Design and implementation of an adaptive hypermedia model based on the thinking style

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Abstract

This article discusses the theory of learner's psycho-pedagogical criteria in the adaptation of a hypermedia educational system. To measure learning preferences, several adaptive systems are based on taking into account individual differences, in particular, the "thinking style". This concept refers to a set of pipes and strategies in how to manage and organize information. However, these systems face several challenges, rising important questions, such as: The styles used in the training context, among the multitude of styles defined in the literature? How to identify such styles? The proposed approach is based on measuring the learner performance, where the learning objective is designed respecting on the features offered by the HBDI (Herrmann Brain Dominance Instrument model) model to infer the learner style of thought.
If the learner's performance is satisfactory, then it is likely that the content and teaching strategy proposed matches his style. Otherwise, the course design is to be adapted based on the tracks and paths of the learner.

Keyword: Hypermedia, HBDI, Adaptation, thinking style, learner model.

I. Introduction

Hypermedia represents a best method of transmitting information, their use in an educational setting, have advantages by merging techniques of hypertext and multimedia. Indeed, the multimedia component can improve the visual and fun of the learner and enhance its relevance to the learning system. The hypertext component in turn can improve the quality of learning due to its nonlinear structure which helps the learner to construct knowledge. However, in an educational hypermedia, the learner must be an active player during his learning. It is important to him; he can distinguish its strengths and weaknesses throughout his educational career. This form of education can not provide personalized services for all learners then have access to the same set of teaching resources and tools, without taking into account the different levels of knowledge, interests, motivations and objectives.

The solution was to adapt the presentation of knowledge in the learner profile [15] [1]. This adaptation helps it to better navigate in the hyperspace and to move to build the appropriate learning path. Our research is fully within this dynamic and is particularly interested in the consideration of thinking style [2] of the learner as a criterion of adaptation, throughout his educational career.

II. Theory Base

A. Thinking style (TS)

Sternberg has proposed a theory of thinking style intended to help illuminate the differences in the way people think, contending that there are different ways that people use their abilities [4]; those preferred ways are constructed as “thinking styles”. Tennant’s definition of cognitive style [8] is “an individual’s characteristic and consistent approach to organizing and processing information”.

Cognitive style is considered to be a central and unchanging part of the individual’s personal and psychological makeup, it also describes one’s preferred approach to use the information he or she has perceived and remembered to solve problems.

There are some models for the measurement of cognitive style: Myers-Briggs Type Indicator (MBTI) [5], the field dependence-independence model [12], Cognitive Style Index (CSI) [19] [11], and Sternberg's Thinking Styles Inventory [4].

The Herrmann Brain Dominance Instrument (HBDI®) is a typical cognitive style measurement and model similar to MBTI [5]. Among the different proposals for modeling TS, we choose the HBDI tools since it is the more powerful tools for personal and team success.

B. *HBDI*

HBDI® was developed by Ned Hermann [14], based on his extensive research on brain dominance, which is natural and normal for all human beings and influences all four specialized thinking structures of the brain. HBDI® is an assessment tool that quantifies the degree of a person's preference for a specific thinking style taking the form of a survey consisting of 120 questions to be completed by an individual.

Different quadrants of the whole brain are indicated in Figure 1.

