have been some trend in e-learning systems, regarding adaptive aspects [9][19] or the tutoring one [22].

(2) The logical analysis standpoint has contained a wide range of formal systems since its organization ([11][15][17]).
- Hybrid logic, which involves both state-dependent and modal operators, is a formal system with logical meanings of states and worlds ([1][2]).
- Relations between the events are discussed through predicates in classical and modal logic ([7][13]). The event as the cause-and-effect relationship is made clear from the view of complexity ([10]).

(3) Correlation between action and knowledge has been also studied ([20]). A mathematical behaviour of action is also formulated in [18].

(4) The agent technology style is compiled in [21], where algebraic approach originates from [12][16].

As current topics, the e-learning methodologies are closely related to the problem which this paper deals with. Among the methodologies, the e-learning systems involve adaptive aspects [8] so that the exercise may be devoted to adaptation. From the visualization view of points, we have an implemented system of adaptive e-learning ([24]). The concept of adaptation is regarded as primary for e-learnings as in [4][5][6]. On the other hand, the concept of tutoring for navigation as in [3] is relevant to methodologies of self-learning. Observing adaptation and tutoring methodologies, we pay attention to mechanization of learning process with reference to exercise practice.

To learn programming languages, the exercise practice can be of use. This is because some compilation of exercise practice to acquire knowledge may conceive automated process of learning step by step:

- An exercise is by itself basic, if we complete it.
- An exercise leads to subsidiary exercises for recovery learning, if we do not complete the original exercise.

We can continue to learn by ourselves, trying exercises and following the way depending on whether we complete the given exercise, or we do not complete but take recovery with subsidiary exercises. If we could observe an automated process of learning as above mentioned, then it may be mechanized for the learner's manual. This is why we organize an automated process of learning with reference to exercise practice.

We focus on the design problem of a formal system for exercise practice in programming language. The formal system contains the constraints:

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(a) the exercises are organized in advance.
(b) the practices are interactive with respect to situations.
(c) an interactive effect of practice causes situation transition and a step to the next exercise.

We then design a formal system whose mechanism is analyzed as follows. A sequence of operations $x_1 \cdots x_n \ (n \geq 0)$ makes a performance of the form $\sigma_1, Sem[x_1], \sigma_2, Sem[x_2], \sigma_3, \cdots, \sigma_n, Sem[x_n], \sigma_{n+1}$ where $Sem[x_i] \ (1 \leq i \leq n)$ denotes an implementation of the operation x_i, and $\sigma_1, \cdots, \sigma_{n+1}$ are a corresponding sequence of situations. The system regarding formation of operation sequences has characters such that

(i) the operations contain objective knowledge,
(ii) the situation is referred to by name, and
(iii) the organization of operation sequences may be automated.

The paper is organized as follows. Section 2 is concerned with a formal system. In Section 3, we have a procedure for formation of operation-sequences. In Section 4, we have an application of the system to exercise practices in programming. Section 5 contains concluding remarks.

2. FORMAL SYSTEM FOR KNOWLEDGE STRUCTURE

For the formation of operation sequences, we formulate a formal calculus of illustrating it in [23][28]. Different from the previous works, the system of this paper is constructed with top down rule base so that it is applied to exercise practices in programming. Compared with the former version, we have elaborate points for implementation of a language learning system. If we need a rule to substitute a sequence of operations for the operation x, that is, a logic program: $x \leftarrow$, or $x \leftarrow y_1, \cdots, y_n \ (n > 0)$, then the performance may be
$Sem[\varepsilon], Sem[x],$
$or\ Sem[y_1], \cdots, Sem[y_n], Sem[x].$
In this paper, to make the rule of substituting operations for an operation by top-down design, we regard it as defined for an operation x such that $x \to \varepsilon$, or $x \to y_1, \cdots, y_n \ (n > 0)$, and the performance is a sequence of
$Sem[x], Sem[y_1], \cdots, Sem[y_n],$
$or\ Sem[x], Sem[\varepsilon].$
That is,

The sequential relation of operations is in this paper determined by rewriting rules, but not by logic programs with negation (as in [25][27][29][30]).
The top-down application of operations is preferable, while the bottom-up application is adopted in the former version.
A performance is caused by implemented operation sequences with situation transition sequences:
$\sigma_1, Sem[x_1], \sigma_2, Sem[x_2], \sigma_3, \cdots, \sigma_n, Sem[x_n], \sigma_{n+1}$
.
A rewriting rule is used as a form: $x \to \varepsilon$ (empty sequence), or $x \to y_1, \cdots, y_n \ (n > 0)$ for an operation x to be involved in a sequence of performance. In this section, the system is formulated by means of rewriting rules.
This version of the system is a model to effectively perform a sequence of operations for learning.
A system is a quadruple $\Im = (C, \sum, Sem, R)$, where:

(i) C is a set of operations.
(ii) $\sum$ is a set of situations.
(iii) $Sem : C \to (\sum \to \sum)$ is a semantic function.
(iv) R is a set of rewriting rules of the form $A \to \alpha \ in \ C \times C^*$. Note that $C^* = \{x_1 \cdots x_n \mid n \geq 0, x_1, \cdots, x_n \in C\}$.
The empty sequence in C^* is denoted by ε.

A member of C^* is a sequence of operations. The semantic function Sem is extended. The original function assigns a situation transition to each operation. Intuitively speaking, the extended function Sem assigns a situation transition to each sequence of operations so that it gives a meaning of a sequence over objective knowledge of operation.

Definition 1. The semantic function Sem is extended to be a function $Sem : C^* \to (\sum \to \sum)$ by:

(1) $Sem[\varepsilon]\sigma = \sigma$.
(2) $Sem[\gamma x]\sigma = Sem[x](Sem[\gamma]\sigma)$ $(x \in C, \gamma \in C^*)$.

Inference rules for $\Im$ by means of the follower relation R :

We define the derivation as the least set satisfying the closure of following inference rules (1), (2) and (3), on the assumption that a system $\Im = (C, \sum, Sem, R)$ is given. (See [14] for such formality in signed data.) We denote the

derivation of $move_R(G;\sigma_1;\sigma_2)$ by applying the inference rules (1)-(3) finitely many times, with the predicate $move_R(G;\sigma_1;\sigma_2)$.

(1) $\dfrac{}{move_R(\varepsilon;\sigma;\sigma)}$

(2) $\dfrac{(x \to G) \in R \quad move_R(G;\sigma_3;\sigma_2) \quad Sem[x]\sigma_1 = \sigma_3}{move_R(x;\sigma_1;\sigma_2)}$

(3) $\dfrac{move_R(G_1;\sigma_1;\sigma_4) \quad move_R(G_2;\sigma_4;\sigma_2)}{move_R(G_1G_2;\sigma_1;\sigma_2)}$

In other words, the relation $move_R \subseteq C^* \times \sum \times \sum$ is defined such that by $move_R(\gamma;\sigma_1;\sigma_2)$, we mean that:
Given the sequence γ initiated, the situation transition from σ_1 to σ_2 is caused by rewriting and reducing γ to the empty sequence.

3. FORMATION OF OPERATION SEQUENCES

Semantics of a sequence of operations is defined for the system $\Im = (C, \sum, Sem, R)$. The following lemma suggests a relation of the application of the Sem function to concatenation of two sequences β and γ with the composition of Sem functions.

Lemma 1. Assume a system $\Im = (C, \sum, Sem, R)$. Then
$Sem[\beta\gamma]\sigma = Sem[\gamma](Sem[\beta]\sigma)$.

Proof. It is proved by induction on the structure of the sequence γ.

(1) In the case that $\gamma = \varepsilon$,
$$Sem[\beta\gamma]\sigma = Sem[\beta]\sigma = Sem[\gamma](Sem[\beta]\sigma)$$

(2) In the case that $\gamma = \gamma_1 x$ for some $x \in C$,
$$\begin{aligned} Sem[\beta\lambda]\sigma &= Sem[\beta\gamma_1 x]\sigma \\ &= Sem[x](Sem[\beta\gamma_1]\sigma) \\ &= Sem[x](Sem[\gamma_1](Sem[\beta]\sigma)) \\ &\quad (by\ induction\ hypothesis) \\ &= Sem[\gamma_1 x](Sem[\beta]\sigma) \\ &= Sem[\gamma](Sem[\beta]\sigma) \end{aligned}$$

Now assume a system $\Im = (C, \sum, Sem, R)$. We need a procedure to form a sequence of operations for the system $\Im$. The procedure contains not only deterministic cases but also nondeterministic ones to get an existing sequence. ***Operation-sequence formation for*** $\Im$***:***

$Formation(G;\sigma_1;\sigma_2) \Leftarrow$
if $G = \varepsilon$
then
  if $\sigma_1 = \sigma_2$ **then** ε (empty sequence)
else
  if $G = xG_2$ such that $x \to G_2$ is in R
  then
    if $Sem[x]\sigma_1 = \sigma_3$
    then $x.Formation(G_1G_2;\sigma_3;\sigma_2)$
  else
    if $G = G_1G_2$ such that
      $Formation(G_1;\sigma_1;\sigma_4)$ and
      $Formation(G_2;\sigma_4;\sigma_2)$ are defined
    then
$Formation(G_1;\sigma_1;\sigma_4)Formation(G_2;\sigma_4;\sigma_2)$

By means of the above procedure $Formation$, we can have an operation-sequence formation for the relation $move_R(G;\sigma_1;\sigma_2)$. That is, if we could have the predicate $move_R$ on the triplet of G (a sequence of operations), and two situations σ_1 and σ_2, we may have some sequence β to cause the situation transition from σ_1 to σ_2.

Theorem 1. Assume that $move_R(G;\sigma_1;\sigma_2)$ for some $\sigma_1, \sigma_2 \in \sum$. It follows that
$\exists \beta \in C^*.[Sem[\beta]\sigma_1 = \sigma_2]$.

