An Adaptive Hypermedia System Integrating Thinking Style (AHS-TS): Model and Experiment

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Abstract

This paper presents an approach to integrate thinking styles into adaptive hypermedia system. The main objective was to develop an adaptive system and assess the effect of adapting pedagogical activities individualized to the student's thinking style. The proposed approach used adaptive hypermedia technology to improve learning process by adapting course content presentation to student thinking styles. The design of adaptive hypermedia is based on quantitative and qualitative research. The adaptation rules are deduced from the results of a psychological questionnaire. Pedagogical activities are the outcome of a series of inferences; the final activity sets are manifested in adaptive hypermedia system. Stereotype user model is used to cluster all possible users into groups, providing mapping from a specific combination of user features to one of the stereotypes. Our approach is inspired by HBDI® model, focusing on the perspective of learner, meeting the needs of an adaptive hypermedia system.

Keywords: *Aadaptive Hypermedia, Thinking style, HBDI®, pedagogical activities, Bayes' theorem*

1. Introduction

The adaptive hypermedia research received more attention during the last two decades in the area of technology-based education. There are many systems developed for learning purposes, which are referred to as adaptive hypermedia. An adaptive hypermedia is an approach whose target is to personalize the learning experience for the learner [1] [2]. A number of Adaptive Hypermedia Systems (AHS) have been developed to support learning style as a source for adaptation. AEC-CS [3], INSPIRE [4], iWeaver [5], ILASH [6] and [7] are good examples.

However, most of these systems based their adaptation to user's level of knowledge [29] [8]. Other learner features taken into account are background, hyperspace experience, preferences and interests [9] [8]. However, less attention was paid to thinking styles and their effects on learning.

In recent years, the technology of adaptive hypermedia in learning has received increased attention. Adaptive hypermedia systems can offer a richer learning experience by giving more attention to personalization to thinking styles. Most approaches to adaptive hypermedia were based around acquiring and representing user's knowledge. While this is crucial for user modelling in general adaptive hypermedia, it is very limited for e-learning because it does not address the far more fundamental problem which is "students learn in different ways and different thinking styles".

The design of Adaptive Hypermedia System-Thinking Style (AHS-TS) in this work is based on quantitative and qualitative research; the adaptive rules are deduced from the results of a psychological questionnaire. Pedagogical activities are the outcome of a series of deductions; the final activity sets are manifested in adaptive hypermedia.

2. Thinking Style and Models

Sternberg has proposed a theory of thinking style intended to illuminate the differences in the way people think, showing that there are different ways for people to use their abilities [10]; these preferred ways are considered as "thinking styles". Tennant's definition of cognitive style [11] is "an individual's characteristic and consistent approach to organising 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.

Models of thinking styles are varied, some of which are concerned with thinker's personality traits, and others were interested in answering the question of how a thinker receives, processes, and aligns experiences, whereas others were focused on the sensory perceptual medium most preferable to a thinker when receiving, processing and aligning experiences. As a result, thinking styles were depicted with various models and graphics with unilateral, bilateral, multiple and interfered polarizations [12]. These models are: Carl Jung, Kolb, Dunn and Dunn thinking style Model, Myers-Brigg [13], McCarthy, Honey and Mumford [14] [15], Felder Silverman [16] [17], and Herrmann model [18] [19] [20] [21].

This study will adopt the Herrmann Whole Brain Model (HBDI), because HBDI® is popularly used to measure people's thinking style for the reason that its premise focuses on thinking preferences. Since the basis of the HBDI® is the metaphor of the brain, the premise is that we all have a brain; just that everyone uses it in a different way. Also, HBDI® introduces individual accountability since it was created for a business environment to help people get to application to gain benefit. Furthermore, this model is a validated assessment. Bundersons' validity study shows that the instrument provides a "valid, reliable measure of human mental preferences when applied in a professional way, interpreted in conformity with the four-quadrant model and scored by means of the approved scoring method" [22]. HBDI® is the only instrument that quantifies a person's preference for thinking in four different modes based on the task specialised function of the physical brain [23]. It is also a tool to encourage a person to understand his or her strengths and weaknesses, preferences and avoidances [24].

In the education domain ,this model helps to understand mental diversity and the important role that it has not only for effective teaching and learning, but as well as a tool to design and deliver teaching and learning activities in all four brain quadrants. The model further indicates clearly the iterative nature of the activities and the correlation of the physiology of the interconnected brain.