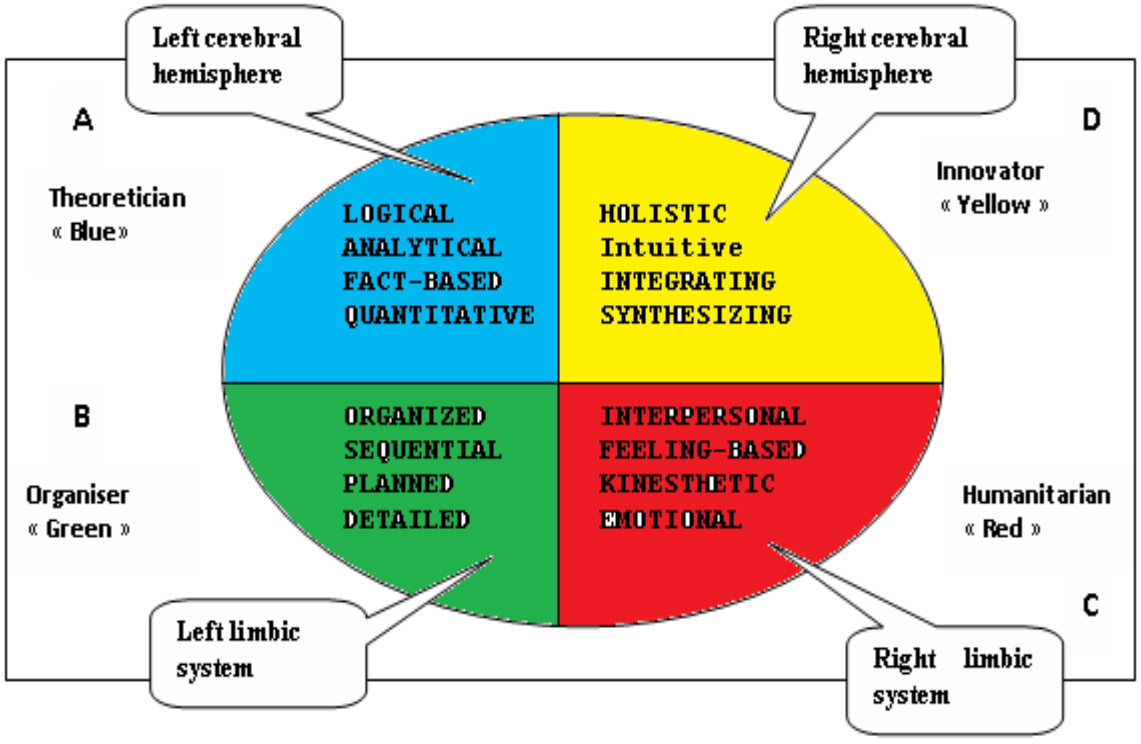


Figure 1. The Whole Brain® Thinking Model

In this model, human's brain is metaphorically divided into four quadrants, and each quadrant has its "colour" signifying one's thinking style preference; each "colour" has its corresponding "turn on" activities. According to [6], the preference for the A-quadrant (left cerebral hemisphere – analytical) means that one's favourite activities involve logical, analytical and factual information combined with an ability to perceive, verbalise and express information precisely; the preference of B-quadrant (left limbic system – sequential) favours organized, sequential, planned and detailed information, that means the people are conservative in their actions and like to keep things as they are. We can also see its similarities to an A-quadrant thinking preference in terms of the linear approach to activities, in A-quadrant and B-quadrant, ambiguity is rejected. A preference for the C-quadrant (right limbic system – interpersonal) indicates a preference for interpersonal information involving emotion; the preference for the D-quadrant (right cerebral hemisphere – imaginative) is mainly characterized by a holistic approach.

In our research, we classify learners being examined into four groups [14]: theoretician that has the thinking style of "blue", organizer that has the thinking style of "green", humanitarian (socials) that has the thinking style of "red" and innovator that has the thinking style of "yellow". The correspondent "turn-on" activities of each group are also shown in Table 1.

Our model is inspired by HBDI, because HBDI ® is the only instrument that quantifies a person's preference for thinking in four different modes depending on how the brain functions [6]. It is also a tool to encourage a person to understand his or her strengths and weaknesses, preferences and avoidances.

Quadrant	Color	Prefered activities and working characteristics
Left cerebral hemisphere	Blue	Theoreticians: They like the facts, the details, critical thinking, the precise definitions, unambiguous instructions. Features of work: Works alone; analyze and diagnose; presents a relational problem by the logic; solves difficult problems in matrix; likes challenges.

Left limbic system	Green	Organiser: They love the instructions step by step, the schemas, checklists, Time Lines, problem solving with the steps and specific procedures. Features of work: likes structure; puts in order; plans, organizes and manages "execution" of projects; preserves the status quo; attentive to details; integrates information in a sequential manner.
Right limbic system	Red	The socials (Humanitarians): They prefer collaborative learning, group discussions, role-playing, personal approaches and personal examples. Features of work: Builds relations before constructing the project; loves persuade, advise, listen, be part of a team; expresses his ideas with emotion; sensitive to what other people think.
Right cerebral hemisphere	Yellow	Innovators: They prefer brainstorm, metaphors, illustrations, images, summaries, holistic approaches, the pace (rhythm) alert. Features of work: Takes risks; experiments; loves variety, energy, novelty; plans the future, likes to talk about strategy; uses his intuition, overview, Interrelations.

Table 1 Classification of "turn-on" activities according to HBDI® model.

C. Dominant preferences

Current research indicates that learners can use more than one style, each student may have preferences primary, secondary preferences and preferences tertiary [14].

We present the algorithm that identifies what the dominant preference for a learner, from the work of [2]:

Firstly, we regard di (i=1, 2, 3, 4) as the values of a respondent's four quadrants of preferences, and rank them: d1> d2> d3> d4, suppose s as the sum of d1, d2, d3 and d4; e= (d1− d2)/s, f= (d2− d3)/s, g= (d3− d4)/s;

Secondly, for identifying the dominance of certain style, a threshold tv is set. In order to study all possible cases, the value of tv is set as 0.015 in our research; the thinking style identification should be consistent with following rules:

if tv < e, then the style of d1 is the unique dominance (i.e. the respondent has the unique thinking style of the group that d1 represents;

if tv > = e, then observe f:

if tv < f, then d1 and d2 are the two dominances;

if tv > = f, then observe g:

else d1, d2, d3 and d4 have the same dominance degree. It means that the user has a "whole brain" thinking style.