Proof. Assume that $move_R(G;\sigma_1;\sigma_2)$ for some $\sigma_1, \sigma_2 \in \sum$. Take the procedure for operation sequences. By structural induction on the sequence, we see that if $Formation(G;\sigma_1;\sigma_2)$ yields γ, then $Sem[\gamma]\sigma_1 = \sigma_2$.

(1) If $G = \varepsilon$, then $\sigma_1 = \sigma_2$ so that $Formation(\varepsilon;\sigma_1;\sigma_1) = \varepsilon$ and $Sem[\varepsilon]\sigma_1 = \sigma_1$.

(2) If $G = xG_2$ for some operation x and $Sem[x]\sigma_1 = \sigma_3$ such that $move_R(xG_2;\sigma_1;\sigma_2)$, then we must assume that some rule $x \to G_1$ is in R, and $move_R(G_1G_2;\sigma_3;\sigma_2)$. Assume that $Formation(G_1G_2;\sigma_3;\sigma_2)$ yields γ_1, and that $Sem[\gamma_1]\sigma_3 = \sigma_2$. By the procedure, $Formation(G;\sigma_1;\sigma_2)$ provides $x\gamma_1$. It follows that

$$Sem\left[x\gamma_1\right]\sigma_1 = Sem\left[\gamma_1\right]\left(Sem\left[x\right]\sigma_1\right) = Sem\left[\gamma_1\right]\sigma_3 = \sigma_2$$

(3) If $G = G_1G_2$ such that relations $move_R\left(G_1;\sigma_1;\sigma_4\right)$ and $move_R\left(G_2;\sigma_4;\sigma_2\right)$, then we must assume that $move_R\left(G_1G_2;\sigma_4;\sigma_2\right)$. Assume that $Formation\left(G_2;\sigma_1;\sigma_4\right)$ yields a sequence β and $Formation\left(G_2;\sigma_4;\sigma_2\right)$ yields a sequence γ, respectively such that $Sem\left[\beta\right]\sigma_1 = \sigma_4$ and $Sem\left[\gamma\right]\sigma_4 = \sigma_2$. It follows that $Formation\left(G_1G_2\right)$ provides a sequence $\beta\gamma$ such that

$$Sem\left[\beta\gamma\right]\sigma_1 = Sem\left[\gamma\right]\left(Sem\left[\beta\right]\sigma_1\right) = Sem\left[\gamma\right]\sigma_4 = \sigma_2$$

by means of Lemma 1. This concludes the proof.

Implementation for Exercise Practice

For a learner to practice exercise, the system is implemented. The system is regarded as providing a learning course. That is, automated process of learning is offered by means of courses involving exercises in the programming language ML (as in [26]).

Module	*Elements*
Database	*Operation table* *Exercise table* *Course table* *(A set of rewriting rules)*
Operation management	*Operation provider* *Grade checker* *(Generation of semantic function)* *Next operation decider* *(Based on the inference rule)*

Table 1. System Construction.

The system is constructed as shown in Table 1, where it contains two modules.

Databse which is constructed by means of MySQL, for data involved in the system.

Operation management (engine) which provides chart sequences with interaction of learners.

(1) Database

The system makes use of three tables:

Operation table

Exercise table

Course table

These tables are supposedly given by some expert in ML programming.

(a) The *Operation table* involves the operations which learners use. The operation contains the explanations and examples. It is observed by Web-browser such that it is written in terms of html-file. The *Operation table* consists of a relation between the operation and its html-file.

(b) The Exercise table involves examination problems for test, by which learners' grade of understanding is evaluated. The examination problem is made by some expert and observable by Web-browser.

(c) The *Course table* involves courses of learning languages from operations in order. They are rule-based.

(2) Operation management engine

The *Operation management* is a module to provide the operation, evaluate the answer of the learner for the examination problem, and decide what operation to be next provided. It contains three parts:

Operation provider which demonstrates the indicated operation for each course.

Checking the grade of understanding for learners.

Decision of the next operation which is made for the course.

For example of an ML learning course, we have an operation named by "*ML_standard_course*" which contains operations named by:

(a) "*BasicType*"
(b) "*Function Definitions*"
(c) "*Local Environment*"
(d) "*Exception*"
(e) "*HigherOrderFunctions*''
(f) in the case that we could not be successful in some interaction regarding the operation *ML_standard_course*.

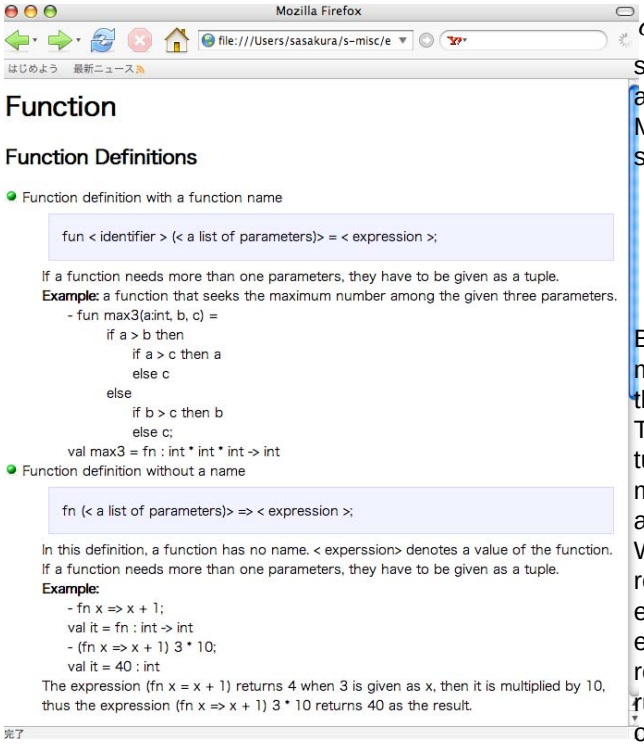

Figure 1. Web page for definition.

Even if a routine of the process fails, some recovery routine is ready until it is successful. That is, the rewriting system is adopted like the forms:

$x \to \varepsilon$ (in a successful case)

$x \to y_1 \cdots y_n$ (in a recovery case)

We demonstrate a part for exercise practices of some subsets of ML. We present a structure of function definition containing an operation "*FunctionDefinitions*" in Fig. 1. It contains syntactic explanations in the cases of function definitions with name and without name. In each case, a simple and typical example is illustrated.

By the operation, we can refer to the exercise. Three questions and exercises are set, which are based on [26], while the system may work in response to answers for the exercises. The reaction of the system causes a situation transition so that the system, by rewriting rules, provides the next operation(s).

4. CONCLUSION

We present a formal system to obtain a performance of sequences

$\sigma_1, Sem[x_1], \sigma_2, Sem[x_2], \sigma_3, \cdots, \sigma_n, Sem[x_n], \sigma_{n+1}$

where $Sem[x_i]$ $(1 \le i \le n)$ denotes an implementation of the operation x_i, and $\sigma_1, \cdots, \sigma_{n+1}$ are a corresponding sequence of situations. Based on the system, we implement an e-learning system for the beginner to practice ML programming exercise. We are now ready to say that:

(i) The operation sequence is a learning process in terms of rewriting rules.

(ii) The situation is abstract to be applied to some constraint on the formation of operation sequences.

Because the rewriting rule is regarded as a given method for self-learning, this paper suggests that this formal system is applicable to an e-learning. The methodology is not always adaptive, nor a tutoring. The implemented system offers a method different from proper adaptive methods and tutoring systems.

We have some remark on the manner of giving rewriting rules. For the system to implement exercise practices, we must design: (a) the exercise assigned to each operation, (b) the relation of the operations by means of rewriting rules, and (c) the situation transition which an operation causes.

We may assume the integrity constraint on the situation set, if the situation transition should be restricted. As far as the integrity constraint on the set of situations is recursively enumerable, we can effectively form a sequence of operations for the specified initial sequence with the situation transition.

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E-Learning: An Assessment Tool Based on a Bayesian Approach

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Abstract - Assessment of student learning is an important task in a teaching and learning process. It has a strong influence on students' approaches to learning and their outcomes. But what is assessment? Assessment, in the context of education, is the process of characterizing what a student knows. The reasons to perform evaluation are quite varied, ranging from a need to informally understand student learning progress in a course to a need to characterize student expertise in a subject. Finding an appropriate and effective assessment approach is a central challenge in designing a tutoring approach. However, it sometimes happens that the assessment criteria and their corresponding weights are solely determined by the lecturers in charge and on the other hand an effective assessment program is extremely difficult to maintain as class sizes increase. The aim of this paper is the introduction of a tutoring approach based on the assessment results. This strategy is mainly developed for the supporting of the E-Learning formative process. The starting point of the proposed approach is the representation of the course knowledge domain by the use of the ontology formalism. In this way, by an original mapping strategy between ontology and Bayesian network, we can design a tool for the generation of adapted questionnaires in order to test the student's knowledge of every domain's subject. Analyzing the obtained results of the evaluation an intelligent tutoring system can help students offering an effective support to learning process and adapting their learning paths.

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1. INTRODUCTION

Our "information-oriented" society shows an increasing demand of life-long learning. In such framework, on-line learning is becoming a real solution that allows flexibility and quality in the learning process. In the last decade the evolution on educational technologies forced an extraordinary interest in new methods for delivering learning content to learners. Distance education represents today an effective way for supporting and sometimes substituting the traditional formative processes. However the role of technology has often been overestimated and on the other hand the amount of information students can obtain from the Internet is huge and they can easily be confused. Teachers can also be disconcerted by this quantity of contents and they are often unable to suggest the correct contents to their students. In the open scientific literature, it is widely recognized that an important factor of this success is related with the capability of customizing the learning process for the specific needs of a given learner. This feature is still far to have been reached and there is a real interest for investigating new approaches and tools to adapt the formative process on specific individual needs. In this field the assessment phase is acquiring a strategic interest. In fact, assessment is an important and difficult task in the whole teaching and learning process [1][2]. It has a strong influence on students' approaches to learning and their learning outcomes. An effective assessment program is extremely difficult to maintain as class sizes increase. One recent analysis [EXC00] showed that, for classes in excess of 100 students, the instructor devoted more time to preparing and marking just the final examination than to all teaching duties: lecturing, lecture preparation, tutorials, etc. Other studies have shown that the assessment system is the main influence on how students structure their learning, determining both their effort and their focus [MIL74], [SNY71]. Further, less assessment entails less feedback to students, and for large classes feedback may be delayed significantly. The importance of prompt feedback is well established [FRE87], [MEH98]. One landmark study concluded that "formative assessment is an essential component of classroom work. We know of no other way of

raising standards for which such a strong prima facie case can be made" [BLA98].