2.1. Model Inspired by HBDI®

HBDI® was developed by Ned Hermann [25], based on his extensive research on brain dominance, which is natural and normal for all human beings and influences all four specialised 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 some Adaptive Educational Hypermedia Systems (AEHS), this model is employed to observe learner's thinking styles [8] [26] [27].

Based on the research of Herrmann, we classify learners being examined into four groups: theoretician that has the thinking style of "blue", organiser 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.

Table 1. Classification of "turn-on" Activities According to HBDI® Model

Quadrant	Color	Preferred activities and working characteristics
Left cerebral hemisphere	Blue	Theoreticians: They like the facts, the details, critical cognitive, 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, advice, 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…

Before designing adaptive hypermedia system-thinking style (AHS-TS), to observe the psychological and pedagogical characteristics of a learner and to verify the hypothesis of existing research, we conducted a research based on questionnaire and interviews.

3. Psychological Questionnaire Design

In this section, we begin with a psychological research observing learner's decision making behavior for pedagogical activities; and then from the aspects of thinking style.

3.1 Instrument

A psychological questionnaire was designed. It mainly includes two parts:

(1) A series of questions consisting of statements about the pedagogical activities;

(2) A test of thinking style;

The pedagogical activity items are classified in two groups: presentation of theory and practical application.

These activities are categorised in 12 types. For the presentation of theory, eight activities are provided: AG1 (the course structured in learning objectives), AG2 (additional information for the course), AG3 (the course based on examples and analogies), AG4 (multiple-choice questions), AG5 (little theoretical activity), AG6 (little theoretical in groups), AG7 (large theoretical activity), AG8 (large theoretical activity in groups).

For the practical application, four activities provided: AG9 (little practical application), AG10 (little practical application in groups), AG11 (great practical), AG12 (great practical in groups).

In part 2 of our questionnaire, the test of thinking style is derived from the model of HBDI® and includes 60 statements of daily life. This test has been applied and has been validated in university of Annaba.

3.2 Thinking Style and Pedagogical Activities

With the thinking style test, theoretician, organizer, humanitarian, innovator, or the combination of them can be identified as the people who has thinking style of “blue”, “green”, “red” and “yellow”. The data we collected may give us implications on activity recommendation adapting to this psychological characteristic of learner.

3.2.1. Data processing on thinking style: In thinking style test, statements are grouped into four colors: blue, green, red and yellow, which signify the corresponding thinking styles. For data processing, every chosen item is given a value: “1” represents the agreement with the statement, “0” represents “not agree”. Besides “Yes”, “No”, the third choice “no opinion” with the weight of “0.4” is for observing the preference tendency more precisely between definitely “Yes” and definitely “No”.

There are also the cases in which a respondent has two or three dominant preferences even four, signifying that he or she has similar degrees on more than one thinking styles.

The existing research indicates that people may use more than one style primarily. Each person can have primary preferences (areas of the brain he or she goes too easily and enjoys), secondary preferences (areas of the brain that can be and are accessed when necessary) and tertiary preferences (areas a person may have difficulty accessing or may even avoid) [24]. We choose the following algorithm to identify which are the dominant thinking style preferences for a learner [7].

3.2.2 Data analysis on thinking style and pedagogical activities: In thinking style test, to examine the corresponding pedagogical activities of certain thinking style, we observe the data from 58 respondents of which total number of response items is more than 64 (>50% of the total).

The goal for launching the questionnaire is to recommend pedagogical activities for learner based on learners’ features. For observing the probabilities of the pedagogical activities in condition of thinking style, we use Bayes’ theorem in probability theory [28]. The key idea of

Bayes' theorem is that probability of event A given event B depends not only on the relationship between A and B but also on the absolute probability of A not concerning B.

The simple statement of Bayes' theorem is

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}.$$

P(A) is the prior probability or marginal probability of A. It is "prior" in the sense that it does not take into account any information about B.

P(A\B) is the conditional probability of A given B. It is also called the posterior probability because it is derived from or depends upon the specified value of B;

P(B\A) is the conditional probability of B given A. It is also called the likelihood;

P(B) is the prior or marginal probability of B:

$$P(B) = P(A,B) + P(A^c,B) = P(B|A)P(A) + P(B|A^c)P(A^c)$$

Where A^c is the complementary event of A, so an alternative form of the theorem is

$$P(A|B) = \frac{P(B|A)P(A)}{P(B|A)P(A) + P(B|A^c)P(A^c)}.$$

More generally, for any A_i in the partition, Bayes' theorem states that

$$P(A_i|B) = \frac{P(B|A_i)P(A_i)}{\sum_{j=1}^{n} P(B|A_j)P(A_j)}, (j = 1,2,\dots,n).$$

Bayes' theorem in this form gives a mathematical representation of how the conditional probability of event A given B is related to the converse conditional probability of B given A.