D. Pedagogical approaches

There are great schools of thought that influenced psycho educational systems and educational technologies in particular. We distinguish:

1. **Behaviorist pedagogy** aims to promote and modify observable behavior. It considers learning to be a behavior that shows acquisition of knowledge or skills [9].

2. In **Cognitive** theories knowledge is viewed as symbolic, mental constructions in the minds of individuals, and learning becomes the process of committing these symbolic representations to memory where they may be processed.

3. **Constructivism** is first of all a theory of learning based on the idea that knowledge is constructed by the knower based on mental activity. Learners are considered to be active organisms seeking meaning. [27] [26].

4. **Socio-constructivism** can be defined as an approach according to which individual knowledge relies on its social construction of it. [25] Teaching strategies using social constructivism as a referent include teaching in contexts that might be personally meaningful to students, negotiating taken-as-shared meanings with students, class discussion, small-group collaboration, and valuing meaningful activity over correct answers [17].

5. **The *active pedagogy*** facilitates the work in group in stressing the members' importance by the project realization and allows learners (the member of a project) to develop a global view on a project, and a better understanding of the combination of several subjects or disciplines [2].

We classify the general pedagogical approaches and their corresponding pedagogical activities in five categories, as in table 2:

Pedagogical approach	General pedagogical activity
Cognitivist	Presentation of the theoretical concepts and then the resolution of the exercises (and solution)
Behaviorist & cognitivist	Discover the theoretical concepts from the exercises and the case (from example)
Constructivist Learning	Learning from project, in the context of an individual work (student-centred)
Socio-constructivist	Learning from project, in the context of a collective work (collaborative learning)
Active pedagogy	The cooperation between the students (each student communicates with his/her peers to seek help)

Table 2 Pedagogical approaches and general pedagogical activities

E. Relationship between pedagogical approaches and color

The system provides a learning path for teaching his concept based on thinking of the learner based on the relationship between pedagogy and the colors of the HBDI model (Table 3).

Pedagogical approaches	**colour**
Cognitivist	green
Behaviorist and Cognitivist	bleu/yellow
Constructivist	bleu/red/yellow
Socio-constructivist	red
Active pedagogy	red/ Green/ yellow

Table 3 Relationship between teaching approach and colour

Thus, four learning paths are distinguished:

- In the theoretician path the learners begin by analyzing and solving the problem. However, the teacher presents the theory of the concept to provide the necessary information, and then the teacher has additional applications in the form of exercises to make it easy for the learning.

- The humanitarian path begins with a project, followed by application exercises, and finally the teacher presents the theoretical concepts to provide additional information.

- In the innovator path the teachers begin by presenting the theory on the course. Learners try to analyze and solve problems using knowledge of the course. The teacher may re-use theoretical concepts to facilitate the learning process. This approach is used for the traditional model of education.

- In the organizer path teachers begin by presenting the theoretical concepts on a course after students attempting to analyze and solve practical exercises using knowledge of the course. Then, the teacher presents additional applications and solving problems.

III. Proposed system architecture

In this paper, a new personalized education system is presented according to the learning model based on personality. This module is displayed in figure 2. Our general purpose may be viewed as being comprised of at least the following three elements:

- Domain Model: Consist of concepts and the relations that exist between them. Typically the domain model gives a domain expert's view of domain.

- Learner Model: Consists of relevant information about the user that is pertinent to the personalization of the thinking style.

- Adaptation Model: Consists of a set of strategies for describing the runtime behaviour of the system as well as how the domain model relates to the user model to specify adaptation.