Traditionally assessment activity has been seen like task aside of the e-learning process and there is a danger in focusing research on assessment specifically, as this tends to isolate the assessment process from teaching and learning in general [BAR05]. This is a not effective approach: the evaluation should be one of the first considerations of design when you prepare an online course, integrating it in the program and not considered by apart [KEN00]. On the other hand the implementation of an effectiveness on-line evaluation strategy can be very difficult. It is very common opinion that the assessment phase is the weak point in the e-learning process. There are two problems in this phase. The first one is related to the concept of virtual identity (a typical problem in the internet world). The latter expresses the difficulty of teacher in the evaluation of student's knowledge on the basis of few data. Many of currently existing E-Learning assessment systems focus on simple assessment strategies, e.g. only on single or multiple-choice questions (MCQ) with several answers, and radio-buttons to select the correct answer. Furthermore most of them are unable to support the different needs of individual users and focus mainly on the assessment of the "average user". In this way teachers can give only a mere quantitative evaluation of students' knowledge and cannot fill in the gaps in their learning approach. In particular teacher cannot know if the proposed learning path or the teaching approach is really effective for students. Assessment provides an effective method to gather information about student's learning and it is a good starting point in order to arrange feedback's strategy. Finding an appropriate assessment tool is a central challenge in designing an assessment approach [4], [5]. The difficulty arises because of the diversity of learning objectives [4], the diversity in what counts as evidence of learning, the diversity of tools available, the varying resources available, and the varying assessment contexts. One way to address these various assessment goals and challenges is through the use of concept maps [RIC98][TUR00], which are node and arc representations of the relationships among concepts. Concept maps represent a valuable assessment tool because they provide a means to capture and represent student knowledge and are particularly effective for representing the organization that students see among concepts [SHU02]. So starting from this general framework in this paper we describe our system for assessment and tutoring based on Ontology formalism (the generalization of concept maps) and metadata standards. The concept of ontology was taken from philosophy where it means a systematic explanation of being. In recent years, however, this concept has been introduced and used in different contexts, thereby playing a predominant role in knowledge engineering and in artificial intelligence [7]. In E-Learning field ontology can easily manage the knowledge domain of a course allowing a more detailed organization and adaptation of student's learning path. This task can be accomplished through the combined use of the ontology formalism and the user and learning object through metadata standard [8]. Ontology explains in a generic and intuitive way the organization of a course. In particular teacher can delineate the course's subjects and the relationships between the same one. In the next section of this paper we give more details about ontology. In this paper we represent ontology through Bayesian Networks formalism because in this way we can depict and estimate the preparatory links between the various subjects belonging to knowledge domain. In this way it is easier to understand the real knowledge shortage of students [9]. In fact teacher or an Intelligent Tutoring System can build and analyze questionnaires keeping in mind the reference ontology and the relationships between the subjects. In this paper we design and implement a tool that arranges the best assessment strategy and adapts the best learning path according to the information inferred by the analysis of questionnaires. Our tool can test the knowledge of students on every subject of ontology adopting various approaches. For example it can examine deeply some subject rather than other if student shows some lacks in certain subjects. The Bayesian approach, used for the representation of ontology, allows quantizing the probability of correct answer of students in a particular subject. In this way tool can propose to the student the question with the lower (or higher) probabilities of correct answer. At the end of the assessment student's profile is updated and at the same time tool proposes the most suitable learning objects in order to improve their knowledge. The paper is organized as follows: in Section 2, we provide the motivations and the details of the proposed assessment tool. In particular we give some details on ontology and their mapping through Bayesian Networks. In section 3 we describe the proposed approach. In section 4 the experimental results are reported. Finally, in the last section we draw conclusions and indicate future directions of our research.

2. AN ONTOLOGY APPROACH FOR SUPPORTING ASSESSMENT PHASE

Some of the tasks that an E-Learning platform should carry out are to allow people to find, evaluate and acquire adapted learning objects. These activities are common and easy to carry out in traditional learning processes; however, we can not say the same when new technologies are used. While designing and organizing a course, a teacher has to choose the most appropriate training contents: this digital contents' selection presents notable difficulties, also due to the huge amount of information available, of which only a minimum part really meets teachers' needs. The possibility of accessing to contents that could be useless or not related to the subjects of interest is considerable. A solution to these problems derives from the ever more detailed description of each training contents, a process known in literature as process of creating metadata. Metadata is descriptive information and is data about data [10]. The E-Learning industry is concerned with establishing rules to be commonly used in the process of creating metadata and, consequently, in describing contents, users, ontology and course structure. In particular the use of standardized metadata allows current E-Learning platforms to integrate new and more powerful services. In fact, in addition to reusability and sharing of training resources with other platforms, it is possible to design and implement "intelligent" services able to help students and teachers during the formative process. These services can add value to an E-Learning platform and guarantee an improvement in the pedagogical quality of the training process and adapt the learning path of every student. One of the most important services is the student's tracking: the selection, collection and analysis of a set of parameters of students' learning process that are essential for an effective teaching process organization. On the other hand in this framework a very important role is played by the assessment phase. Assessment gives to the learning environment the most direct information about the student's knowledge. The best assessment approach provides questionnaires that are built dynamically on the basis of the student model. Questions have to cover the topics most recently completed, as well as those that should be reviewed. Each question has a level of difficulty, which is also used in the updating phase of student model. Correctly answering a harder question demonstrates greater ability than correctly answering an easier one [11]. The assessment framework combines researches from two major research disciplines: adaptive educational hypermedia and semantic web technologies. Research in adaptive educational hypermedia has ascertained several techniques for adaptation [12]. These techniques can be divided into two categories: navigational level adaptation in which the learner is provided with a set of recommended links, and content level adaptation, which selects the text fragments that have to be assembled together for a specific user need. Through combining both techniques, the learner will be provided with a flexible learning process. It is worth noting that the assessment framework works at its best when it provides the learner with two kinds of content: learning content, containing the courses and their different sections, and assessment content, containing the tests for evaluation of the learner knowledge. During the learning process, a dynamic selection and presentation of both contents have to be accomplished. We have to underline that conceptualizing the learning process to its basic elements, we can identify at last the following elements [BAR05]:

- The educational material to be taught by the teacher
- The teaching and learning activities
- The assessment activity to measure the student learning
- The report of the score results given by the teachers to the students

As we can note, the tests and evaluations not only are an integral part of the learning process, but also is an element that complete and close a circular activity, contributing as a feedback source for: the users (giving the scores and feedback), for the instructors (by giving support and feedback) and for the instructional designer (to update the contents of the learning system) as well. This circular conceptualization of the learning process allow us to see the significance of the assessment because it helps to the adaptation of the system by setting a new user knowledge level, evaluating and determining new learning profiles, assign the user grades and, in consequence, performing user content re-adaptation.

In general the previously described framework can be implemented by the use of tools depicted in figure 1.

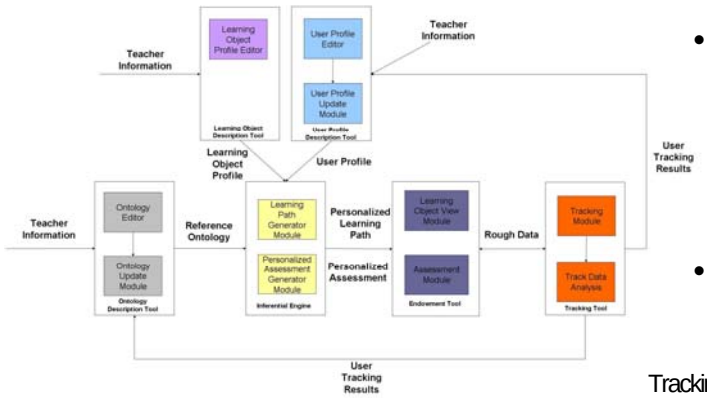

Figure 1: Student Learning Cycle

The previous schema could be considered as a general schema of a modern E-Learning environment. In the previous picture we have the following blocks:

- Ontology Description Tool: this tool allows the ontology definition. In particular teacher can build the reference ontology for a course but also introduce various levels of details for the same one. In fact for the same course teacher can define a basic ontology and, by the introduction of new topics, some advanced ontology. The Ontology Update Module can update the ontology and select one of the advanced ontology according to the information acquired during the learning phase.
- Learning Object Description Tool: this tool allows the description, according to the "de facto" standards that are in literature, of learning objects. This description could be used by the inferential engine in order to create the best personalized learning path.
- User Profile Description Tool: this tool allows the description, according to the "de facto" standards that are in literature, of the user learning model. It contains two distinct sub-models, one for representing the learner's state of knowledge, and another one for representing learner's cognitive characteristics and learning preferences (such as learning style, working memory capacity etc.). This distinction is made due to the fact that the first model (Learner Knowledge Space) can be frequently updated. On the other hand, learner's cognitive characteristics and learning preferences are more static and have the same property values during a significant learning period.
- Inferential Engine: this tool has the aim to build the personalized learning path and the personalized assessment. In particular by the combined use of student profile and learning object descriptions a personalized learning path could be built and updated.
- Endowment Tool: by the use of this tool students can access to learning object and collaborative services as chat, forum, e-mail and so on.