In our research, event A is that the learner chooses pedagogical activity and event B is that the learner who have thinking style; n is the number of types of pedagogical activity (n=12).

From the probability distribution according to activity and according to thinking style, we can get the probabilities of choosing each activity regardless of any other information (regardless of thinking style) P(A) and the conditional probabilities of "thinking style" given "choosing certain activity" P(B\A) (see Table 2).

Table 2. Prior Probability of Choosing Pedagogical Activity and Conditional Probability given Thinking Style

	AG1	AG2	AG3	AG4	AG5	AG6	AG7	AG8	AG9	AG10	AG11	AG12	Total
P(A)	0,17	0,09	0,13	0,06	0,06	0,15	0,03	0,073	0,06	0,066	0,044	0,07	1
P(Bblue\A)	0,32	0,56	0,07	0,2	0,26	0,08	0,41	0,047	0,1	0,139	0,079	0,05	
P(Bgreen\A)	0,49	0,15	0,2	0,54	0,22	0,03	0,11	0,059	0,23	0,066	0,079	0,08	
P(Bred\A)	0,12	0,15	0,07	0,2	0,19	0,82	0,27	0,815	0,1	0,663	0,13	0,7	
P(Byellow\A)	0,08	0,14	0,66	0,05	0,33	0,06	0,21	0,078	0,58	0,132	0,713	0,17	
Total	1	1	1	1	1	1	1	1	1	1	1	1	

Then, for the given thinking styles, the probability of choosing pedagogical activities can be obtained (see Table 3):

Table 3: Probability of Choosing Pedagogical Activity given Thinking Style (sample size=58)

	AG1	AG2	AG3	AG4	AG5	AG6	AG7	AG8	AG9	AG10	AG11	AG12	total
P(A\Bblue)	0,27	0,26	0,05	0,07	0,08	0,067	0,07	0,02	0,03	0,048	0,018	0,018	1
P(A\Bgreen)	0,39	0,07	0,12	0,17	0,07	0,021	0,02	0,02	0,07	0,021	0,017	0,028	1
P(A\Bred)	0,06	0,04	0,03	0,04	0,03	0,358	0,03	0,17	0,02	0,127	0,017	0,148	1
P(A\Byellow)	0,06	0,05	0,37	0,02	0,09	0,04	0,03	0,02	0,15	0,038	0,137	0,055	1

In Table 3, for learners who have "blue" thinking style, the probabilities of choosing pedagogical activities AG1, AG2, AG5, AG7 and AG4 (>0.05) much higher than those of AG3, AG9, AG10, AG11 and AG12. This result is accord with the Hermann's Whole Brain theory that people of this style like "the facts, the logical problem-solving, and the unambiguous instruction".

Learners owning style of "green" show interest in AG1, AG3, AG4, AG5 and AG9. In this case, Hermann's point of view on the "turn-on" work of style "yellow" is verified: "integrating ideas and concepts, exploring"…

For the learners of "red" style, AG1, AG6, AG8, AG12 and AG10 are accepted.

Learners owning style of "yellow" show interest in AG1, AG3, AG9, AG5 and AG11.

In general, AG1 can be accepted by the groups of "blue" and "green" (which is accord again with the statement in Whole Brain theory: the "green" one as an organizer likes to "integrate information in a sequential manner"); furthermore, AG4 is rarely accepted as a preference. The highest probability of choosing AG6 appears in group "red". In other words, they accept little theoretical in groups than the other groups of style.

All of these results signify that the sample is representative and can act as basis for further research. The recommending activities for the four thinking styles are listed in Table 4:

Table 4. The recommending activities for the four thinking styles (the symbol "?" means an optional activity; the symbol "/ /" means two activities in parallel).

