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A Proposed Conception of the Learner Model for Adaptive Hypermedia

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Abstract

This article is a continuation of our work concerning the development of the learner model; which is a fundamental element to develop an adaptive hypermedia.

In a previous work we proposed a new learner model that regroups six facets representing the different dimensions of the learner.

The objective of this paper is to discuss the research we have done on each of these facets and according to the collected information we will present our own conception of the learning model.

Keyword- Learner model, Adaptive hypermedia, E-learning, Domain model, Adaptation model, Knowledge, Skills, Historic, Psychological profile, Cognitive ability, Emotional state.

INTRODUCTION

Over the last years, the technological revolution has transformed our way of life, bringing new demands, as well as novel expectations concerning education and learning, such as convenient flexibility in time, location and structure (Heloisa Moura, 2006).

It also leads us to a new category of learners: 'the online learners', and according to the annual report of the state of online learning in U.S. Higher education (The Online Learning Consortium 'OLC', 2016), a year-to-year 3.9% increase in the number of distance education students, up from the 3.7% rate recorded last years.

This type of Education also known as 'E-learning' was defined by Commission of the European Communities (2001), as the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services, as well as exchanges and collaboration from distance.

Several approaches and systems (LMS, MOOC...) have taken the step towards E-learning and have dominated Internet education over the last two decades. Among these approaches we quote our previous article 'Proposal of an Approach of Online Course Design and Implementation: A Case Study of an Algorithmic Course' (M. Benslimane, K. Ouazzani, M. Tmimi, M. Berrada, 2016) where we proposed an online course approach based on a solid set of specifications for our course (algorithmic course), and ending with its implementation on the LMS (Learning Management System) Moodle.

Due to the diversity and preferences of the learners, these traditional e-learning systems have a common problem that is the same course with the same structure is dedicated to all learners.

As a result, a new generation of advanced learning systems has emerged, by giving the learner an active role to learn and build his knowledge. These systems are highly interactive and integrate a more user-centric vision (A. Behaz, M. Djoudi, 2009) while making the content knowledge to be learned more complicated or simpler according to the needs and the demands of the learner (Kaya, G., Altun, A., 2011).

Adaptive hypermedia systems is one of the advanced learning systems that offer solutions to these problems and can be described as adaptive e-learning and more precisely as Brusilovsky (1998) has defined it: "An Adaptive Hypermedia System is a hypertext or hypermedia system that reflects certain characteristics of the user in a user model, and applies that model to adapt certain visible aspects of the system to that user".

As Brusilovsky had mentioned in the previous definition, the user Model is a fundamental element to develop an adaptive hypermedia, It allows the system to maintain a deep knowledge of each learner through the extraction of relevant characteristics that can better describe it, measure his performance, his motivation, identify its level of knowledge, define his goals, interests, emotions and style learning (L.Dounas, O. El Beqqali, 2014). In this paper, we will propose a new conception of the user model and precisely learner model that we will use it later for the development of our own adaptive hypermedia, which is the main goal of our works.

RELATED WORK

Learner model is a very promising solution to represent and describe the information about a learner, in the purpose to provide a complete and faithful description of all aspects related to the conduct of the learner in the learning phase (A. Behaz, M. Djoudi, 2009). As a real example of the use of this model, when a student learns a target material, the data in the learner model about their understanding is updated to reflect their current beliefs (S. Bull, 2004).

In Our previous work (M. Tmimi, M. Benslimane, M. Berrada, K. Ouazzani, 2016), we proposed the basic elements of our

new learner model that we deduced from a set of existing learner approaches and ontologies, our proposal regarding the learning model is based firstly on six facets (Personal information, Knowledge and skills, Historic, Psychological profile, Cognitive ability, Emotional state) which are dimensions that the learner can have and which will be useful in the phase of learning and adaptation in adaptive hypermedia, and secondly on the LMPA123 model which defines the articulation between the generality of a modeling language and the specificity of the learning profiles.

