

Educative and Adaptive System for Personalized Learning: Learning Styles and Content Adaptation

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Abstract: *The use of electronic environment in our life has become inevitable fact. In the educational field, the learners find many difficulties to attend a classical mode of learning (in class) that obliges them to be present according to daily schedule. Thus, the E-learning allows the process of learning anywhere and any when. However, the absence of the teacher, in the E-learning process, leads to the isolation of the learners. Generally, these learners have different backgrounds, preferences, needs, objectives, intellectual abilities and personal characteristics; and they do not understand and acquire the knowledge using the same courses and the same learning styles. Several aspects influence the effective learning process. Thus, different concepts, views and models of learning styles exist in literature. Many models and classifications of learning styles were proposed according to several angles of view. For this aim, we propose an educational system that provides the accurate learning content and use the most appropriate learning style that meets the needs and preference of each learner (personalized learning). Our system provides several learning styles for the learners; however, the essential task is to find the best course and learner style for each learner according to his characteristics. The adaptation of the content and styles allows the dynamicity in the learning process and gives a new chance for many kinds of learners to enhance their knowledge in personal manner. Moreover, the modeling of our system using multi-agents system increases its interaction and flexibility.*

Keywords: *E-Learning, personalized learning, adaptive learning, content adaptation, learning styles.*

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1. Introduction

Our present life is characterized by speed lifestyle; most people have several personal and professional occupations. In particular, the classical learning (in class) obliges the learners to be present in specific places (school, university) and at specific times. So the traditional training has become impossible for many of them. In addition, the emerging technology, particularly the communication and information technologies, reveals a new learning technique known as the E-Learning that allows a quick and effective learning with minimal problems (saving time, economic, saving the fee of transport ...etc). In the E-learning environment, the learner is free to choose the time and the place of the learning process.

Distance education is "the use of information and telecommunications technology in the field of learning in order to overcome the distance, acquire the skills and facilitate the access to knowledge" [10]. This new mode of learning gives the opportunity to the learner to learn in the appropriate time and space and using the preferred style.

One of the main problems in E-learning environment is the isolation of learners because of the

absence of a human teacher. Moreover, the existing learning systems provide a set of courses without taking into account the difference between learners' characteristics. In an e-learning environment, learners are usually heterogeneous and so they have different backgrounds, different intellectual abilities and preferences and different goals and needs [1, 2]. Thus, learners will not effectively learn if we use the same courses and the same learning styles in all situations. Therefore, the use of the same content for all learners guides to a low quality of understanding for most learners. To overcome this limitation and increase effective learning, adaptive and personalized learning is currently an active research area. We must use content adaptation techniques and strategies according to each individual to meet the needs and preferences of diverse learners and provide personalized learning for each learner. So adaptation according to several criteria and situations is an inevitable technique.

The agent is a promising tool in the process of modeling of opened systems such as: E-learning system because it allows a high degree of flexibility and autonomy. Also, it facilitates all kinds of interaction between the components of the system.

For this aim, we propose a multi-agents system that ensures personal guidance of the learner according to

his characteristics and needs. Our system uses special course units to help the failed learners to understand the course using a different learning style. In addition, our system uses the information stored in the learner profile, and analyzes the tracks (activities) of the learner in the system to detect the pertinent learning style in order to provide a learning process that suits the learner. The objective of our system is to keep, always, the learners motivated to continue learning and to provide a personal learning and the accurate learning styles for each learner according to his characteristics.

2. Related Works

In [1] the authors defined an adaptive system that provides an adaptation technique. The adaptation used in this work is the content adaptation according to the intellectual and social characteristics of the learner and with his background (previous knowledge). Using the results of learners, the system launches an adaptation process to define the appropriate new content for every failed learner. In this work, the author did not use the learning styles adaptation which is an important technique in current systems.

The authors of [6] developed a dynamic educational system that uses the individual learner's profile. To satisfy the needs of heterogeneous learner, the authors present an adaptive and personalized learning system. They defined a novel ontology-based approach to design an E-learning decision support system which includes major adaptive features (different learning backgrounds, knowledge levels, learning styles, and abilities). The ontological learner, domain and content model are separately designed to support adaptive learning. The proposed system utilizes the captured learner's model during the registration phase for determining learners' characteristics. The system also tracks learners' activities and tests during the learning process. Test results are analyzed according to the Item Response Theory in order to calculate learner's abilities. The learner model is updated based on the result of activities, results of test and learner's ability for use in the adaptation process.

