

Designing an adaptive hypermedia system based on the use of psycho pedagogical criteria

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Abstract

This article discusses the theory of psycho-educational criteria of the learner as a means of hypermedia educational system adaptation. To measure learning preferences, several adaptive systems take into account individual differences particularly, the "learning style" and "style of thought". These concepts refer to a set of pipes and strategies on how to manage and organize information. However, there is still several challenges to deal with such as those related to the identification of the used styles and their specification. In our approach, we measure the performance of a learner with regard to the learning objectives while integrating the characteristics of the model proposed by Felder to describe the learning style of the learner. Moreover, we use the features defined by the HBDI model to infer the style of thought of the learner. We consider that the content and teaching strategy proposed match the learner's style when its performance factor is satisfactory. Otherwise, the course design is to be adapted based on the tracks and paths of the learner.

Keywords: *Hypermedia, Adaptation, Felder, HBDI, Certainty factor, Trace.*

1. Introduction

Hypermedia represents a new 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]. 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 learning styles [1] and style of thought [2] of the learner as a criterion of adaptation, throughout his educational career.

2. Style of thinking

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) [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] (Myers and McCaulley, 1985).

HBDI® was developed by Ned Herrmann [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.

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 figure 1.

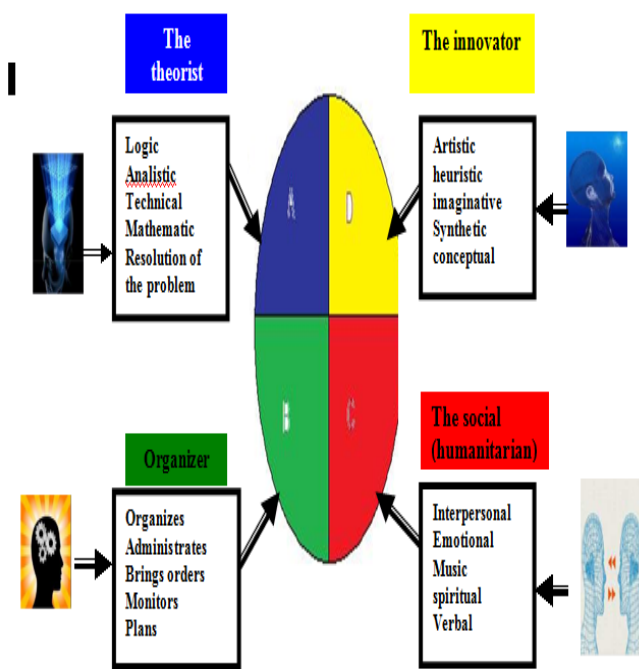


Fig. 1: The model "Whole Brain" by Ned Herrmann.

The main theme of the approach developed by Ned Herrmann [6] is particularly known as right brain left brain is inspired by the work of the psychoanalyst YOUNG, indeed, according to the theory [14], there are four styles psycho educational profile.

Theorist: It likes facts, details, critical thinking, precise definitions, and unambiguous instructions. Characteristics of work: Working alone, analysis and diagnosis; approach a relationship problem by logic; solve difficult problems in a matrix; likes challenges...

Organizer: He likes step instructions, diagrams, checklists, time difference, the resolution of problems with specific steps and procedures.

His job characteristics: Likes structure; brings order, plans, organizes and manages the "execution" of projects; preserves the status quo, attentive to detail includes information sequentially...

The social (humanitarian): He preferred the collaborative work, group discussions, role playing, approaches and personal examples. His work features: Built relationships before building the project, likes to persuade, advise, listen, be part of a team and expresses his ideas with emotion, sensitive to what others think ...

Innovator: It prefers brainstorming, metaphors, illustrations, images, summaries, holistic approaches, the pace alert.

His work features: Takes risks, experimenting, likes the variety, energy, novelty, is projected into the future, and likes to talk about strategy, using his intuition overview, interrelations (Figure 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. It consists of 120 items, which after processing in the model; provide a picture of preferential treatment methods used by one person.