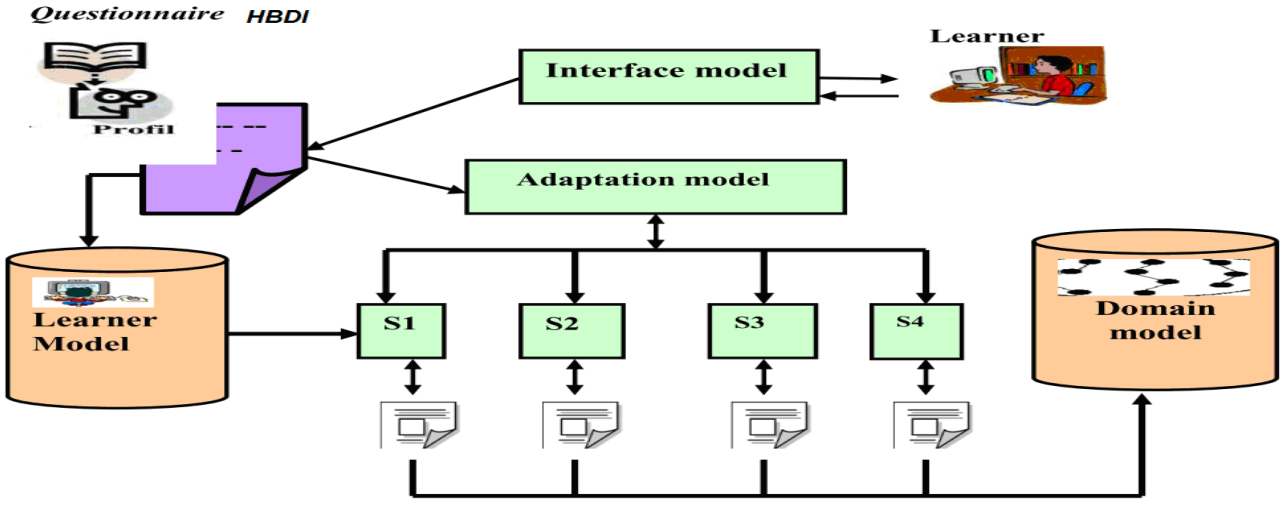


Figure 2. Proposed System Architecture

A. Learner Model

The selection of styles of learners is conducted using questionnaire of HBDI. This tool help to establish a static model of each learner based on the dimensions of thinking styles (theorist, organizer, humanitarian, and innovator).

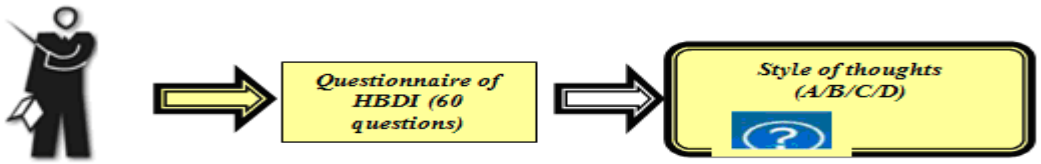


Figure 3. The learner model established by the instrument (HBDI)