Tracking Tool: This module observes the student activity during his period of studying. The two main targets of this methodology are:

- to maintain up-to-date information about student model's parameters (as for example the studying time, the number and the average time used to study a learning resource, preparation level, level of interest for determined type of media

- to provide an evaluation of the learner action related to his entire learning path by using information acquired during the observation activity. In this way it is possible to evaluate the learner performance by providing a global assessment usually based only on the final test mark.

In this paper the attention is on the assessment phase and in particular in the designing of an adapted assessment generator. In the next section this approach is introduced and described in its main features. In particular the methodology for the description of ontology by the use of Bayesian Network is showed and how it is a good starting point for the introduction of new and smart services that will be introduced in the third section.

2.1. ONTOLOGY

The concept of ontology is originally taken from philosophy where it means a systematic explanation of being. In recent years, however, this concept has been introduced and used in different contexts, thereby playing a predominant role in knowledge engineering and in artificial intelligence [7bis]. In 1991, Neches stated that ontology defines the basic terms and relations comprising the vocabulary of a topic area, as well as the rules for combining terms and relations to define extensions to the vocabulary [1bis]. Later on, Gruber, in the context of knowledge sharing, used the term to refer to an explicit specification of a conceptualization [8bis]. Mizoguchi summarized the merits of ontology as following: "Ontology provides a common vocabulary, and an explication of what

has been often left implicit". According to Mizoguchi, the systematization of knowledge and the standardization constitutes the backbone of knowledge within a knowledge-based system. He also pointed out that a metamodel functionality specifies the concepts and relations among them, which are used as the main building blocks. Ontology engineering has contributed several interesting aspects to modeling. Maedche and Staab [27bis] stressed that ontologies could be considered as "metadata schemas providing a controlled vocabulary of concepts". An interesting clarification of the philosophical term ontology is provided by [29bis]. This paper summarized several common definitions of ontology and tried to elaborate further the main consideration that ontology is a specification of a conceptualization. According to this approach ontology could be depicted as a philosophical discipline:

- An informal conceptual system
- A formal semantic account
- A specification of a "conceptualization"
- As a representation of a conceptual system via a logical theory
    - characterized by specific formal properties
    - characterized only by its specific purposes
- As the vocabulary used by a logical theory
- As a (meta-level) specification of a logical theory

In the field of computer science, ontology represents a tool useful to the learning processes that are typical of artificial intelligence. In fact, the use of ontologies is rapidly growing thanks to the significant functions they are carrying out in information systems, semantic web and knowledge-based systems. The current attention to ontologies paid by the AI community also arises from its recent interest in content theories, an interest that is greater than the one in mechanism theories. In this regard, Chandrasekaran [7bis] makes a clear distinction between these theories by asserting that, though mechanisms are important since they are proposed as the secret of making intelligent machines, they can not do much without a good content theory of the domain on which they have to work. Besides, once a good content theory is available, many different mechanisms can be used to implement effective systems, all using essentially the same content. Following this point of view, ontologies are content theories, since their principal contribution consists in identifying specific classes of objects and relations existing in some knowledge domains [9bis]. Ontological analysis, therefore, clarifies knowledge structures: given a domain, its ontology represents the heart of any knowledge representation system for that domain. Another reason for creating and developing ontology is the possibility of sharing and reusing knowledge domain among people or software agents. In general, ontology is a complex structure made up of a series of elements, each of which is composed of a kind of Relation and a series of related Concepts. Ontology in the context of e-learning means that we the presence of an (unspecified) conceptual system is admitted (a common hypothesis in E-Learning implementations). For example, as far as concerning University Courses, by means of an ontology built by the teacher, it will be possible to describe the knowledge domain, the subjects constituting it, the relations among the various subjects, as well as methodologies and means with which they are presented. These explicit specifications help users to understand what specific terms signify in a given domain [2bis] and reduce terminological and conceptual ambiguity. The content of an ontology depends both on the amount of information and on the degree of formality that is used to express it. Generally, two main types of ontologies are distinguished: lightweight and heavyweight [3bis]. A lightweight ontology is a structured representation of knowledge, which ranges from a simple enumeration of terms to a graph or taxonomy where the concepts are arranged in a hierarchy with a simple (specialization, is-a) relationship between them. Heavyweight ontology adds more meaning to this structure by providing axioms and broader descriptions of the knowledge. In this paper, the lightweight approach is adopted according to this definition of ontology: "ontology may take a variety of forms, but it will necessarily include a vocabulary of terms and some specification of their meaning. This includes definitions and an indication of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretations of terms" [10bis]. In the next section an approach to the representation of ontology by the use of Bayesian networks formalism is showed

2.2. ONTOLOGY AND BAYESIAN NETWORKS

As previously said in this section, how Bayesian Networks can be used "to map" and "to represent" ontology is described. Bayesian Networks have been successfully used to model knowledge under conditions of uncertainty within

expert systems, and methods have been developed from data combination and expert system knowledge in order to learn them [11]. Bayesian Networks represent a "hot" topic in the research field; the interested reader can find some interesting good surveys in [12][13]. In this paper a key role is played by the learning process of Bayesian Networks that shows two important advantages: firstly, it is easy to encode knowledge of an expert and such knowledge can be used to improve learning efficiency and accuracy. Secondly, nodes and arcs of the learned Bayesian network are recognizable links and causal relationships. So users can understand and exploit more easily the knowledge encoded in the representation. A Bayesian network is a graph-based model encoding the joint probability distribution of a set of random variables $\mathbf{X}=\{X_1, \ldots, X_n\}$. It is composed by:

- A directed acyclic graph S (called structure) where each node is associated with one random variable $\mathbf{X_i}$ and each arc represents the conditional dependence among the nodes that it joins
- A set P of local probability distributions, each of which is associated with a random variable $\mathbf{X_i}$ and conditioned by the variables corresponding to the source nodes of the arcs entering the node with which $\mathbf{X_i}$ is associated. The lack of an arc between two nodes implies conditional independence. On the other hand, the presence of an arc from the node $\mathbf{X_i}$ to the node $\mathbf{X_j}$ represents that $\mathbf{X_i}$ is considered a direct cause of $\mathbf{X_j}$.

Given a structure S and the local probability distributions of each node $p(X|\mathbf{Pa_i})$, where $\mathbf{Pa_i}$ represents the set of parent nodes of $\mathbf{X_j}$, the joint probability distribution $p(\mathbf{X})$ is obtained from: $p(\mathbf{X}) = \prod p(\mathbf{X_i}|\mathbf{Pa_i})$ with i=1, …, n. So the couple (S, P) encodes $p(\mathbf{X})$ unequivocally (on the hypothesis of conditional independence of the $\mathbf{X_j}$ given the) [11].

In order to build a Bayesian Network for a given set of variables, some arcs from the causal states to the other ones that represent their direct effects obtaining a network that accurately describes the conditional independence relations among the variables have to be defined. The aim of this paper is the introduction of an algorithm, based on the formalism of the Bayesian networks, able to infer the propaedeutic relationships among different subjects (in other terms the ontology) belonging to the knowledge domain of university curricula. The first step of this algorithm is the introduction of a mapping between Ontology and Bayesian Network. In our ontology model, nodes represent the subjects belonging to the knowledge domain (the course) while the arcs mean a propaedeutic relationship among the nodes. This ontology graph can be mapped in a Bayesian Network in the following way: the Bayesian Network nodes model the subjects belonging to the course Knowledge Domain and the knowledge of subject by students while arcs in the same way mean the propaedeutic relationships among the nodes. Given the previous mapping strategy, the aim is to define the ontology used by a teacher in his/her course. Obviously, data type and data set for this approach have to be defined. As previously said, student's answers to the evaluation tests represent a source of implicit evidence, because teachers through the end-of-course evaluation tests not only assess student's knowledge for every subject, but describe the course ontology and outline the propaedeutic aspects that relate subjects each other.

3. THE PROPOSED SYSTEM

In this section the detailed architecture of the proposed assessment tool, named Virtual Teacher, and the assessment and tutoring strategies are described. As previously said the aim is to design a tool for assessment able to support in an effective way students and teachers during the learning process.

The tool was designed analyzing the main needs of students and teachers. From a technological point of view it respects these constraints derived from web usability theory [NIE01]:

- Web based approach
- Aesthetic and minimalist design
- Flexibility and efficiency of use
- Help users recognize, diagnose, and recover from errors.

The design phase was conducted according to the UML approach and in particular the Use Case Diagrams, the Sequence Diagrams and the E-R Diagrams was produced. So the actors of the system and the use cases was pointed out. We identified three typologies of actors in the system: Administrator, Teacher and Student defining their roles and tasks can be summarized:

- Administrator: this actor can introduce and define new courses, students, teachers and manage the accesses to the tool
- Teacher: this actor can design the reference ontology, describe the learning objects and the questions linked to the nodes, and so the course

topics, of ontology. Teachers can also arrange reports on students learning process in order to better supervise their progress and support them.

- Student: this actor can use tool in three different ways: Exam, Normal and Bayesian test. In the Exam way Student has to solve a classical final test. At the end of the exam the system produces a report analyzing the performance of student in every subject. The Normal test approach can be used by Student during his learning path. The main aim of this service is to support Student to learn better the various learning objects. The more interesting service offered by our tool is the Bayesian test. This service makes the most of the matching between ontology and Bayesian Network. The first step is the introduction of a mapping strategy between Ontology and Bayesian Network. As said in the previous sections in the proposed ontology model nodes represent the subjects belonging to the knowledge domain of the course and the arcs mean a preparatory relationship among the nodes. In this way we can map the ontology graph in a Bayesian Network in the following way: the nodes of Bayesian Network model the subjects belonging to the course while the states (that are two: yes and not) of nodes represent the knowledge of student in the subject. The arcs mean the propaedeutical relationships among the nodes. So a node of Bayesian Network-ontology represents the Knowledge domain of a course and quantizes, by the use of the Bayesian rules, Student knowledge of this node-topic. When student accesses to the Bayesian Service the system select a set of questions associated to every network node. At the end of this first phase system, through a Bayesian approach infers what subjects the students knows better than others. In fact through the Bayesian analysis the system can measure the percentage of correct answer in a subject. In particular it can predict the percentage of correct answer to a subject after a correct (or not) answer to questions related to propaedeutic subjects. At this point it can apply various strategies: for example it can select and propose to the student the question with the smaller percentage of correct answer. At the end of Bayesian test a detailed report on the knowledge of student in the various subjects is sent to teacher and to student himself. In particular after the Bayesian test the system proposes to the student some learning object for deepening some subjects. At the same time tool proposes to the teacher a periodic report with the analysis of performances of various students in every topic. In this way teacher can understand easily where students need more help. At the end of Bayesian Test the system updates student user profile and builds its new adapted learning path.