3. Learning style

Learning style is defined by distinctive behavior at the cognitive, emotional, physiological and sociological behaviors are relatively stable indicators of how an individual perceives and processes information, interacts and responds to the environment learning.

For this study, we choose the instrument "Index of Learning Styles (ILS) whose bases were made by [3]. Several factors have motivated our choice. First, the tool is relatively recent and still current, completed by one hundred thousand people each year. Overall, the tool meets all the criteria of reliability, internal consistency, external validity of the construct, reliability repetition, etc., ILS also has a number of strengths and skills with various additional resources. It is available free online in its entirety (there are even versions in different languages including French), with its scale and grid interpretation. Simple and fast to use (it only takes ten minutes to

complete), it can fit in one sheet double-sided and results were quickly apprehended.

This instrument consists of 44 forced choice questions, 11 for each of the four dimensions, it scales from polar. Thus, on each dimension, the score is an odd number between -11 and 11; further away zero, the greater the preference is strong (see Table 1).

Table 1: Scale ILS

Echelon:	-11	-9	-7	-5	-3	-1	+1	+3	+5	+7	+9	+11
Preference:	High	Average		low	low	average		high				

Since this is a polar scale, one is necessarily negative and one positive, it means that the positive scores mean "best". Similarly, a score close to zero reflects a balance between two extremes, but is not necessarily desirable. In addition, each individual is able to exhibit all the traits in different contexts: it is only trends and not absolute exclusive, even with a high score. Finally, the instrument measures only preferences, not abilities: although there is often a tendency to prefer an area where there is strong, it does not follow inevitably [13].

The four dimensions are as follows: "active-reflective," "sensing-intuitive," "visual-verbal", "sequential-global". Terminology poses little problem in translation for the most part, except as sensing, which was made at different times by "sensitive", "logical" and "sensory". The former may seem a contradiction; the second can cause confusion with "sequential" and is therefore "sensory" which was incorporated here. The table below briefly describes all of these dimensions.

Table 2: Dimensions ILS

Active	Learn by experimenting, working well in groups
Reflective	Learn by reflecting, prefers to work alone or with one regular partner.
Sensory	A reflection concrete, practical, oriented toward facts and procedures.
Intuitive	with abstract thinking, innovative, oriented toward theories and underlying meaning
Visual	Prefers visual representations of new information, including images, diagrams, and graphs.

Proceedings	Prefers verbal explanations written or oral.
Sequential	With linear thinking, learning incrementally steps by step.
Global	With holistic thinking, suddenly learns from an overview.

In any case, no tool can claim to account for the infinite number of human styles [7].

4. Pedagogical approaches

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

Behaviorist: Discover the theoretical concepts from the exercises and the case (from example) [9].

Constructivist: 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) [10].

Cognitivist: Presentation of the theoretical concepts and then the resolution of the exercises (and solution).

Active Pedagogy: The cooperation between the students (each student communicates with his/her peers to seek help).

5. Proposed system architecture

The architecture of our system is issued from the standard architecture of adaptive hypermedia, in which the learner is modeled by his learning style and his style of thoughts (Figure 2).