B. Domain Model

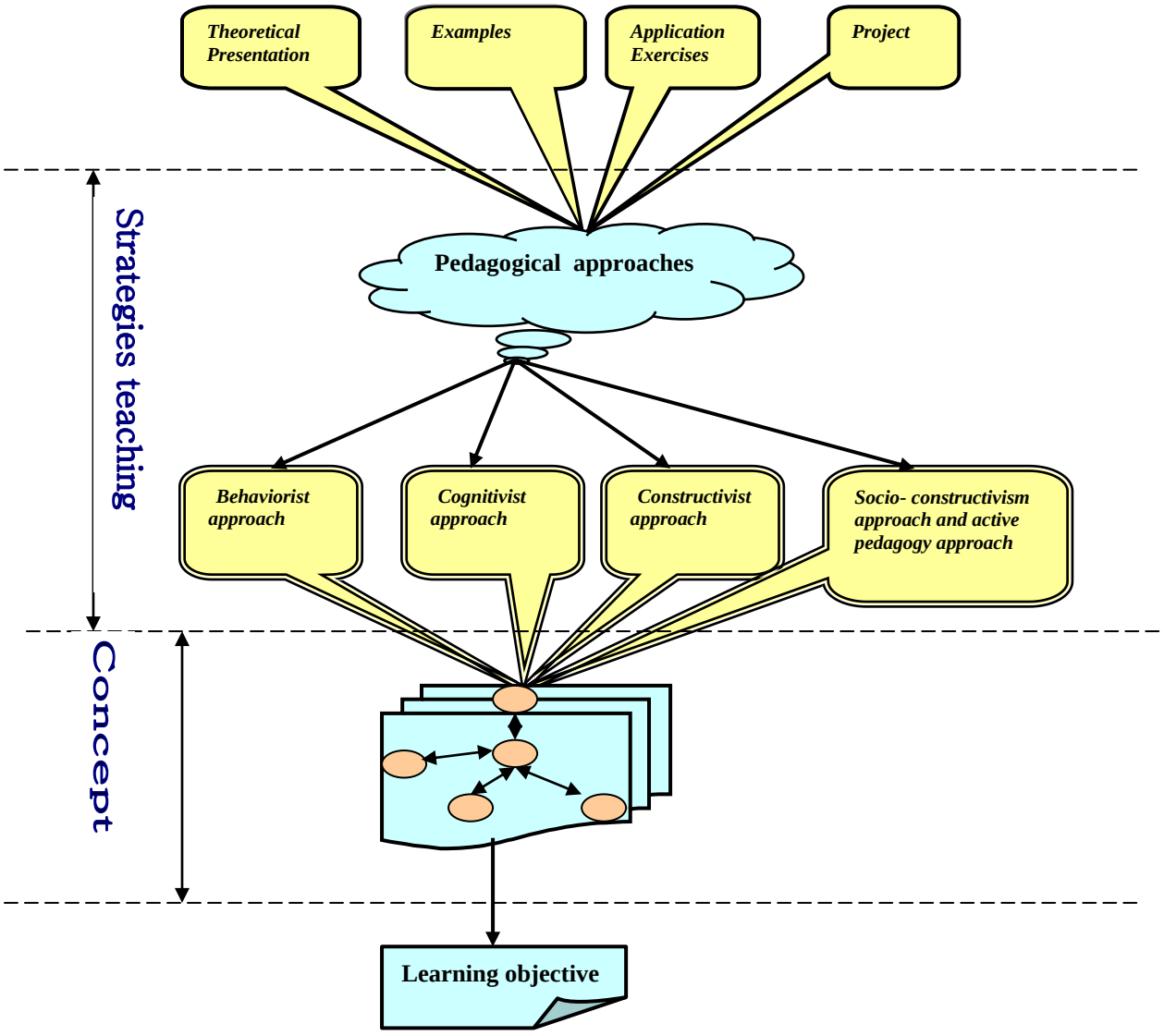


Figure 4: Domain Model

As part of our approach, the domain model is designed as a graph of pedagogical objectives. Each objective is associated with a set of domain concepts and to explore each concept is it self connected to a set of learning activities that constitute resources that will handle the learner during the learning (Figure 4).

We used several types of pedagogical activities to introduce a concept namely: presentation of theory, exercises, practical work (or project).

C. Incorporating Intelligent Question/Answer into the Teachable Agent

Before starting the course, a learner is invited to meet the HBDI questionnaire to determine its mode of thought. After complete and validated, the system calculates and stores the result in the learner model. The learner can access the system via a user-friendly interface allowing him to describe his application. Select the learning objective and then choose between concepts via multiple choice lists.

The system provides a learning path for teaching his concept based on the relationship between pedagogy and the colors of the HBDI model.

IV. Scenarios for Using the System

In order to validate our approach, to verify whether these techniques of adaptation can make an adaptive hypermedia system more adaptable, we have done some experimentation with the learners from different disciplines.

A. Identification of the style

Once the learner comes to the thinking style module, a test with 60 questions will be presented . After this test, a user may get the information of thinking style in his/her profile, including the analysis about the results. Here, the users can find their characteristics of working, the suggestion for work and what should be avoided for their efficient communication. Also,

according the user's profile, a course is provided by default if he/she would like to preview it. By clicking button Validate.

At the same time, integrating the preliminary results of our research on thinking style and pedagogical approach, we also provide the guide information, together with the information of thinking style in one's profile (see figure 5).