Tool was developed using open source frameworks as PHP language, mySql Server and the web server Apache. Students have to use only a common web browser in order to access to tool services, in this way the system portability is insured. In the server side some modules, in particular the Bayesian inferential engine, were developed in Java.

4. EXPERIMENTAL RESULTS

In order to test the effectiveness of our tool we used it during the course of Introduction to Computer Science at Foreign Literature and Language Faculty of University of Salerno. This course is composed by seven modules: Introduction to PC Architecture, Introduction to Operative System, Microsoft Word, Microsoft Excel, Microsoft Access, Microsoft Power Point, Internet. The course was divided in modules, one for each topic, that contain didactic units that are composed by learning objects. Students can test their knowledge level at the end of every didactic units. In order to access at the next module students have to pass the Bayesian Assessment Phase referred to the didactic module. If the result of the test is positive then he can access to a study in depth module and according to the obtained result his profile and learning path is updated. In the case of negative result student has to study a supporting module, tailored on his didactic gaps and to sustain a new test. According to the new obtained result his profile and learning path is updated. The organization of every module can be so depicted (figure 3).

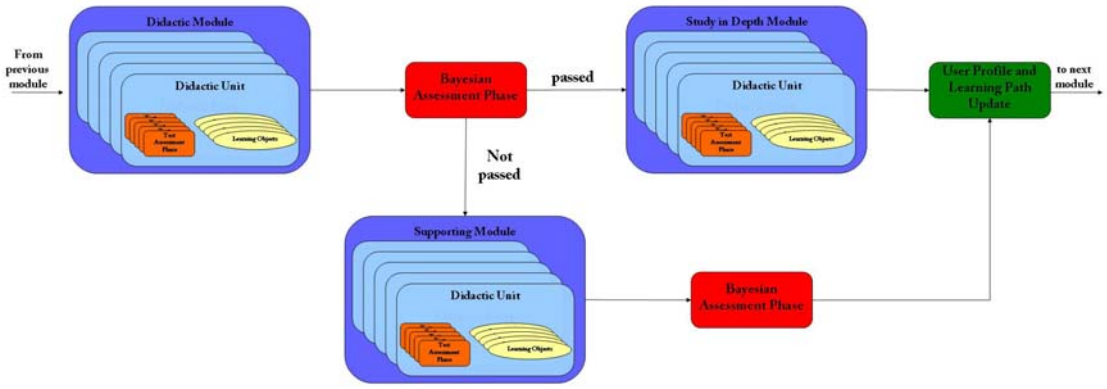

Figure 3: Organization of every module

On the basis of the considerations of previous section, teacher designed the reference ontology. Each node of the networks has two states and shows the probability that a generic learner knows the subject associated with the same node. We have supposed that each node can assume only the following two states (random Bernoullian variable): state 'Yes': complete knowledge of the subject and state 'Not': total ignorance on the subject. The student level of knowledge could be evaluated on the basis of the answers given to the questions (a set of questions is proposed for each subject). At the end of the course students have to get through a final examination's test composed by forty questions. The questions belong to every subject of knowledge domain.

The number of student's course was about 300 and at the starting of the course we arranged them in six group (named A, B, C, D, E and F). The first three groups had a classical support to course activities and used only the normal test approach while the second one used also all functionalities of the tool as didactic support. At the beginning of the course teachers designed every module's ontology in order to organize the contents. In particular an assessment entry test was realized with the aim to measure the starting knowledge level of students. The results are in the table 1.

	A Group	B Group	C Group	D Group	E Group	F Group
0-10	11	10	12	7	9	8
11-15	11	10	8	12	17	11
16-20	12	11	12	13	11	12
21-25	6	12	10	14	5	12
26-28	7	4	6	3	5	4
29-30	3	3	2	1	3	3
Average Level	15,96	15,98	14.46	15.52	13.36	16.08

Table 1: Results of Assessment Tool. The meaning of range is: [0-10]: very poor knowledge, [11-15]: poor knowledge, [16-20]: medium knowledge, [21-25]: good knowledge, [26-30]: very good knowledge

At the same time students filled also the ILS questionnaire [] in order to get other information about their learning style. The aim of this test is to allow a first description of student through a metadata structure. These information are essential in the definition of user model and, in particular, in the User Profile an Learning path update phase. In this phase is used the approach defined in the paper []. At this point the system organized for students of each groups a personalized learning path. In particular it selects the most suitable contents through a matching between the metadata of learning objects and the description of the student according to the strategy of []. As previously said during the course the students of the six groups attended to the lessons and used the assessment tool. In particular students of A, B and C group at the end of every module sustained a Bayesian Test, while the other groups had a traditional support. At the end of course students had their final course exam. In table 2 and 3 the obtained results are depicted:

	A Group	B Group	C Group	D Group	E Group	F Group
0-10	2	2	7	4	8	2
11-15	1	5	7	12	5	5
16-20	9	8	6	11	11	7
21-25	20	16	6	12	9	19
26-28	11	10	14	5	11	10
29-30	7	9	10	6	6	7
Average Level	23,28	15,98	14.46	15.52	13.36	16.08

Blue Group		*Red Group*	
Final Test	*Students*	*Final Test*	*Students*
0-10	*4*	*0-10*	*3*
11-15	*9*	*11-15*	*5*
16-20	*8*	*16-20*	*6*
21-25	*10*	*21-25*	*12*
26-30	*5*	*26-30*	*9*
Total	*36*	*Total*	*35*

Table 2: Results of Final Test

If we analyze the difference between the assessment and the final exam (table 1 and 2) we can note that the percentage of students that get through the assessment test is 37% in the red group and 42% in the blue group while in the case of the final examination the percentage is 77% in the red group and 64% in the blue group. We can note as more students of red group get through the final exam and improve their performance respect the assessment test (about 40%). In particular we can note that the students of the blue group has a minor improvement (about 22%) than the students of the red group. At the same time the percentage of red group's students that have a mark in the range 26-30 is higher than in the case of blue group: 26% to 8%. In order to collect more information about the effectiveness of our tool at the end of course we submitted a questionnaire to every student. In the questionnaire we asked the effectiveness of Bayesian test and of learning objects furnished by system at the end of the test. The 87 % of students said that the support of Virtual Teacher tool was very important in the learning process. In particular, the 73% of students declared that the supporting learning object helped them in a better knowledge of the various subjects.

5. CONCLUSION

In this paper we proposed a tool for the assessment and tutoring of students during a learning process. This is based on the use of ontology and Bayesian Network. In particular through the matching between ontology and Bayesian Network our tool allow an effective tutoring and a better adaptation of learning path to demands of students. The assessment based on Bayesian approach allows a deeper analysis of student's knowledge. The first experimental results seem to confirm our approach. As a future step of our research we intend to evaluate the performance of the proposed system when some students' tracking strategies are used.

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Quality of Education (QOE)

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Abstract - We will consider a program of a new education which enables children to make progress the ability of thinking by emotion or sentiment. Children's ability of thinking is brought by the combination of both sides of understanding, i.e. scientific and artistic, logical and aesthetic, intellectual and emotional. For children today, it is essential to acquire abilities of deep emotion, aesthetic judgment and productive imagination. We will try to consider the education of these abilities from the standpoint of the learning of the 'past'. Without this education, their thinking won't be expected to show full creativity.

Keywords - classics, creativity, emotion, Noh, past

INTRODUCTION: WHAT IS THE ABILITY OF EMOTION TO THINK?

Today, in the field of creative education some remarkable attempts are being made internationally. This movement has a typical feature against the established education, and aims to overcome the traditional method of teaching. These attempts take commonly account of the education of emotion or sensibility. The keynote of this movement lies in the trial to improve emotional ability to think in education.

For children today, the ability of human emotion is absolutely important. Emotion spreads in continuous variation from animal emotion to cultural-moral emotion, and the latter is indispensable for the growth of their mind. The reason why we must think about an education of emotion lies in the fact that children are confronted to the collapse of mind. Today, the revolution of the contemporary social life has utterly overturned their mind, the order of their feeling and thinking. They may spoil their mind.

From this point of view, we want to show a new program of education, which lays stress on the past culture, i.e. art, religion and literature of Japan. We think creativity connects to the past rather than to the future or present. The learning of the past is not derived by the mere knowledge but by some spiritual inheritance or sympathetic identification. And the secret of this education lies in the devices about the oldest materials for the newest education. This will be a trial for the promotion of Quality of Education (QOE).

1. ON THE ABILITY OF HUMAN EMOTION

The education of emotion relates closely to the ability of thinking and understanding. The ability of emotion links with various abilities, such as that of reading various sort of materials, interpreting and realizing the historical cultural records, inferring the relation and connection between many facts, explaining and informing ones own ideas and thought, and so on.

The ability of thinking is consisted of logical-reasonable and emotional-sentimental component. For the creativity, the latter is no less important than the former. And we think the problem of combination of thinking and emotion is most important for the development of children's mind. Today many children fall into various difficulties of mind, such as the weakening of the ability to think, disorder of sentiment and unsettledness of mind. The root of these troubles lies evidently in the collapse of emotion. Their mind will be cut by a slightest tension like a inferior thread. They have scarcely learned fundamental emotions and human sentiments for his life. They are suffering from the absence of the reality of the self-existence, without having full interest about the affairs around them. On the other hand, they have a new excellent power, i.e. virtual sensibility, quick processing of information, sharp sense of self- expression. They have acquired a new modern sense peculiar to the new generation.