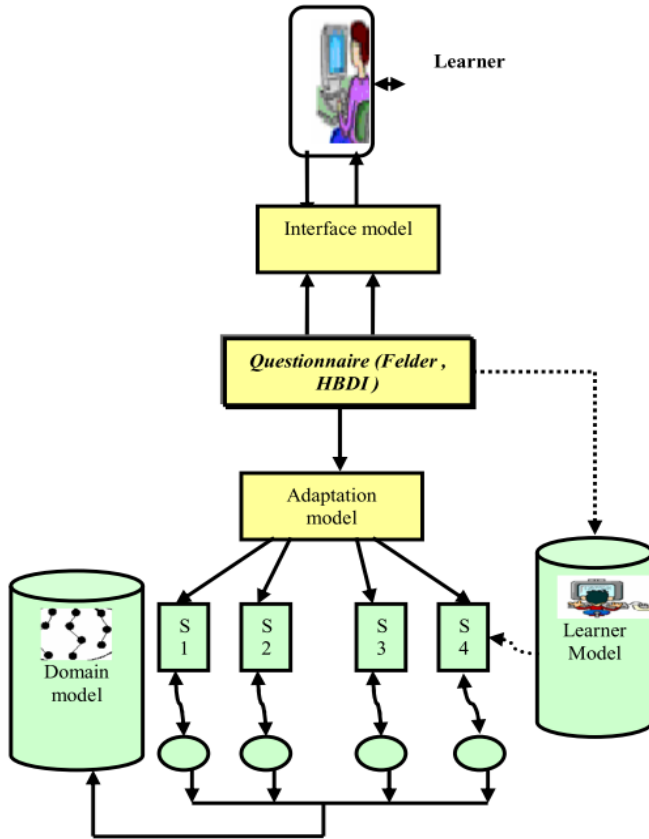


Fig. 2: Proposed System Architecture

Taking into account the concepts mentioned above, this architecture includes:

- A learner model which provides information on learning style and his style of thought.
- A domain model that provides information on the concepts to be taught.
- A probabilistic model of adaptation which adapts the course according to the learner model.
- An interface module is responsible for the content play and interacts with the learner.

5.1 Model learning

The selection of styles of learners is conducted using questionnaires of Felder and HBDI. These tools help to establish a static model of each learner based on the one hand dimensions of learning styles (think tank, reasoning, sensory, progression), and other dimensions of thinking styles (theorist, organizer, humanitarian, innovator).

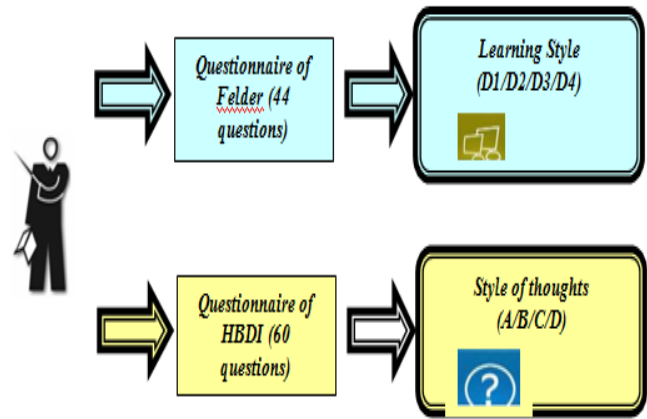


Fig. 3: The learner model established by the instrument (Felder / HBDI)

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 d_i ($i=1, 2, 3, 4$) as the values of a respondent's four quadrants of preferences, and rank them: $d_1 > d_2 > d_3 > d_4$, suppose s as the sum of d_1, d_2, d_3 and d_4 ; $e = (d_1 - d_2)/s$, $f = (d_2 - d_3)/s$, $g = (d_3 - d_4)/s$;

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

- if $t_v < e$, then the style of d_1 is the unique dominance (i.e. the respondent has the unique thinking style of the group that d_1 represents;
- if $t_v > = e$, then observe f ;
- if $t_v < f$, then d_1 and d_2 are the two dominances;
- if $t_v > = f$, then observe g ;
- else d_1, d_2, d_3 and d_4 have the same dominance degree. It means that the user has a "whole brain" thinking style.