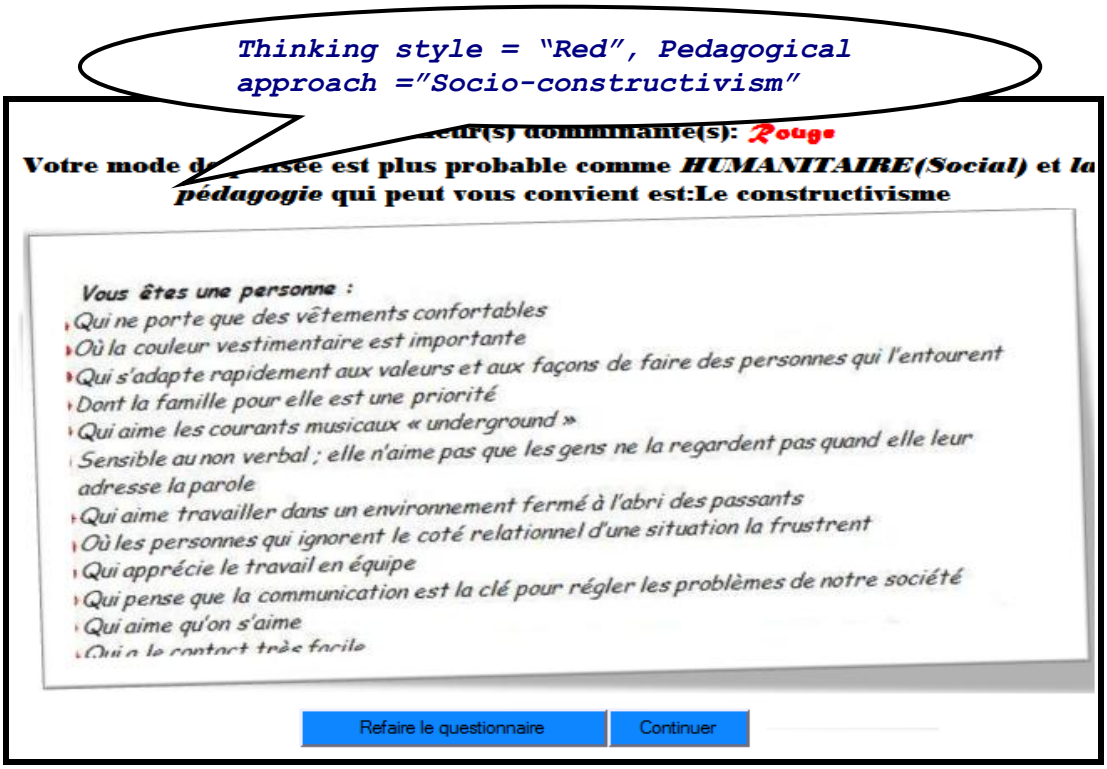
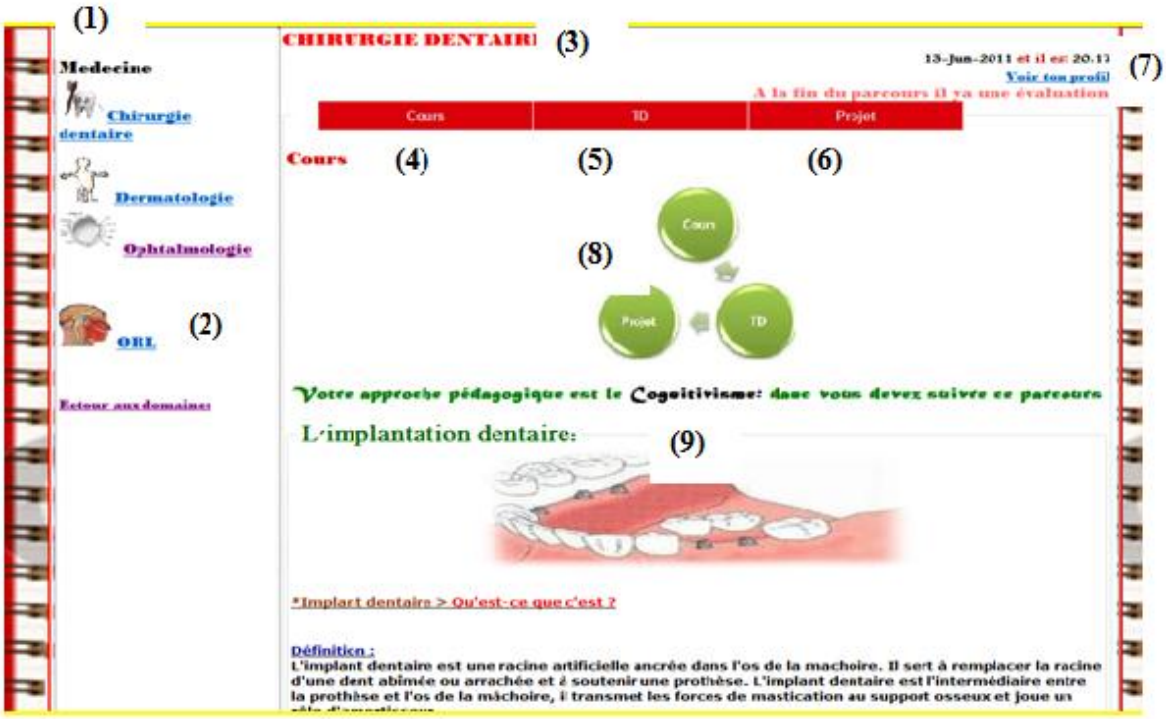


Figure 5: An example for the result of thinking style with pedagogical approach.

B. Adaptation of the course

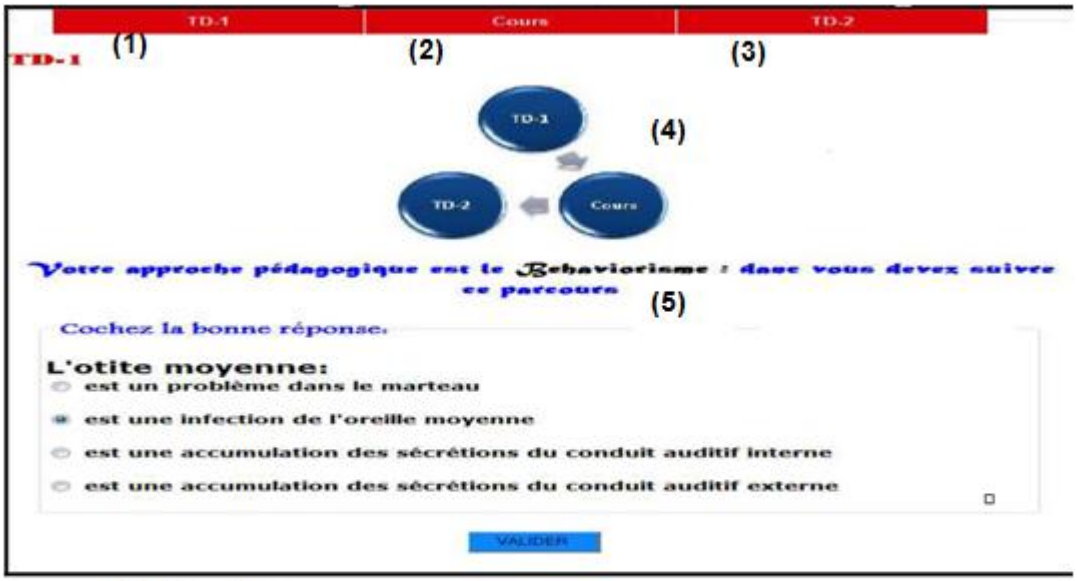
For example, if a user works in the domain of medical, once he or she gets his/her thinking style (e.g. green) from the test, system will automatically add the corresponding activities and plays of this into the template of domain (e.g. medical).