Dimension HBDI	description	teaching method	sequencing of activities	The main activities
Blue	Theory	Top to down	ag2//ag1, ag5(ag6)?, (ag8)?, (ag4)?	ag2, ag5, ag7
Green	structured	Top to down	ag1, (ag3)?, ag4, (ag5 (ag6)?)?//((ag9)(ag10)?) ?	ag1, ag4
Yellow	large project	Down to top	ag3, ag9, ag 11(ag12) ?, (ag7)?	ag3, ag9, ag11
Red	Group	Down to top	ag6, ag8, ag10, ag12, (ag1)?	ag6, ag8, ag10, ag12

Based on previous results, we propose the following pedagogical approach:

Table 5. Pedagogical Approach HBDI Dimension

HBDI Dimension	Pedagogical approach proposed
Theorist (blue)	Teachers begin by presenting additional information theory, and they offer individual exercises for learners to make learning easier, after the learners attempt to solve individual problems.
Organizer (green)	Teachers begin by presenting a formal course in several learning objectives, and they offer an overall assessment in the form of multiple choice questions.
Innovator (yellow)	Teachers begin by illustrating it through examples and analogies, then offer individual learners to solve small practical applications, and finally the students are trying to solve large practical applications individually.
Humanitarian (red)	Teachers offer learners to solve small activities theory in groups, then, learners try to analyze and solve big problem in groups, after they go through analysis of small practical applications in groups, therefore the teacher wants the learners to solve large practical applications in groups.

In next section, we will elaborate the adaptive hypermedia system-thinking style (AHS-TS), a system through which users (learners, teachers) could take part in the construction of course structure, by adapting the pedagogical activities to their profiles.

4. Adaptive Hypermedia System-Thinking Style (AHS-TS)

The main characteristic of AHS-TS is that it can be adapted to the thinking style and to the level of knowledge acquired by the student. The system was organized in the form of three basic components: The domain model, the learner model and the adaptation model. These three components interacted to adapt different aspects of the instructional process. Figure 1 illustrates the system architecture.

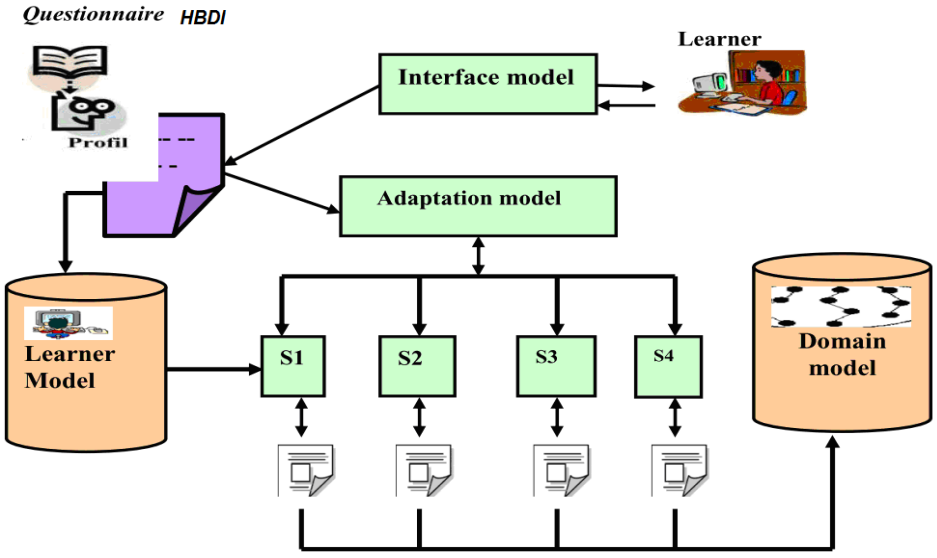

Figure 1. Proposed System Architecture

4.1 Learner Model

A distinct feature of an adaptive hypermedia system is the learner model it employs, that is, a representation of information about an individual learner. Learner modelling and adaptation are strongly correlated, in the sense that the amount and nature of the information represented in the learner model depend largely on the kind of adaptation effect that the system has to deliver.

The learner model in adaptive hypermedia system-thinking style (AHS-TS) was defined as three sub-models: The profile sub-model, the knowledge state overlay sub-model and the thinking style preferences overlay sub-model. The learner profile was implemented as a set of attributes which store static personal characteristics about the learner, for example username, password, unique ID, age, e-mail and thinking style. The knowledge level recorded by the system for student's knowledge about each domain knowledge concept; It is an overlay of the knowledge concepts. It associated learner's knowledge level with each concept of the domain sub-model knowledge. The thinking style state stores values for pedagogical activities to match learner's thinking style that is, media type.

4.2 Domain Model

This model describes the structure of the information content of the application. It consists of concepts and concept relationships. A concept is an abstract representation of an information item from the application domain. The domain model of the system is based on the notion of learning goals that the learner can select and study, and provides learners with a plurality of concepts and pedagogical activities.