The problem of emotion by children has another contemporary importance, especially in relation to moral education. Needless to say, emotion is *conditio sine qua non* for moral, and without it any moral act is appreciated by the actor himself. On the other hand, for the cultivation of emotion the acquaintance of classical literature and art has a significant meaning. Classical culture has an ideal power for stimulating

their sensibility and intellect. Therefore education of emotion is connected with moral education and at the same time overlaps to classical art studies. Today it is indispensable to wake up their cultural sensibility in order to acquire a human way of thinking. If they acquire this sensibility, they will begin to think vividly and bring themselves forth in their real world.

1.1. PHILOSOPHICAL HINTS

In the history of philosophy, many philosophers have pointed the significance of emotion for the understanding of human nature. They thought that emotion plays an important role for the activity of the whole mind. Spinoza considered the decisive meaning about the effect of emotion in spiritual life and from this standpoint he insisted his thought about the leading of human life (*Ethica,* □). Kant discovered a new emotional world, i.e. a world of beauty and sublimity. He also developed the thought of reflective judgment about the relation between nature and human being by the concept of emotion of pleasure and purposiveness (*Kritik der Urteilskraft, Erste Einleitung*).

In the contemporary philosophy, H. Bergson paid attention to the role of emotional-moral activity for the opened and vivid society. G. Bachelard insisted the reconstruction of nature from the standpoint of emotional foundation of mind. V. Jankelevitch deciphered the problem of the past in the mind and the relation between emotion and death. And K. Kristjansson thought, "Emotions are, after all, an integral part of human pursuits, and to study life is, in many ways, to study people emotions, including one's own." (*The Didactics of Emotion Education*). These thoughts are the sources for our inquiry to an education of emotion.

1.2. SIX POINTS CONCERNING EMOTION

About the significance of emotion in education is the following worthy of notice.

First, emotion is the indispensable collaborator with the scientific thinking. Scientific attitude is generally considered as value-free or apathetic, but this opinion fails to catch a decisive problem. It should not be disregarded that scientific attitude itself is supported by a spiritual tension, and without this tension the power of thinking doesn't work well. Moreover scientific interest itself is regarded as a sort of emotion, i.e. it must have concentration of attentiveness, respect for the fact, eagerness to research the unknown, open mindedness to any objection and so on. Without this impartial sensibility and inquiring heart, science can't progress at all. Between scientific mind and emotional spirit there exists an unknown closeness.

Secondary, the cultivation of emotion links to moral education. Moral education today faces to a serious difficulty, because it is inclined toward the social relationship between people or citizenship, and fails to grasp the emotional nad esthetic aspect by children. Primarily, moral has its meaning in the eagerness to clarify ones own mind through the self control of mind and sincere attitude to the world. Moral is raised not by the precepts of virtues, but by the experience of human impression and pure emotions.

Third, it is important to utilize the 'classics' in various field of education. Classics teach us best what emotion is. Classical learning extends to various genres of human culture, such as literature, art, history, thought, religion and so on. It is, so to speak, the ocean of intellectual heritage of mankind, and without its gifts the land of spirit will soon reduce to desert.

Forth, emotion is required in order to acquire the essential abilities to live, especially vital emotion, self-discovery, self-respect, spiritual elevation and vigorousness. These are the abilities directly combined to the life itself and above all to the cultivation of human character by children.

Fifth, education of emotion is the most important theme in the movements of creative education. We can learn this from theories and movements by F. Froebel, R. Steiner, N. Grundvig and M. Montessori. Their thoughts have commonly a strong opinion that emotion and sensibility are neglected in the established education.

Sixth, education is no other than the inheritance from man to man. Inheritance is the keyword for our understanding of the education of emotion. In Japan, today our inheritable culture and traditional lifestyle are seen in a new light, and if children learn to succeed them, it will have valuable merit for both the education

of emotion and the preservation of traditional culture.

1.3. TEACHER TRAINING

Among teachers in Japan emotion is at last undertook to discuss. But the research for the methodological basis of this ability is delayed. It is important for education of emotion to expose children to various materials, literature, art and other cultural heritages, but in school education these materials are not almost utilized. Education of emotion is not sufficiently positioned in school and teachers don't master enough these materials.

So, we must begin with the training of teacher by this education of emotion. They haven't full ability for this education and aren't accustomed to deal with these materials in their classroom. Education of emotion is fatal delayed in Japan. It is necessary for teachers to realize the significance and emergency of this education. They should know that this education extends to a various aspect of children's life, from nurture and discipline in the age of infant to the elder education in regard to the respect for lives, humanistic culture, religious mind. This teacher training will be the learning of the fundament of their own sensibility and imagination.

Education is no other than the inheritance of human ability throughout generations. Sensibility is inherited and improved by the succession from generation to generation. And it is also the case about intelligence and reason. Japanese emotion is a result of the inheritance of Japanese from age to age. From this point of view, we want to have an outlook for tomorrow education. And we want to show teachers the significance of this education as one of the main component of today's school education.

2. ON THE EDUCATION OF EMOTION MEANING OF THE 'PAST'

The problem about the method and aim of education is always the object of strong interest among people in any countries. Today this interest strengthens more and more, but it is closed up only to the problem of scholastic abilities and understanding. In Japan also the problem of improvement of these abilities occupies the interest of teachers and parents, and the administration and reorganization of education is carried out rapidly by the name of improvement of scholastic abilities.

Besides in Japan, the interest and knowledge to history and culture among children is retreating . They feel unaccustomed to the way of thinking in accordance with the axis of time, and have only a too weakened interest to history and culture. The reason will be the loss of the context of the historical and cultural knowledge and experience, and therefore they have not accustomed to see the world from the historical standpoint. The abundance and variety of information by contraries causes the difficult problems for the acquirement of their ability to the total and well-balanced thinking.

We can find in the thinking of children the situation of 'the loss of the past'. They don't learn not only their own past folk culture and history, but world history, classical literature, art, thought and religion, which are the common heritages throughout the world. They are broken off the context of the past and become extinct to past human beings and human culture. They don't have experience of the historical and cultural affairs handed down from the ancestry. And consequently their abilities to think universally will rapidly retrogress. They will lose their mental roots and deplete their emotional sensibility. They may fail and lose at last their self.

We call this historical and cultural learning 'the learning of the past'. It relates not so much to intellect as to emotion. And emotion relates more to the past than to the future. For the creativity many will think about the future, but it will be insufficient for the exploitation of its content. Creativity connects rather to the past, and needs it as its resource. History has an unwritten principle, that the oldest awake the newest. Because the oldest has been standing most against the wind pressure of history. The hint to education of tomorrow lies in the effort to make the most of oldest materials by the newest method.

2.1. EDUCATION OF THE PAST

Certainly, it will be difficult to let children have interest to the past. But once they have an experience to touch to the historical or the traditional culture and have a mind to sympathize with the past, they will catch something

new. Without having the past, the mind of emotion will not grow up enough. The learning of the past will arouse in their mind the feeling of the connection with wide and fascinating world. And by this feeling of connection, they will get a sort of spiritual awakening and have a stable view about human being.

So, education of emotion should be also that of the historical culture of the past. In every nation and people there exists each original historical culture. If they learn this culture from the early years of their development, it will be one of the most profitable bread for children's mind. By this education they will acquire the ability of aesthetical judgment, sense of pluralistic values, understanding of other cultures and rich imagination.

It is important in today's education that we create a new program of education of emotion having a good command of computer and make use of the materials of classical culture in way of new method. By the software technology it is enabled to make various new programs and to utilize these various new materials in the classroom. The key point of education of emotion will hereafter be that of the development of the method which enables to edit the oldest materials by newest method.

In the ability of children we find both 'digital' and 'analog' possibilities, and the latter is as important as the former. But today school education depends on the principle of digital knowledge and makes much of the world of intellect. The analogical, i.e. moral and emotional education is sent to the corner. It is forgotten that the full activity of intellect is only possible when it is connected with emotion.

Creative thinking needs both digital and analogical, because it is made up of the activity both constructive and affective, systematical and ambiguous, analytical and synthetic, scientific and historical, and in general 'space' and 'time'. Therefore it is absolutely important that these both sides are connected and unified, and we should try to connect digital materials to the circuit of analog. Learning is a synthetic activity, so we must teach children to observe things with both abilities and think with their whole brain. Therefore, for this education we should connect computer with historical materials, and try to let classroom transform into museum, theater, or historical stage by all devices of computer.

From this point of view, we can prospect a combination of information science and emotional education. We want to collect the materials of past arts, historical works and classical literature as the source of emotion and guide children to experience the wideness and depth of mankind and to feel the unknown world of human emotion. And for these problems, we want to utilize information science. Computer is a best tool to let children lead to the way of thinking from the axis of time and meet the spiritual life world.

Revolution of information today is far and away favorable for the education of the past. We can now with information tools produce the curriculum using classical materials and re-create the past world. Yet until now, we haven't any advanced software for this education. This software is not for the compramentary material. It opens up a new vista for the creation of emotional education.

2.2. TRIAL TO AN NEW EDUCATION OF EMOTION TRADITIONAL JAPANESE PERFORMING ARTS

The materials of the education of emotion are large and various. Today in school education traditional Japanese performing arts are recently revaluated, and many trials begin to be made. In this education, it is important for teachers to guide children to the best materials and chances, then children will think and express for themselves by leaps and bounds. These classical materials, involving movement, performance, expression, execution, will lead to awaken their aesthetic emotions. To enable this education, it is indispensable to combine their thinking with emotion, in other words we must guide them to think of what they feel and perceive. For children today, practicing and expressing with their body and mind is more and more important for their development.