(1) Working domain
(2) Concept
(3) Learning objective
(4) Theory
(5) Directed works
(6) Projects
(7) View your profile
(8) Learning Path
(9) Cognitive approach

Figure 6: Explanation Concept that the cognitive approach.

Figure 7 shows an example of structure of a course which is enriched by the complementary element of thinking style.



(1) Exercises
(2) Theory
(3) Problem solving
(4) Learning path
(5) Behaviorist approach

Figure 7. Example of concept with behaviorist approach in ORL.

C. Updated style

If the evaluation results are weak, the system checks whether the student has followed the path indicated, if it is not the case the system gives him a chance to rebuild his career (See Figure 8).

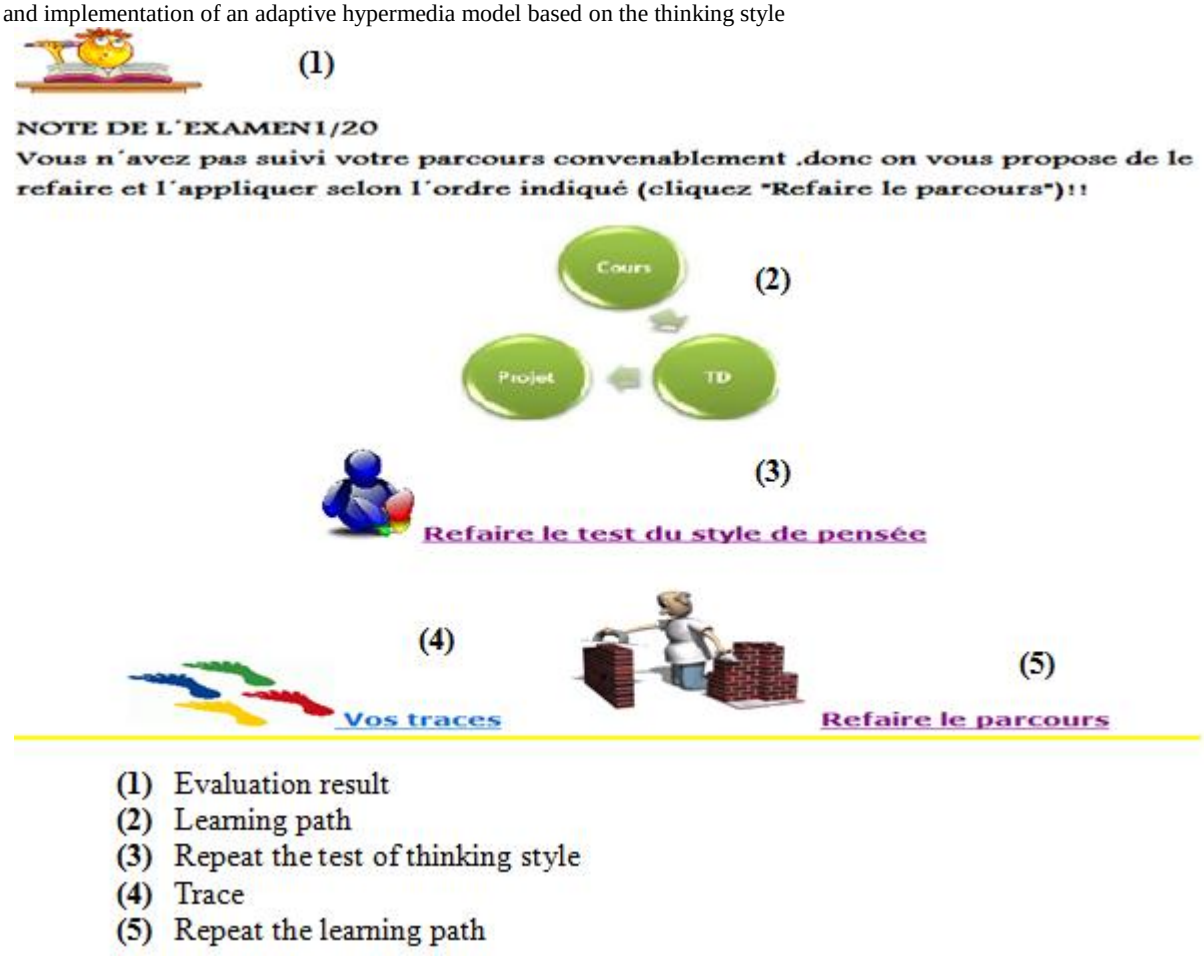


Figure 8. Rrepeat the learning path.