A learning goal corresponds to a topic of the domain knowledge, which can be recognized and selected even by a learner. Each goal is associated with a subset of concepts of the domain knowledge. Pedagogical approaches hold a one-to-one relationship with the thinking styles. There can be one pedagogical approach that accommodates one thinking style. Each concept is associated with a pedagogical approach according to learner's preferences. Each pedagogical approach can be also associated with appropriate pedagogical activities.

4.3 Adaptation Model

The adaptation model in AHS-TS specified the way in which the learners' knowledge and thinking style modify the presentation of the content. It was implemented as a set of the rules. These rules form the connection between the domain model and learner model to update the learner model and provide appropriate pedagogical activities. The adaptation model was divided into two layers: Knowledge adaptation layer and thinking style adaptation layer. The knowledge adaptation layer consisted of abstract concept selection rules that determine which concepts from the knowledge space sub-model to be covered based on the knowledge attribute in the learner model.

The thinking style adaptation layer consisted of pedagogical activities selection rules that determine which pedagogical activities from the resources space sub model to be included in the presentation. The inclusion of appropriate pedagogical activities is based on the thinking style attribute associated with the learner model.

To support adaptability, AHS-TS used a combination of adaptive navigation support and adaptive presentation technique following [29] which aimed to adapt the information presented to the user according to his thinking style and knowledge state.

AHS-TS implemented adaptive presentation by classifying learners according to their current thinking styles. Learners with different thinking styles view different presentations of the same educational material. The system implemented various adaptive navigation support technologies, which help the user in navigating the domain space. It offered linear navigation (direct guidance, next and previous units); hierarchical navigation (through the tree-like structure of contents) and relational navigation (link insertion and link disabling through prerequisite concepts relationship).

When first time learners enter AHS-TS, they signed up to the system by using a registration form. Once a learner registers, a learner profile will be created to store all his information and will be saved in the database, a unique identification (ID) is generated for the learner for further reference and tracking of his progress.

After successful registration, AHS-TS show an introduction page to the learner, explaining the thinking style categories and their general characteristics. Then it offers two choices either to answer the thinking style questionnaire, or to select his suitable thinking style based on the provided information. AHS-TS compute the answers given by the user and deduce a thinking style based on the HBDI model (see figure 2, in French).

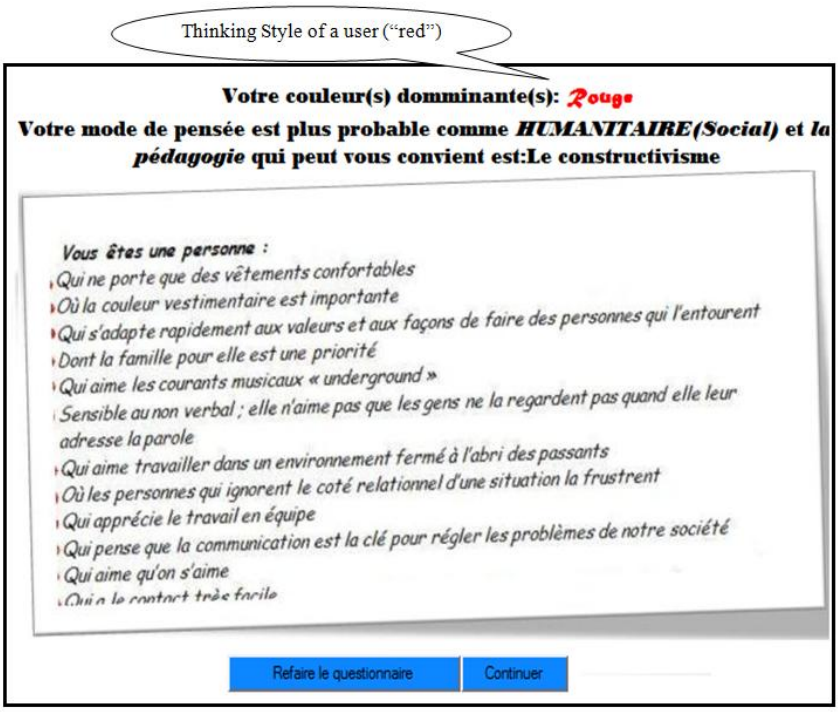

Figure 2. An Example for the Result of Thinking Style

The thinking style preference is then saved in MySQL database (learner profile) and the learner is re-directed to the learning objective page.