Also, in a parallel work 'Inspiration and Pre-Conception of an intelligent and dynamic system supporting learner ontologies' (M. Tmimi, M. Benslimane, M. Berrada, K. Ouazzani, 2017) we offered a new scalable, flexible system that will imitate human complexity in order to present and describe the learning profile in every detail. This system will solve the major problem of the existing learning models that resides in the stability and scalability, in the sense that ontologies or learner models are like elements with values that differ from a learner to an other, however human nature is far from being as simple as that.

In the next chapter we will detail the six facets of our proposed learner model while discussing all the work and the research that contributed to the realization of this model that we will propose later in this paper.

OUR PROPOSITION

In a first place we had to do some research in the different facets of our ontology in order to have as much information as possible that we will use to elaborate our conception of the learner model.

A. The Six Facets

As we mentioned in the previous chapter our proposal regarding the learner model contains six facets, which are dimensions that the learner can have and which will be useful in the phase of learning and adaptation in adaptive hypermedia.

Let's discuss these facets and all the related works that we have studied.

1) *'Personal information':* These are the learner's personal data, i.e. his / her identity, gender, age, etc. Generally, this type of information in unlikely to change over time (we can describe it as the static part of the learner model (S. Jean-Daubias, T.T.H. Phan, 2011), but it may have an influence on styles and preferences of learning. As an example: Collier expresses that successful language acquisition depends on the learner's age (Collier, V. P., 1988).

2) *'Competency and knowledge':* The concept of competence has often been a topic of current interest that researchers constantly try to define it properly while focusing on the difference between the terms: performance, knowledge, competency and skill (George E. Miller, M.D., 1990).

At the base of the Miller's pyramid (as shown in Fig. 1.), the students must first knows what is required in order to carry out a professional function effectively, and then they must also know how to use the knowledge accumulated.

The student must not only know and know how they should also show how they do it, which can be resumed in the performance.

And finally the 'does' section, which is the ability that the students reproduce performance independently in different situations, this section requires also a real time assessment that needs to be valid and reliable (D Pitts D, Rowley DI, Sher JL , 2005).

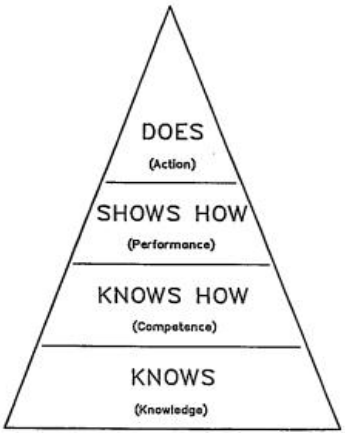

Figure 1: Miller's pyramid (George E. Miller, M.D., 1990)

These entire elements can be regrouped on one definition: 'Competency is the implementation by a person, in a given situation and in a context, of a set of diversified and coordinated resources. This implementation is based on the selection, mobilization and organization of these resources and the relevant actions that these resources allow for a successful treatment of this situation.' (Jonnaert P. et al, 2004)

In view of the importance of the term competency, a new pedagogical current has emerged which consists in considering learning by the concept of competency.

This current (also called competence approach) and as the previous definition shows, the concept competence encompasses not only the learning model but also the domain model. This is clearly seen in the majority of works that contributes in this direction, we quote the works of (A. Hachmoud, A. Khartoch, L. Oughdir, S. K. Alami , 2017) who proposed a conception of the ontology of competence approach that we have taken into consideration to develop our proposal shown later in this paper.

1) *'Historic':* This facet is responsible for keeping track of all the actions performed by the learner in adaptive hypermedia.

Two major problems are foreseen in this facet: the great diversity of actions, and the volume that increase exponentially.