Otherwise the system concludes that the proposed approach does not suit the style of the learner and asked him to redo the questionnaire or another approach that may be suitable for style (See Figure 9), by using the relationship between teaching approach and style of thinking of the learner already explained in Table 2.

(1)

NOTE DE L´EXAMEN 1/20

.e parcours pédagogique proposé ne vous convient pas ,on vous propose un autre parcours!!!!

Refaire le test du style de pensée

Vos traces

(2)

2ème parcours

(1) Evaluation result
(2) Second Learning path

Figure 9. Change of pedagogical approach in the case of failures.

V. Results and Discussion

We present in what follows (Table 3) some responses of the learners about the main questions of the questionnaire. This questionnaire includes the questions about the functions of Thinking Style; the questions about the effect of adaptive course structure and pedagogical activities, which is how the course adapts to the user's preference; the questions about the general impression of system, including the effect of interaction between user and system.

We collected the responses of 10 learners from the aforementioned domains.

Questions	**Answers**			
How do you think the domain list provided by system?	**More general**	**appropriate**	**More detailed**	
	10%	**50%**	**40%**	
When you do thinking style test in system,	**Very suitable**	**Suitable**	**Quite suitable**	**Not suitable**

do you think the length of time is suitable?	**0(0%)**	**3(30%)**	**5(50%)**	**2(20%)**
When you navigate in system, how do you feel about the navigation among these modules?	**very convenient**	**convenient**	**quite convenient**	**not convenient**
	3(30%)	**4(40%)**	**2(20%)**	**1(10%)**
On which level the recommended activities from system match your need for pedagogical activities?	**Very good**	**good**	**average**	**weak**
	2(20%)	**4(40%)**	**2(20%)**	**2(20%)**
Does the function of modification of the course structure is necessary for your course?	**very necessary**	**necessary**	**Quite necessary**	**not necessary**
	3(30%)	**4(40%)**	**2(20%)**	**1(10%)**
Do you think it is useful for your later work when system provides the information about pedagogical approaches?	**very useful**	**useful**	**Quite useful**	**not useful**
	1(10%)	**0(0%)**	**3(30%)**	**6(60%)**
How do you think the interface of system for generating your courses?	**very interactive**	**interactive**	**Quite interactive**	**not interactive**
	4(40%)	**3(30%)**	**2(20%)**	**1(10%)**

Table 3. Responses of learners after the experiment

For the question about module of domain, 50.0% think the existing list of disciplines in system is appropriate while 40.0% think the list should be more detailed, and the rest think that it should be more general.

The question about the utilisation of thinking style test, 8 learners (80% of the total) thinks the length of time spent on thinking style test is suitable.

For the question about the navigation among these modules, 70% of the users feel very convenient or convenient (value ≥ 4) when navigate in the abovementioned modules of system; besides the 20% of the users who show the average satisfaction degree, 10% feel the navigation among these modules is not convenient (value ≤ 2).

Once the user fulfilled the test or the questionnaire, the adaptive activities are automatically recommended by the system. 60% of the respondents appreciate the recommended activities, 30% of the respondents hold the neutral opinions.

Besides, there exist 10% respondents who are not satisfied with the activities by default.

The user' opinions on module of modification are obviously positive. This function can make sure to modify the course structure with which the user is not satisfied after viewing it in system.

The negative opinions are discovered from the result for question "do you think it is useful for your later work when system provides the information about pedagogical approaches?" A relatively large proportion of learners do not mind whether the pedagogical approach information being provided in their profile by system. They stated that the information was too general to find the clear indication for their following activities.

IV. Conclusion and Future Work

In this paper, we presented the implementation of an adaptive hypermedia system of education centered on the use of psycho-criteria (thinking style). Also, we have given importance to the use of

several types of courses and many types of resources because they must reflect the dimensions related to the different styles adopted in our approach.

The objectives of our approach is to achieve the following purposes:

- Determine the thinking style of the learner according to a test;

- Use of this style as a distinguishing characteristic to adapt the course;

- Determine the appropriate pedagogical approach for each style;

- Evaluate the performance of learners with respect to adaptation;

- In case of failure in the evaluation of treatments are applied such as a change of teaching approach based on appropriate evidence acquired during the training.

As a future work, more services should be integrated in system:

- More pedagogical activities should be explored and integrated into system;

- We plan to use Bayesian networks to detect thinking styles, to make the system more adaptive and dynamic.

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