Next, the first lesson is displayed with learning materials and media presentation based on learner profile (see figure 3, in French).

(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 3. An Integrated in Adaptive Hypermedia: Domain (medical) and Thinking Style (green)

5. Experimentation

The effect of adaptation to different thinking styles is tested via a survey. This experimentation focuses on the course structure manifesting pedagogical activities in system; the different tools of AHS-TS will be tested by 10 learners from the University of Annaba. The disciplines they are working for includes computer science, mathematics, mechanics, human and social sciences, language, science of economy and science of earth.

In general, the survey is divided into 3 parts. Among them, part 1 includes the questions about the Thinking Style, pedagogical approaches and Pedagogical Activity; part 2 puts the questions about the effect of adaptive course structure and pedagogical activities, that is how the course adapts to the user's preference, which is one of the goal of this work; the last part of the survey is about the general impression of AHS-TS, including the effect of interaction between user and system.

Part 1: In this part, we aim to know the relevance of each element for generating courses.

Firstly about Working Domain:

- How do you think the domain list provided by the AHS-TS?

A. should be more general. B. is appropriate. C. should be more detailed

Then the questions are about thinking style:

- When you do thinking style test in AHS-TS, do you think the length of time is suitable?

Very suitable 5 4 3 2 1 0 not suitable

The following question is put for users to evaluate the effect of the integration of psychological elements in adaptive hypermedia system:

- How do you feel about the navigation in system?

Very convenient 5 4 3 2 1 0 not convenient

Part 2: The question is put to know whether the activities we provided in system are adapt to learners' preferences, and on which level the user evaluates the AHS-TS:

- On which level the recommended activities from AHS-TS match your need for pedagogical activities?

Very much 5 4 3 2 1 0 not at all

For the course structure, we render possibilities to modify it if a user is not satisfied with the one he or she just constructed. Users' opinions on this function are obtained by the following question:

- Does the function of modification of the course structure is necessary for your course?

Very necessary 5 4 3 2 1 0 not at all necessary

Also, we ask the question about other adaptive functions of AHS-TS:

- Do you think it is useful for your later work when AHS-TS provide the information about pedagogical approaches?

Very useful 5 4 3 2 1 0 not useful

Part 3: In this part, the general questions about the effect of AHS-TS are proposed:

- How do you think the interface of AHS-TS for generating your courses?

Very interactive 5 4 3 2 1 0 not at all interactive

- Do you think that it is adaptable to create your courses with AHS-TS**?**

Very much 5 4 3 2 1 0 not at all

5.1 Interpretation of the Results

We collected the answers of 10 learners from the previously mentioned domains. The charts of the results (from Excel of Microsoft Office 2007) are for the computable questions (series 1-10 signify the learners); analysis of the result is done according to the three parts of the survey:

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

Figure 4 shows the results for questions about the utilisation of thinking style test. It shows that 8 learners (80%) are generally satisfied (value ≥ 3) with the length of the time spent on thinking style questionnaire.

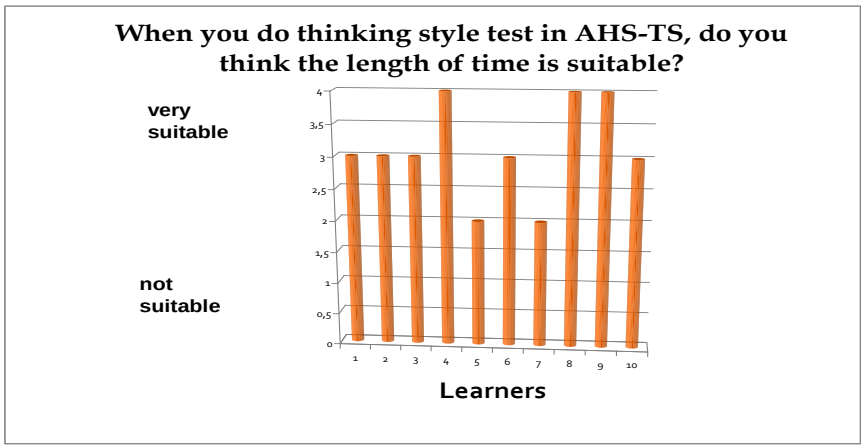

Figure 4. The Utilization of Thinking Style

For the facility of navigation in system, figure 5 signifies the appreciation degree, that is how easy to navigate various elements for generating their courses. 70% of the users feel very convenient or convenient (value ≥ 4) when navigate in AHS-TS; besides the 20% of the users who show the average satisfaction degree, 10% feel the navigation is not convenient (value ≤ 2).