The difficulty is that most teachers are almost ignorant of these traditional performing arts. So we must begin with the training of teachers. Moreover for the practice of this education it is necessary to get the collaborators of stage art. Today this education is just about to start, and for the promotion we must get over many difficulties. But if we progress in this trial, it will be some contribution to the quality of education.

2.3. SKETCH OF THE NOH EDUCATION

Here, for example, we will take up Japanese classical stage art Noh for the education of emotion.

Noh is stage art and is made up of drama, song, dance and performance. So, Noh education is synthetic and will be carried out in a style of combination of desk studies and work-shop learning. In Japan, so far, education of stage art has been practiced at school in a subject of drama and chorus. In both case it is hard to say that the lectures are taken place on a standpoint of connection of thinking and emotion. Noh-education is the complex of learning of classical literature and performance at stage. Children are quite ignorant about the classics of their own country, and hardly accustomed to the manner of Japanese life. If they meet this unknown art, they will surely be astonished and awaked.

Especially Noh is closely related to Japanese oldest short poetry Waka such as Mannyou-shu or Kokin Waka-shu, and masterpieces of Japanese literature such as The Tale of Genji or The Tale of Heike. Throughout the history of Japan, these works have brought up and influenced deeply the mind of Japanese. Noh education will be available for the learning of these poetry and literature.

Noh is scarcely known to children and young people. It is even today a dismissed art. But if they become familiar to this art, they will be undoubtedly fascinated, for them Noh is a mysterious world with quite a new song, dance and atmosphere. For them it will surely be exciting to present this unknown world of Japanese stage art on their own expression and movement.

The method of Noh education is scarcely devised today, it is one of the most backward genre in education. So, we must develop the theory of its learning.

We think it is necessary for children to learn Noh at least four elements; historical-social (for example, middle age of Japan, society of warrior, feudal system, etc.), natural-geographical element (landform of Japan, Miyako (Kyoto) and other cities, district of Japan, etc.), cultural element (Waka, tales, art, old lifestyle, etc.) and spiritual element (religion, love, sorrow, death, ghost, god and demon etc.).

And the work-shop of Noh is also synthetic. Noh is constructed of many parts; song (Utai is very different from European song, it is at the same time song and narration. The diction is also unique.), play and dance (Noh dance is characterized by Kata (form) and Kamae (attitude). It has a strict rule in each movement), Sahou (manner) and Kiai (spirit) (By Japanese expressional art spirit is most important) and performance (Noh may somewhat similar to Opera).

We are now trying to prepare the curriculum of Noh-education. For this, it is necessary to teach children various fundamental matters, such as Japanese history and literature, map in the old days, Buddhism and people's life. We must teach them also a grounding of stage art, spiritual side of this art, its beauty and aesthetic elements. And then we instruct them songs and dances of Noh. So Noh-education is above all a synthetic education.

3. CONCLUSION

Emotion will be certainly inspired by the education of the classic art. When we try to teach children (about 10-14) songs and dances of Noh, they at first feel confused and puzzled, and then they enter quickly into the world of Noh.

To learn Japanese classical art with their full bodies and souls is for them certainly incredibly fresh experience, and they expand both their sensibility and understanding. As emotion is the 'fountainhead' of all mental activity, they will surely develop their intellectual abilities.

We believe that this sort of education will take an active part in education as a bridge between scientific studies and cultural mentality. The heart of children should be always fulfilled with fresh interest and emotion, and then they can actualize their abilities in intellectual studies.

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Travel in Europe: An Online Environment to Promote Cultural Heritage

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Abstract— The paper discusses the Travel in Europe (TiE) online environment, an innovative means to promote and divulgate heritage to European people. Users of TiE live challenging and compelling game experiences by interacting with virtual representations of European heritage. TiE exploits the concept of travel, which is both engaging by itself and also supports geographic contextualization. A player of TiE moves in several 3D reconstructions of European cities as in a commercial videogame, but we have studied further mechanisms that could be inserted in the 3D environment so to make it more appropriate to deliver educational contents: an algorithm to produce high quality models of cities and regions, the exploitation of 2D games in the 3D virtual world and the interaction in natural language with conversational virtual humans.

Index Terms— Serious games, virtual worlds ,

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1. INTRODUCTION

Games have always been an important aspect of human life, also having a meaningful impact on education. However, their design has to be careful, in order to support real knowledge acquisition. Several games have little, if any, educational value or may be misused. These concerns are strengthened in the case of the video-games, that provide meaningful additional features (e.g. possibility of using large databases and of exploiting interactivity, immersiveness and personalization [1]), but may also create dependency and promote/induce dangerous behaviors [2], [3]. State of the art computer games typically involve a 3D environment into which the user lives exciting experiences related to an adventure, a historical fact, a sport. Educational games exploit state of the art computing and networking technologies to provide an educational value inside an entertainment framework. However, it is not easy to combine real education and entertainment. This is testified by the fact that it is very rare to find successful commercial games that promote knowledge/skill acquisition in a particular field [4]. On the other hand, educational games tend to be perceived as boring, at least by the general public [5].

Trivial to say, entertainment is a key factor to success. Even the recent successful cognition-activity supporting games (e.g. Nintendo [6]) are perceived more as a challenge rather than an exercise. In this view, we intend to exploit paradigms and models of the state of art games and upgrade them in order to make them suited to deliver educational value. In other words, our idea is to enhance existing game concepts rather than designing educational exercises with a game aspect (e.g. score, penalties, lives). This requires finding appropriate mechanisms that are to be seamlessly embedded in the paradigms that appeal a wide audience. This is fundamental in particular if we do not aim at a specific category of users (e.g. learners that may be motivated to play

a game independent of its appeal) but we strive to promote a knowledge item (e.g. art history, biology, botanic, etc.) to the general public (e.g. in a life-long learning perspective, which is an important objective of current information society's policies). In this perspective, we are interested in exploiting 3d Virtual Reality (VR) environments, that are very popular, in particular among the youngsters. Necessary steps in the design of a VR educational game include the definition of the contents, plot and rules (e.g. concerning assignment of the score).

In this paper, we investigate in detail the Travel in Europe (TiE) online environment, where general users can live compelling experiences concerning the artistic heritage of European cities and regions. The environment supports performing adventures similar to state of the art videogames, but provides mechanisms and patterns of use that will support knowledge acquisition and effective fruition/understanding of the heritage. Having a full environment is a significant added-value, since it will not mean developing a single game, but an extensible platform on the top of which a number of different games may be built, each one of them being able to exploit the educational/cultural features, mechanisms and functions provided by the TiE environment. The main TiE features are: an algorithm to efficiently produce models of cities and regions, the exploitation of 2D games embedded in the 3D virtual world and the implementation of conversational virtual humans to interact with the player in a natural way. As a meaningful example of the potentialities of the TiE environment, we have built a sample game, a sort of a cultural treasure-hunting game to be performed among a number of virtual reconstructions of European cities.

2. RELATED WORKS

Research work argues that computer games are an engaging medium for learning since they can stimulate cognitive processes as reading explicit and implicit information, deductive and inductive reasoning, problem solving, and making inferences from information displayed across a number of screens [7]. These results have been achieved through a numbers of games that either have a direct educational value or provide knowledge/stimulate skills as a side-effect [4].

The idea of using networked Virtual Worlds (VWs) as educational medium started in nineties (e.g. ExploreNet Experiment [8]). Today, with the increasing availability of PCs and wide-band connections, VWs can reach potentially enormous communities of would-be learners. Some virtual learning worlds (e.g active worlds learning environment [9]) tend to mirror a classroom environment [10]. The social interaction enabled by VWs can contribute to improve engagement, participation and maintain learner's interest. Indeed, students perceive more satisfaction in a course if they are actively involved in it and they are allowed to develop relationship with other learners. In this perspective, an important opportunity is given by the current successful trend of Massively Multiplayer Online Game (MMOGs), that have developed, for entertainment purposes, powerful tools that may be exploited to provide knowledge to thousands of players [11].

A specific computer science research field - the Serious Gaming [4], [12] - has recently developed in order to exploit the potential of games in practical education. According to the constructivist approach [13], learning depends on the active engagement of the subject that learns, and on her/his ability to construct knowledge and understanding on the basis of her/his interaction with the environment.

Several advanced computing technologies have been used for games. They are substantially related to 3D visualization, and range, for instance, from object modeling to real-time computation, from Virtual Humans to artificial intelligence. Examining the brain's electrical activity, Kahana and others [2] have shown from a neuroscientific point of view that computer games engage spatial learning [14]. This is particularly true for 3D games, where the reconstructed environment allows a more complete and immersive experience of the space and context, at least in principle. The player can get more familiarity with the surrounding space, through exploration that may be spurred by a game by proposing to the player the accomplishment of challenging missions. Missions and tasks may spur the sense of site and critical reasoning, also through social interaction with other players.

However, there are still educational aspects that have to be further studied in order to better exploit the potential of computer technologies for the education. A significant issue concerns the risk that the player gets easily lost in the knowledge space of the simulated environment. This requires a meaningful, compelling plot and proper guidance (e.g. through spatial landmarks [15]), that can drive the player through a suited (e.g. not dispersive) knowledge path or, in a more constructive approach, can effectively support her/him

in her/his free exploration. But also other game mechanisms need to be defined and implemented in order to achieve effective and aware learning. The mechanisms should significantly enrich the environment (e.g. by supporting orientation, providing more detailed information, etc.), and should be well integrated in the game logic and aesthetic (they should not appear as "boring educational add-ons"). In the end, the environment has to be stimulating. Some such mechanisms have already been presented in the literature and in commercial games. These include the criteria for the evaluation of player enjoyment (the Flow Channel theory) [16] and the multimodal environment interaction [17].