Table 1: FSLSM's dimensions and their Semantic (Sabine Graf, Silvia Rita Viola, Kinshuk, Tommaso Leo, 2006)

Style	Semantic group	Style	Semantic group
Active	• Trying something out • Social oriented	Reflective	• Think about material • Impersonal oriented
Sensing	• Existing ways • Concrete material • Careful with details	Intuitive	• New ways • Abstract Material • Not careful with details
Visual	• Pictures	Verbal	• Spoken words • Written words • Difficulty with visual Style
Sequential	• Detail oriented • Sequential progress • From parts to the whole	Global	• Overall picture • Non-Sequential progress • Relations/Connections

For the diversity of actions, we opted for computer logging mechanisms (Thierry Vaira, 2015), which is the sequential recording in a file or database of all events affecting a particular process (application, activity of a computer network, etc.). To ensure this mechanism, we have developed our own philosophy: no matter what kind of action that the learner does; we will always have an element concerned and a type of actions (consultation/display: select, modify: update, insert or delete).

And regarding the volume we plan to use the database archiving system which consists in taking an object and transferring it under certain conditions in a system that will ensure the preservation for a certain period of time with all the required security (A. Hulstaert, G. Ogonowski, 2013).

In conclusion, this facet will merge the two systems cited before that are: logging and archiving.

→ Before moving to the last three facets, we need to mention that these three next facets are so related and can be grouped on the concept of learning style or preferences of the student on the learning phase. In fact, during the past decade, educational research has identified a number of factors that account for some of the differences in how students learn.

Learning styles is one of these factors, and it is described as "cognitive, affective, and physiological traits that are relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (JOY M. REID, 1987)

2) *'Psychological profiles:* There are several psychological profile theories, which we have already discussed in our previous work. We chose the Felder-Silverman Learning Style Model (FSLSM), which combines the majority of style models and describes the learning style in many details compared to other theories (Sridhar Iyer, 2011).

The model proposes four dimensions:

- Active / Reflective
- Sensing / Intuitive
- Visual / Verbal
- Sequential / Global

Each dimension contains two poles, which oppose each other.

It is assumed that each learner uses each of the four dimensions with different percentages but poles complement each other (example: Visual 80% / Verbal 20%: 80% + 20% = 100%).

Note that a learner may have a natural tendency for a pole of one dimension, but it does not mean that it is better or less desirable than its opposite pole. (Peter Briggs Myers and Katharine D. Myers, 2005)

In addition, we implemented the referential '*Developing cognitive capacities and working methods of apprentices*' (Anon, 2008) proposed in the work of the CAFOC of Nantes / CFA of the Pays de la Loire

This referential does not only propose dimensions but also three levels that describe the degree of interaction of the learner with the learning style (this concept will be expressed in collaboration with the Cognitive Capacity facet).

These levels are:

Level 1: Be able to identify learning methods.

Level 2: Evaluate the one that best me

Level 3: Implement learning methods adapted to the various situations

We have also implemented in this facet a set of preferences concerning the mastery languages and the physical limitations (handicap) of the learner.

3) *'Cognitive Capacity:* Human activities require the collaboration of the cerebral areas dedicated to different specialized treatments as vision, space, language, gestures, coordination, attention, memory and *strategies*...(Dr. Alain POUHET, 2012).

This set of elements describes the cognitive abilities required whatever the domain of knowledge to acquire by the learner.

Based on the referential (Anon, 2008) proposed in the work of the CAFOC of Nantes / CFA of the Pays de la Loire, our learning model will contain five cognitive processes; each process contains a set of elements dispersed over different levels.

- To concentrate:
  - Types of activities
    - ✓ Level 1: be attentive (listen, read)
    - ✓ Level 2: Concentrate to process information
    - ✓ Level 3: Concentrate to carry out activities that correspond to realities of examination or professional situations
  - Level of difficulty of the activity
    - ✓ Level 1: Simple with a single information
    - ✓ Level 2: Moderately complex with multiple information.
    - ✓ Level 3: Complex
  - Duration of the activity
    - ✓ Level 1: Short: Five to ten minutes.
    - ✓ Level 2: Moderately long: Two hours
    - ✓ Level 3: Long: Half day
  - Context
    - ✓ Level 1: Calm: Individual work in class
    - ✓ Level 2: A bit noisy: Work in group
    - ✓ Level 3: noisy: In a workshop