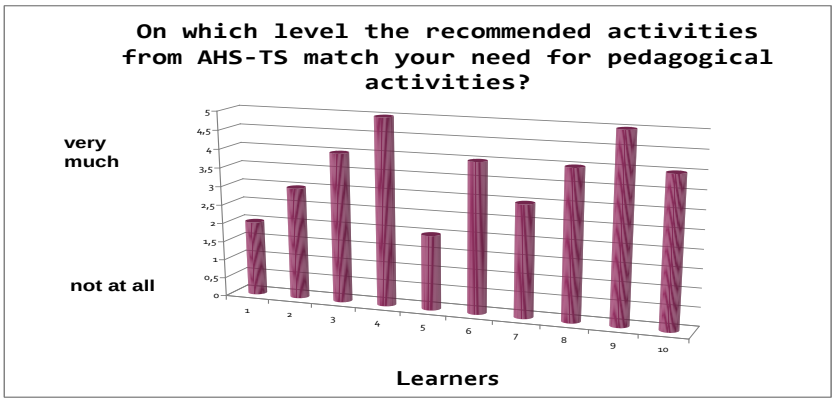

Figure 5. Appreciation on Course Structure and Pedagogical Activities

Once the user filled the test or the questionnaire, the adaptive activities are automatically recommended by the system. Figure 6 shows the opinion of the learners on the effect of course structure manifesting these activities. 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.

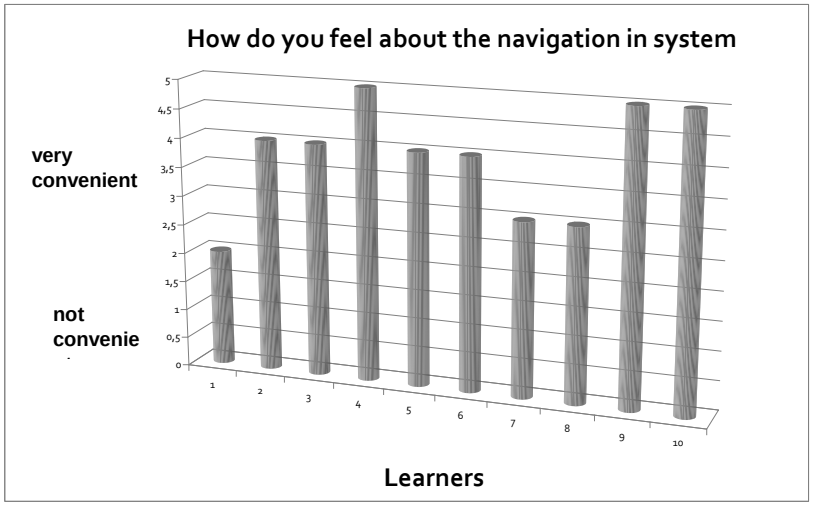

Figure 6. Appreciation for the Navigation in System

Figure 7 shows the appreciation for the function of modification. It is shown that user' opinions of modification of the course structure are obviously positive. This function can make sure to modify the course structure with which the user is not satisfied after viewing it in AHS-TS.

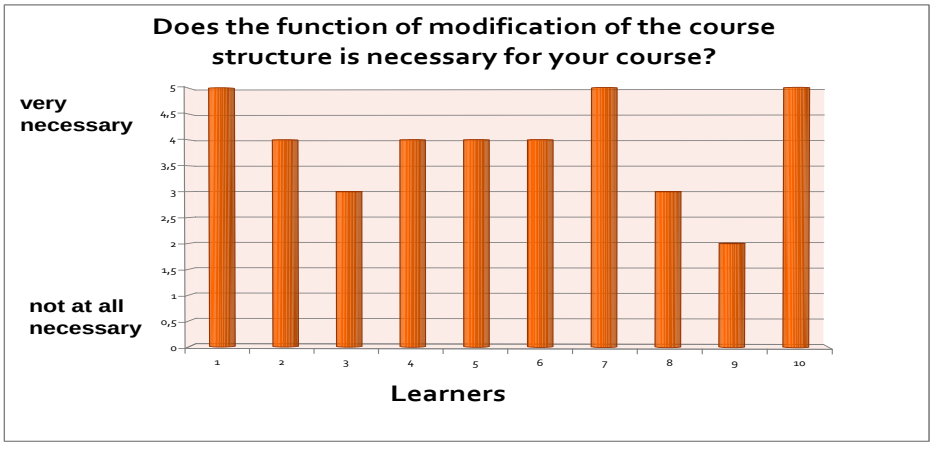

Figure 7. Appreciation for Functions of Modification of the Course Structure

The negative opinions are discovered from the result for question "Do you think it is useful for your later work when AHS-TS provide 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 AHS-TS (see

figure 8). They stated that the information was too general to find the clear indication for their following activities.