3. TiE GAME MODULES

The TiE architecture is based on a standard game engine, with Massive Multiplayer Online Game (MMOG) facilities in order to support a wide and pleasant access [18], plus ad-hoc designed and developed cultural related game modules. These modules include: a methodology for efficient collection of architectonic urban contents and modeling of realistic 3D reconstruction, the support for conversational virtual humans, the education-relevant 2D game templates that can be embedded in the 3D reconstructions.

3.1. 3D MODELING OF CITIES

TiE involves reconstructing a number of culturally-relevant cities and villages throughout the whole Europe. A 3D reconstruction of a city or a region for education/cultural aims within an interactive environment is a process that requires a careful trade-off between the models' photorealism (in order to provide a highly impressive and culturally correct and meaningful experience) and the models' weight (in order to allow interactive real-time online exploration) and complexity.

The first term of the trade-off stresses the importance of having high detailed 3D reconstructions in order to realize a sound reconstruction of the heritage.

The second term highlights the performance problems that the TiE online environment has to overcome to provide users with a playable and enjoyable system. Moreover, complex systems are costly to implement both for the 3D modeling aspect and for the need to create proper textures (which requires taking pictures, rectifying and equalizing them, and composing in the final textures that can be managed by the final graphic engine).

In a highly interactive system, such as a 3D exploration/game, the details of the reconstructed environment are not fundamental to display, as the player moves rapidly there. However, in the case of a cultural heritage game, the player, playing the role of a sort of art detective, has also to carefully examine also the particulars, where relevant.

In order to meet the above stated requirements, we have designed the reconstruction of each covered place (e.g. a city or several areas inside a city).

The 3D model is completely geo-referenced. The ground is elevated from a vector map. So, the placement of the buildings and their borders are precise. This allows compatibility/portability to various Geographic Information Systems (GISs) and expansibility of the system (i.e. possibility of upgrading buildings with their actual textures.

In each covered area, a few Point-Of-Interests (POIs) are implemented. These are rigorous, high-detail reconstructions of a building. We use this approach for culturally meaningful buildings. For instance, the cathedral, the theater, a Renaissance palace, etc.

The textures for all the rest of the palaces are built dynamically by the TiE system using a statistical template-based algorithm [19]. Since several zones within a city are typically characterized by relatively homogeneous buildings (one or few more "styles"), the idea is to exploit a statistical description of the architectonic parameters and to build the buildings' virtual models accordingly, using a limited set of parametric building models and of textures that are instances of architectonic features representative of that area.

In this way, on the one hand the effort to cover extended urban areas is reasonably manageable (in any case, the content creator has the choice of defining the number of buildings' models, textures and parameters for the reconstruction), on the other hand, the reconstructed environment allows users to live experiences somehow similar to a real visit of a city, where a visitor typically perceives the feeling of being in a precise place but usually does not perceive/remember the particulars of each distinct building. We refer to this approach as based on an architectonic-style likelihood principle.

Moreover, the buildings that are particularly meaningful from a cultural point of view are reconstructed with high detail and with their own specific real textures (i.e. not statistically defined). These buildings may be the subject of a more attentive analysis by the player, as suggested by the game plot and rules.

3.2. CONVERSATIONAL VIRTUAL HUMANS

Conversational Virtual Humans (CVHs) are computer-controlled characters equipped with natural language dialogue capabilities which can be used to better engage the player in her/his activity. Their aim is to provide contents to introduce "backstories", assigning tasks and rewarding user performance, and, more in general, offering information to the learner. There are many different approaches to CVHs design. Several systems (e.g. Eliza [20], Parry [21] and Alice that has also its own development language called AIML [22]) are based on a pattern-matching algorithm and sentence reconstruction based on templates, with no processing of the natural language. The cost of scaling up the pattern matching approach is high, as it requires an extensive writing of rules by a human author. Other systems use statistical techniques based on semantic specification [23] or automated latent semantic analysis [24]. Latent semantic analysis [25] builds relationships between a set of documents and the terms they contain. Recent research works are focused on the definition of the character personality [26], the realization of emotional responses [27], and the understanding of the human behaviour during the interaction [28].

The 3D reconstruction of a city can be populated with CVHs to exploit the cultural heritage knowledge. The player has the possibility of asking CVHs - through natural speech queries - about knowledge stored in the system. CAs will be able to accompany users through the resources available in the environments (e.g. palaces, churches, historical places, etc.). CVHs implement Question-answering capabilities to adaptively present the knowledge available. CVHs are also able to provide non-linear interactive storytelling features, structuring the conversation in coherent, meaningful and appealing narrations. Moreover, some of them play specific roles in specific events (e.g. a TiE city can have a CVH that interprets a museum curator and his knowledge is based on the corpus of information about the masterpieces conserved in the museum). Question-answering capabilities are supported by semi-automatic knowledge extraction techniques (based on Latent Semantic Analysis) that allow CVHs to gather knowledge from the content stored in standard way (e.g cultural databases). CVHs are designed taking into account that the player should perceive them as credible in their role, in order to enhance and reinforce the player's "sense of place" [29]. For example, their conversational style has to conform to their role (e.g. a museum curator cannot speak as a greengrocer). The CVHs can also behave in a proactive way by suggesting or making advices that user can accept or refuse. For example, if the TiE environment notices that the player was lost in the virtual space a CVH approaches the player to provide him/her some information on the virtual world map.

3.3. MICROGAMES

MicroGames (MGs) are simple, short games that focus the player's attention on a particular item that she/he finds during her/his exploration of the 3D world. MGs are typically taken from well known game models, such as Puzzle, MemoryGame, FindTheWrongDetails. The idea, in fact, is that they should be immediate to play, so that the player can focus on the contents rather than on learning how to play.

We have defined a library of MG Templates. Every MG is an instance of one of such templates. We broadly divide game templates in three categories, according to the cognitive skills they mostly involve (see Table 1).

MGs categories	Descriptions
Observation games	These games privilege the sight as a sense to investigate and explore the local environment. In general, these games tend to exploit the "knowledge in the world" in order to develop the cognition activity. They aim to stimulate spatial processing skills.
Reflection games	These games tend to favor reflection, discussion among team members, analysis of questions and possible answers considering clues available in the neighborhood and concepts learned previously during the game.
Arcade games	These games stimulate similar skills as observation games. Their specificity lies in the animated graphics and engaging interaction, which helps to create a convincing and pleasant experience.

Table 1. MicroGames categories

4. A SAMPLE TIE GAME : A TREASURE HUNT IN EUROPE

The first realization from the TiE environment is a cultural treasure hunt across the Europe. Figure 1 shows a snapshot from the Genoa historical city centre reconstruction. It is "Strada Nuova" zone, an area that contains outstanding palaces from the Renaissance and Baroque age.

Figure 1. A snapshot from the TiE 3D reconstruction of Strada Nuova in Genoa city center

The player has to visit a fixed number of cities. In each town the player has a mission to accomplish. The mission is time-limited. Every mission is characterized by a number of questions. These are questions the player should think of while exploring the city. We call them visit-driving questions. They are general. The player will have to visit places, ask CVHs and others players, with those items in mind. The final city trial will concern specific challenges related to these general questions. In some cases, instead of questions we may have hints, like: pay attention to the frescoes, look at the facades' colours, etc. Moreover, the player has to reach some point of interest in the city in order to collect objects, whose list is specified in the mission chart.

During the visit the player freely chooses where to go. Orientation in the city and finding the right path are major challenges (the city as a labyrinth). Strategy has to be employed by the player in order to plan the path to all the destinations to reach.

When the player reaches a point of interest, according to the mission plan, the player will have to face a MG. Figure 2 shows a puzzle MG about the façade of Palazzo Ducale played in front of the virtual reconstruction of the building.

Accomplishment of a mission is decided at the end of the city exploration. There is a final trial with a sort of millionaire game on that city with quizzes there are related with the initial visit-driving questions. The games involve responding to questions but also some activity games (e.g. memory game, cultural tetris, also collaborative, etc.). Accomplishment of a mission appoints the player with a city-prize (e.g. a picture, a symbol), that can be conserved in the player's repository.

Figure 2. A snapshot of a MG (Puzzle) about Palazzo Ducale in Genoa. The MG is played in front of the virtual representation of the building.

In this work-in-progress environment we have made preliminary tests with high-school students and experts of art/history and education. The idea is to get some hints about usability and usefulness of the implemented environment in order to inform the further design, that is involving the implementation of the virtual environments representing 15 cities/rural areas other European countries.

Based on this analysis, we propose some indications that we tie to our experience. Of course, the analysis is early and has no statistical value, but we consider it as a useful element for a more aware discussion. We outline the indication in the following:

- the variety of cities/regions to model require a flexible algorithm of semi-automatic reconstruction because it is often needed to add some specific architectural elements or style;
- typologies of MGs should be few (15/20), so that the player can learn easily and play quickly. But variety of instances is important to keep the player motivated and attentive;
- in the 3D implementation of the CVHs interface it is important to consider the character personality, the realization of emotional responses, and the understanding of the human behavior.

5. CONCLUSIONS AND FUTURE WORKS

3D environments are very popular among gamers and ever more used for simulation and serious games. The educational value of setting an adventure/simulation in a virtual reality world is significant, in particular when training workforce in performing dangerous/special tasks (e.g. military simulations). However, when it comes to exploration of a world to learn from it, as it happens in several real-life experiences, there is the risk that a lot of "knowledge in the world" is wasted because of a lack of appropriate guidance and the difficulty of providing more in-depth information about some items without interrupting the flow of the game.

In TiE, we are developing an efficient algorithm to model virtual environments aimed at promoting artistic heritage that can been enhanced with embedded MGs and CVHs. MGs and CVHs allow the player to virtually interact with pieces of the heritage in their context and to discover/investigate some details related to that area. In this way, playing a MGs or conversing with a CVH can be thought of as sort of 1-level links in the "hypertext" represented by the 3D environment where the player lives her/his cultural adventure.

Extended user tests are necessary – and already planned – in order to achieve an appropriate assessment of the proposed approach. However, preliminary informal tests have suggested that the approach is valid.

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