- Memory Develop:
  - Level of memorisation of activities
    - ✓ Level 1: Learning by heart and restoring in the same form what has been memorized.
    - ✓ Level 2: Memorize to restore in a different form, rephrase and Give meaning.
    - ✓ Level 3: Memorize to transfer or apply knowledge in a new situation
  - Number and / or type of information to be to memorize (Short-term memory)
    - ✓ Level 1: the basics
    - ✓ Level 2: Several basic information
    - ✓ Level 3: Several complex information
  - Duration of memorization
    - ✓ Level 1: Instantaneous, Short term
    - ✓ Level 2: Medium Term
    - ✓ Level 3: Long term
  - Mobilization of the senses
    - ✓ Level 1: One of the five senses
    - ✓ Level 2: Two or three senses
    - ✓ Level 3: Mobilization up to the five senses
  - Context
    - ✓ Level 1: Calm with the help of a trainer or another apprentice.
    - ✓ Level 2: A bit noisy
    - ✓ Level 3: Noisy

- To Communicate:
  - Identify and reformulate instructions
    - ✓ Level 1: Understand a two- or three-line concept and identify keywords
    - ✓ Level 2: Reformulate with his own words
    - ✓ Level 3: Formulate a concept in relation to a real or fictitious situation
    - ✓ Level 4: Formulating instructions for the execution of a task
  - Look for information to treat them
    - ✓ Level 1: Read text, use different media
    - ✓ Level 2: Identify key ideas
    - ✓ Level 3: Taking notes in a structured way using the key words
  - Analyse and process Information
    - ✓ Level 1: Understand and reformulate essential ideas
    - ✓ Level 2: Establish information relative to their level of importance and organize them in a coherent way
    - ✓ Level 3: Developing, arguing from the information provided, discussing, debating from the information provided and asserting his opinions from the information provided
    - ✓ Level 4: Identify the importance of secondary
  - Carry out a production following precisely the instructions
    - ✓ Level 1: Write simple sentences and structure a message chronologically

- ✓ Level 2: Compose a paragraph and enrich a simple sentence with the appropriate vocabulary
- ✓ Level 3: Structuring its written production using a plan

- Oral presentation of information
  - ✓ Level 1: Transmitting information to another person
  - ✓ Level 2: Transmit information to a group and answer questions closed (QQOQCP This is a 5W1H Method (Why? What? Whose? When? Who? How much?) Which aims to identify the problem as a whole from 6 questions. And allow to have on all the causes of the problem, sufficient information to determine accurately the main cause. This information is often based on observations, facts recorded during investigations. (Estelle Donadei Facchin, 2011)
  - ✓ Level 3: Ability to answer open-ended questions
  - ✓ Level 4: Know how to question and adapt his speech to evaluate the relevance of the exchange

❖ Get organized:

- Organize his time
  - ✓ Level 1: Identify activities in a prescribed time (over the week) in guided mode and Identify and use time measuring instruments
  - ✓ Level 2: Identify his or her personal organization of time. In semi-guided mode and organize a fictive time
  - ✓ Level 3: Use an annual schedule, In stand-alone mode and Identify his daily activity curve
- Know how to interpret and use Graphic space
  - ✓ Level 1: From a detailed description
  - ✓ Level 2: From a map, give directions
  - ✓ Level 3: Describing a landscape from different points of view
- Organize his priorities
  - ✓ Level 1: Follow the tasks listed and plan his / her work.
  - ✓ Level 2: Determine the objectives and priorities and plan them, have them checked by a resource person.
  - ✓ Level 3: Determine priorities and objectives, plan and determine timeframe, have them checked by a resource person

❖ Search and treat information:

- Organize his research
  - ✓ Level 1: Identify the instruction, identify and understand keywords, ask questions to the resource person
  - ✓ Level 2: Ask questions, organize his research according to a plan
  - ✓ Level 3: Formulating a problematic
- Identify multi-support information sources
  - ✓ Level 1: Identify the different sources at his disposal, know how to locate himself in space
  - ✓ Level 2: Select the appropriate supports, Structuring Info
  - ✓ Level 3: Compare information given by supports
- Read and analyse information
  - ✓ Level 1: Active reading, Knowing how to take notes
  - ✓ Level 2: Analysing information (validity of information?)
  - ✓ Level 3: Data processing, reformulation of reasoning and synthesis of information
- Process and verbalize info
  - ✓ Level 1: Reformulating the problem
  - ✓ Level 2: Develop his ideas
  - ✓ Level 3: Argument your choices Writing (structuring a paragraph…)

➔ We are aware that all of these proposed elements need to be improved and adapted to the needs, it is for this reason in our proposed design, we have kept the system of cognitive processes really abstract and on open mode without any specification and concretization.

4) *'Emotional State:* Emotions have a very strong influence on learner motivation, self-regulation and academic achievement in the teaching process (Bart Rienties, Bethany Alden Rivers, 2014). And despite the frequent use of the term emotion in our daily life, its definition remains incomplete "everyone knows what it [emotion] is until they are asked to define it (LeDoux, J.,1999)", and often

ambiguous with other similar terms like: affect, feeling and mood.

In this article we will not discuss the different vision and current that define the emotion, what concerns us is how to represent it.

Many works have defined emotion and propose approaches for its representation. These approaches are divided into two main categories:

-Discrete approaches, which considers that there are a finite number of emotions.

-Continuous approach, which considers that there are an infinite number of emotions, represented in a multidimensional space.

Each group has its advantages and disadvantages, so the researchers thought of combining the two groups of categories.

One of the proposed approaches, we quote Russel's Circumplex model (Russell, J. A., 1980) that divides the multidimensional space into two dimension space (valence / activation) by forming a circle around these two axes, forming 8 diametrically opposite subspaces to represent four pairs of opposite emotions (Fig. 2.): activation vs. sleep, excitement vs. depression, satisfaction vs. anguish and pleasure vs. sadness (Imène Jraidi, 2013).

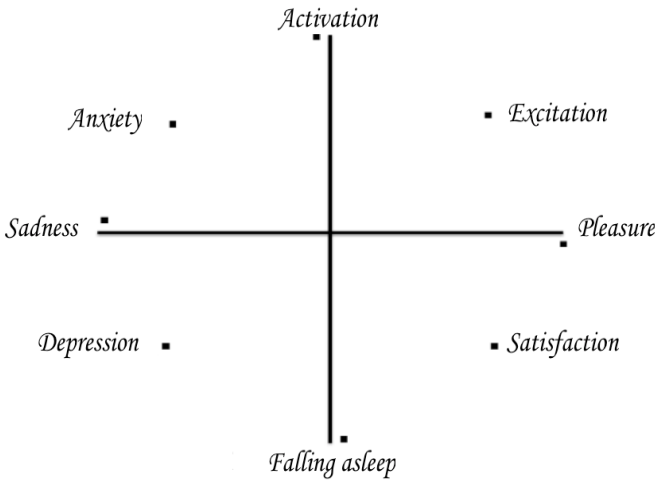

Figure 2: Russel's Circumplex model (Russell, J. A., 1980)

The approach cited above is general and is not devoted to a field of application; as a result several researchers have proposed approaches to modelling emotions in relation to the learning phase. Kort, Reilly and Picard proposed a theoretical model called 'four quadrant model' (Fig. 3.), which aims to classify the learner's emotions according to the learning phases in which they might be involved (Imène Jraidi, 2013).