5.2 Model domain

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

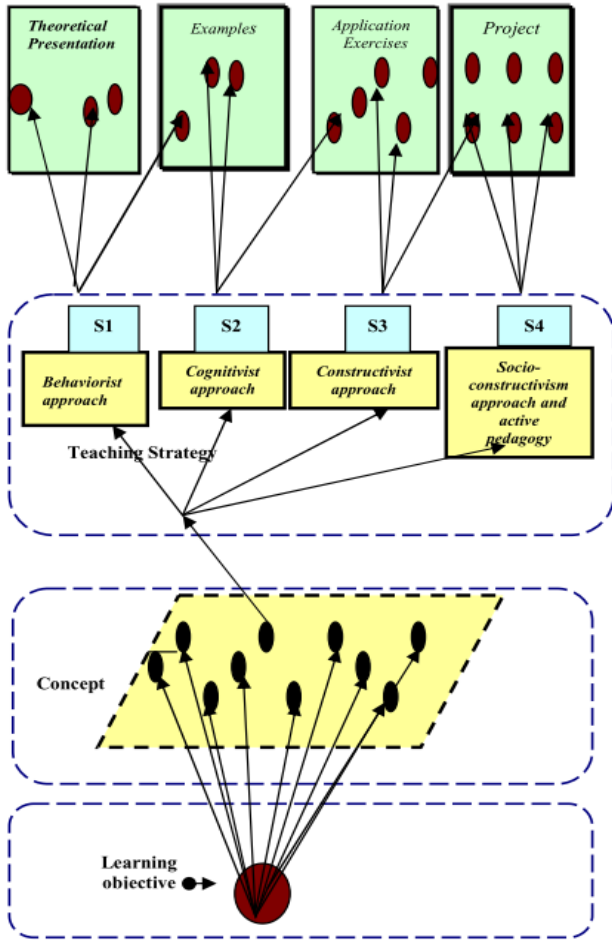


Fig. 4 Domain model

We used several types of educational activities to introduce a concept namely: presentation of theory, exercises, practical work (or project). These activities are categorized into 6 types. For the presentation of the theory, three activities are provided:

- AG1: Course structured learning objective.
- AG2: Additional Information.
- AG3: Share-based examples and analogies.
- AG4: multiple choices, true or false.
- AG5: Problem Solving.
- AG6: Lab / project.

5.3 Model Adaptation

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. Once the style of thinking has been determined, the questionnaire Felder is proposed to him infers the learning style. After the system saves the learning style in the model of the learner, 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 thinking of the learner based on the relationship between pedagogy and the colours of the HBDI model (Table 3).

Table 3: Relationship between teaching approach and color

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

Thus, four learning paths are distinguished:

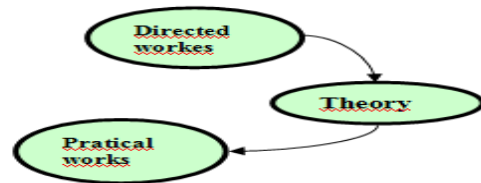


Fig. 5 Path depending on the analytic style

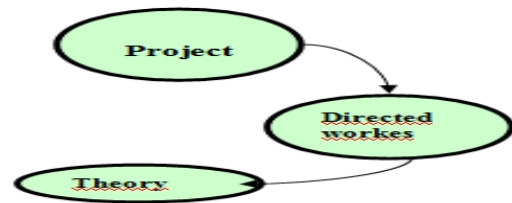


Fig. 6 Path depending on the interpersonal style

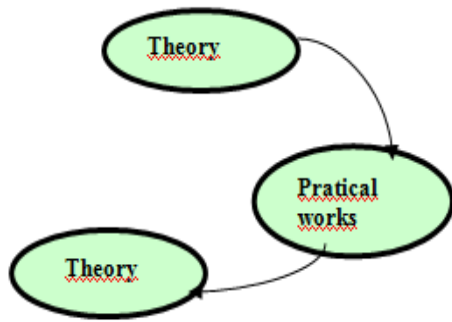


Fig. 7 Path depending on the imaginative style

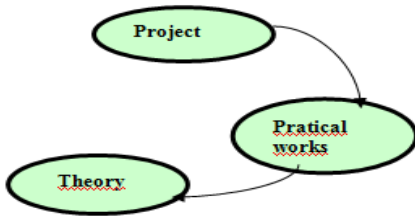


Fig. 8 Path depending on the sequence style

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

- In the course imaginative 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.