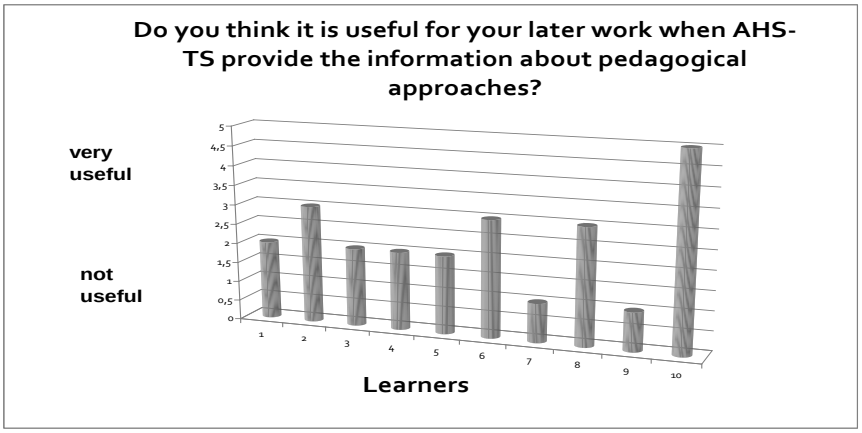

Figure 8. Learners' Needs for Information about Pedagogical Approaches Provide by AHS-TS

Learners in our experimentation are all satisfied with the interface of AHS-TS: the interaction between user and system. At last, for the general question "Do you think that it is adaptable to create your courses with AHS-TS?" the promising result is shown in figure 9.

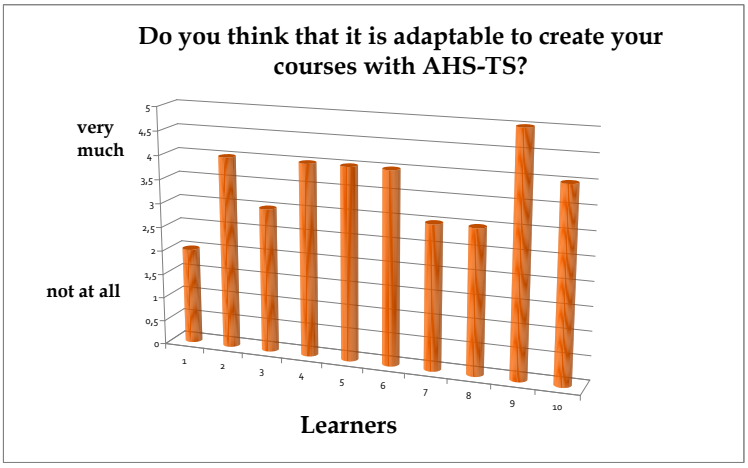

Figure 9. General Evaluation on the Adaptability of AHS-TS

5.2 Further Analysis

Through the result for the survey above, we can conclude by stating the advantages and disadvantages of our work:

The users of AHS-TS are generally satisfied with the integration of psychological elements in adaptive hypermedia system. The facilities of navigation in AHS-TS reflect the adaptabilities of high-level tool of Learning Design. Pedagogical Activity is accepted by almost all of the users; it is especially efficient for users who have clear awareness on their pedagogical activities.

Recommended pedagogical activities by inductive methods are convenient for most of the learners. Put in other words, the AHS-TS have satisfied users in applicability. With the adaptive modification of course structure and other interactive characteristics, AHS-TS are well structured and manifested.

From the survey and experimentation, the following problems should be recognised:

The working domain knowledge should be presented more adaptable. The list of disciplines is limited in the general classification. More explanations for the course structure should be provided; the set of pedagogical activities should be enriched.

6. Conclusion and Future Work

The work presented in this paper describes the development of an integrated thinking style in adaptive hypermedia system.

The objectives of our approach are 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 activities 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 pedagogical approach based on appropriate evidence acquired during the training.

Our work is validated by the users from different disciplines. From the experimentation and survey, general positive results are obtained at last.

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 style, to make the system more adaptive and dynamic.

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