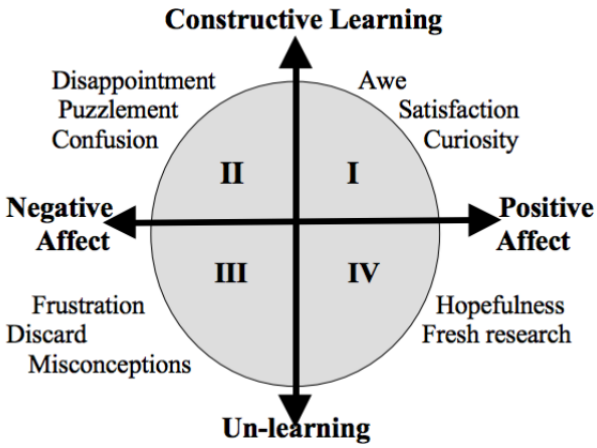

Figure 3: Four-quadrant model of Kort, Reilly and Picard (Kort, B., Reilly, R., & Picard, R., 2001) linking emotions in the learning phases

This model has two axes that are:

- Vertical axis: which describes the state and difficulty of the learning situation, which varies from 'non-learning' to 'constructive learning'.
- Horizontal axis: represents the valence of the emotional state of the learner and which varies from positive emotions to negative emotion.

And like all the approaches we have studied, we have noticed the same criticisms that are summarized in:

- The relationship between emotions and learning is still incomplete, in the sense that we are never sure that positive emotions improve learning, while negative emotions compromise it.
- The learner may have at one point not only an emotion, but also a combination of emotion.

In our conception we took the four-quadrant model as a reference while adding a third dimension, namely the control dimension, also called dominance (Albert Mehrabian, 1996), to represent the ability to control the situation that caused emotion.

Each emotion will be associated with a set of detectors and variables of emotion recognition; these are divides into two groups:

- Implicit:
  - The time spent on a module.
  - Frequency of use of the help button
  - Frequency of use of the mouse (number of clicks)
  - Mistakes in typing
  - The chosen theme
  - Period daytime
  - …

- Explicit:
    - Questionnaires
    - Evaluation system

And in order to solve the above criticisms, we have predicted in our conception that the learner may have at one time given several emotions at the same time, to express this, our way of thinking does not consist in determining these emotions but rather to know their effects (favourable or not favourable for learning) and their triggers, so multiple emotions will be considered as a one single emotion (complex) that will be saved as the average of their (emotions) multiple values of activation, valence and dominance then be associated with one of the strategic regions proposed by Oertel (Oertel, K., Kaiser, R., Voskamp, J. r. & Urban, B., 2007).

And concerning the criticism of the judgment of an emotion (it is favourable or not favourable for learning?), we have predicted that this judgment must be independent of the model but related to the performance of the learner (This is what differs our proposal from the model proposed by Oelter). In the sense that when the learner passes a test or acquires a new knowledge whatever the emotions he has experienced in his learning phase will be considered favourable even if this emotion belongs to a strategic region that is unfavourable for learning.

This facet is very important, we have already elaborate the scenario which is summarized in: Firstly, our system will learn and decipher the behaviour of the learner that starts from the detection of the learning state (favourable or unfavourable) and then collect and associate with this state the data of detectors and variables of emotion recognition. After a certain time, this process will be reversed by controlling the data of the detectors and variables of recognition of emotion to get the desired state of learning.

B. Our proposed conception

After the studies we have done and detailed earlier, we have developed our conception that integrates all six facets.

In the figure, we used different colors to refer each facet in the design.