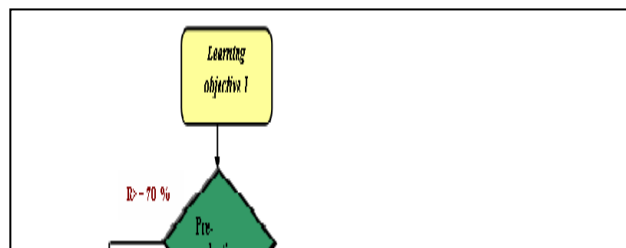
- In the sequential path teachers begin by presenting the theoretical concepts on a course after students attempting to analyze and solve practical exercises using knowledge of the course. Then, the teacher presents additional applications and solving problems. For each activity, the model seeks to adapt the best material to be presented to the learner, observing the following recommendations (Table 4):

Active	<ul style="list-style-type: none"> - Discussion, practice, group work, dialogue. - Including numerous exercises, simulation.
Reflexive	<ul style="list-style-type: none"> - Working alone - Includes less exercise. - Includes questions that encourage reflection
deductive	<ul style="list-style-type: none"> - Includes plenty of facts and practical content. - Give many examples - Includes various multimedia objects
Inductive	<ul style="list-style-type: none"> - Focusing on abstract concepts and theories - Giving fewer examples
Visual	<ul style="list-style-type: none"> - Diagrams, pictures, films, demonstrations present the content - using charts and diagrams.
Verbal	<ul style="list-style-type: none"> - Discussion, oral reports, writing projects, - Includes the text and audio material - Provides opportunities for communication(forum, chat)
Sequential	<ul style="list-style-type: none"> - Includes content presentation step by step - Puts links to related subjects at the end of the course - Views the 'next' and 'previous' - Hides outline. - Presents the testing in shorter intervals.
Global	<ul style="list-style-type: none"> - Includes projects and summaries, integrates links to related topical links in the content of the course. - Integrates related topical links in the content of the course. - Places the exercises at the end of the course.

The following figure summarizes the operating principle of our model of adaptation:

Table 4: Relationship between learning style and course content

<i>Learning Style Activity</i>	<i>Description</i>
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6. Scenario for using the system

6.1 The pre-assessment

The learner starts with a pre-assessment to determine its level. If the result is greater than 70% of the overall score, it will be directed to the important points of the concept. However, if your score is below 70%, it will have to consult the prerequisites of the concept. This transition will enable it to address its shortcomings and have the prerequisites needed to understand the concept. The system will check if his score at the pre-assessment was less than 30%. If so, the learner will always consult the information and explanations about the concepts prerequisites.

This step may contain examples or comparative explanations that stress the differences and similarities between concepts.

6.2 Evaluation

If the evaluation result of the learner is very satisfactory, then it is likely that the content and suggested educational path to better match his style, which implies that this coherence is interpreted by the increase in the certainty factor. In this case, the system goes to the scenario to check the degree of certainty. Otherwise if the evaluation results is less satisfactory, and then it is likely that there is a small distance between the style proposed by the system and style of the learner. This can be interpreted by the stability of certainty factor. The system will verify the scenario of the degree of certainty. Otherwise if the evaluation result is weak, then it is likely that the distance between the style proposed by the system and the system of the learner is very large. This can be interpreted by the decrease in the value of certainty factor. The system will trace the scenario of course.

6.3 Trace path

In this case the system tries to detect the new style of learning through the use of path indicators [16] [17]. So if there is a change in style or thought at learning style, there are many more failures during learning of this concept, so the style is called into question. Otherwise if there is no change in the style and the value of certainty factor is very important, so the learner can continue his learning, otherwise the style is called into question.

6.4 Check the level of certainty

If the value of a degree of certainty is important so the student can continue learning and keep the same route and

Fig. 9 Scenarios for using the system according to the approach of learning theoretical concepts, the class exercises and problem solving inspired by the work of [18].

format content. Otherwise the system will trace the scenario of course;

7. Conclusion and future work

In this paper, we presented the design of an adaptive hypermedia system of education centered on the use of psycho-criteria (learning style, 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 originality of this work lies firstly in the use of a hybrid model to adapt the content according to the style of the learner, and also in the maintenance of style via the trace routes and the degree of adaptation. As a future work, we plan to create a prototype and then validate it with the UTC student population with a wide variety of field work.

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