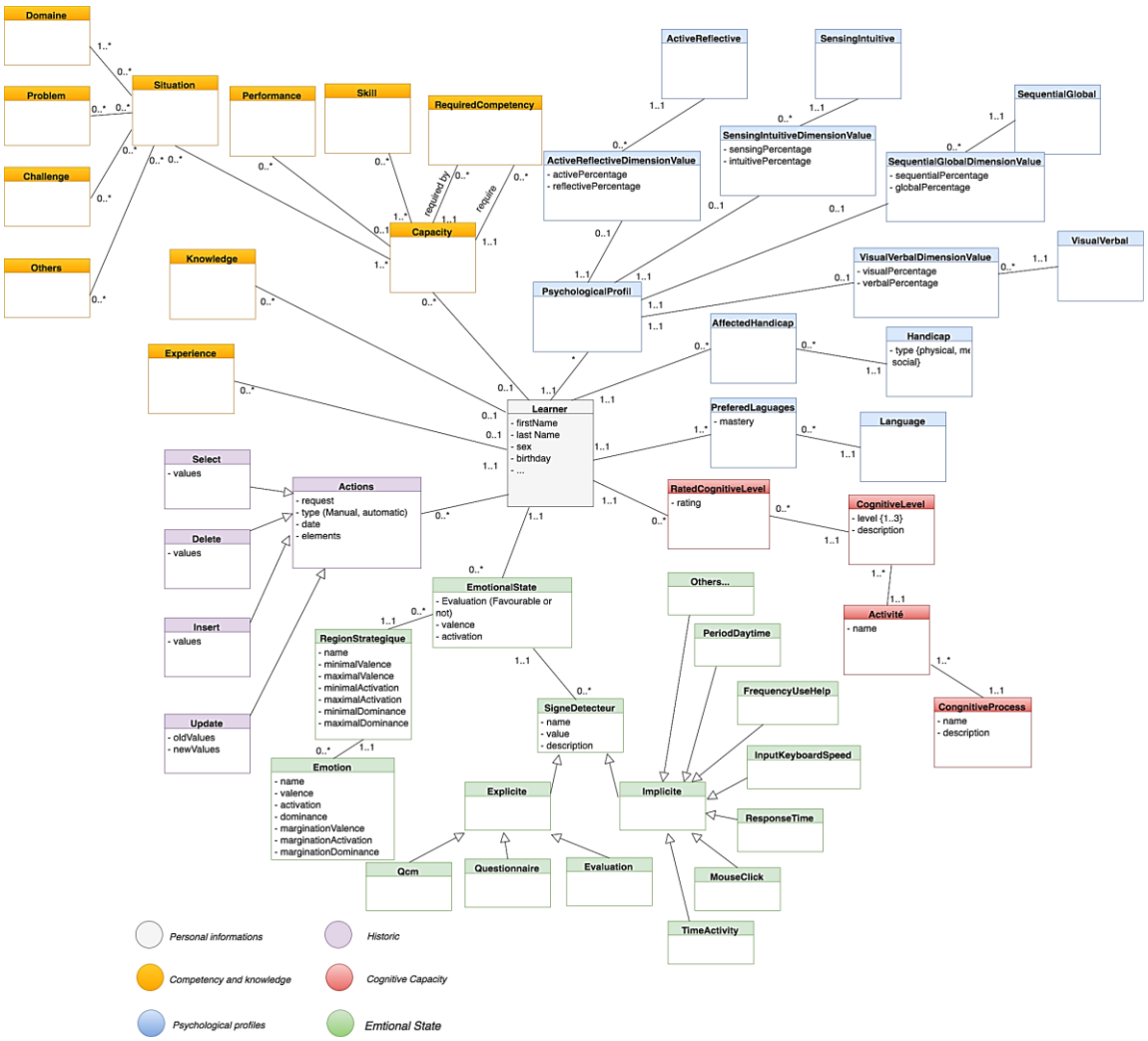

Figure 4: The class diagram of our proposed learner model

CONCLUSION AND PERSPECTIVE

The conception realized represents all the basic elements necessary to represent the learner in his different details. Although our design is still in the improvement phase, they are still elements (especially in the facet competency and knowledge) to be completed or to be connected to other models (domain model and adaptation models).

We will in the near future improve our conception by integrating it with the domain model and the models of adaptation that we will evidently conceive them. And also execute it in the intelligent system (M. Tmimi, M. Benslimane, M. Berrada, K. Ouazzani, 2017.) that we have developed and which will allow our model to go beyond its limits by being more flexible and unlimited in terms of organization of information.

All this will lead us to develop the adaptive hypermedia, which is the main goal of our research.

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