The author of [4] developed a set of courses to facilitate the adaptation for many learners. The important factors in these learning courses is regarding learners' personal differences and developing flexible and intelligent interaction with users through personalization techniques. They presented supported decision system for personalization approach. Their main aim is to reach an intelligent learning facility and increase learning courses productivity. For this aim they proposed the unifying supporter decision tools and electronic learning system. The authors performed a study about decision support systems applications in order to learning management system personalization and then as a research sample, they identified some different requirements of learning management system

users of electronic college of Shiraz university; and suggested some scenarios. Using decision support system capabilities, new scenarios suggested and based on suggesting environment personalization solution to improving function and increasing different learners efficiently learning.

3. Personalized Learning

One of the requirements of distance learning systems is personalized learning. The principle of personalized learning is to deliver for each learner the relevant content according to his preferences, needs, objectives and characteristics (intellectual, personal, social ... etc). Also, we have to use the learning style that is more appropriate for each learner. We detect this accurate style for the learner through his behavior and tests. Strategies (styles) of learning are seen as a crucial point in an E-Learning system. So, our system allows the adaptation of educational content and adaptation of learning styles.

4. Learning Styles

The definition of learning style is not simple. One cannot define the term learning style in a single definition and so many researchers have proposed several definitions. To clarify this concept, we present a set of definitions:

- Honey and Mumford [8] defined learning styles as "a description of the attitudes and behaviors which determine the preferred way of learning for an individual".
- James and Gardner [7] defined learning styles more precisely by saying that learning style is the "complex manner in which, and conditions under which, learners most effectively perceive, process, store, and use what they are attempting to learn".
- Another important definition was proposed by [9][5]: "A learning style is the preferred way to deal personally with the information and experience in learning situations."
- Learning style is personal characteristics, as defined in [9]: "The learning style describes a learner in terms of educational conditions that are most likely to promote his learning. The learner differs by his learning style; it means that some educational approaches are more effective than others for him."

Various theories of learning styles have been developed. Coffield [3] identified 71 models of learning styles and categorized them into 13 main models. Moreover, in the last decade, a lot of works have been used these learning style models. However, important lacks and questions are still under discussion, for our case we have chosen these styles:

4.1. Visual learners

They better understand the information by visualizing the content in form of text, image, video, diagram, or graphics ... etc.).

4.2. Auditory Learners

Auditory learners learn best by listening. They respond well to discussions and other situations that provide an opportunity to discuss and listen to what others are saying.

4.3. Tactual Learners

These learners learn by moving and touching. The practical learning situations are best suitable for them. They like to move when learning something new.

4.4. Active Learners

Active learners prefer the teamwork, it is necessary for them to work with other learners. Here are some suggestions to help active learners:

- Encourage learners to form groups to study and answer the questions and exams.
- Discuss, share knowledge, work together on a common project.
- Encourage learners to use communication tools (email, discussion forums, chats...etc).

4.5. Reflective Learners

This kind of learners prefer to work alone and think quietly first. They receive the questions and try to answer alone.

4.6. Collaborative Learners

Collaborative learners prefer the collaborate works with others. They are characterized as learners who are cooperative, enjoy working with others.

4.7. Competitive Learners

They learn better when they see the others as competitors. They enjoy the competition and want to do better than others. Generally, they see the learning process as a win-lose situation.

4.8. Dependent Learners

These learner prefer to get instruction from the teacher, and learn better when their learning process is controlled by an instructor

4.9. Independent Learners

They are characterized as confident and curious learners. They prefer to think for themselves and work on their own.

4.10. Sequential Learners

These learners are linear and learn in small incremental steps. They prefer to learn step by step and have only a small part of the work.

5. Motivation

Learner motivation is a main aim of an educational system. In the first hand, we use the profile to satisfy their preferences (color, language, ...etc.). Also, we provide entertainment and quizzes from time to time. In the other hand, we provide the content and strategies adaptation when a student fails in a test (to give another chance to learn using an adapted content and style). An adaptation strategy is to change the previous strategy to a new strategy according to the behavior of the learner. The content adaptation refers to the changing the content for a failed learner (add more simple explanations, exercises, schemes, references ...etc).

6. System Modeling

Usually, adaptive systems are composed from learner model and content model, each model includes a number of sub-models.

6.1. Learner Model

It is an important part of our system. The main task of a learner in an educational context is the acquisition of knowledge. The learner model is used to personalize the pedagogical learning path (content and strategies adaptation), and it helps the system to adapt the content and the strategies to meet the needs of each learner individually. This model contains all the information about the learner (learner profile, characteristics and preferences of the learner, the favorite style and strategy of learning ...etc). It contains the following information:

- The information that identify the student (name ID, password).
- The level of knowledge on each course (low, medium, high).
- The chosen domain of training (if there are several formations).
- Preferred language
- The characteristics and preferences of the learner (favorite color, font type, ...etc)
- Learning style (visual, auditory, active, collaborative, reflective, ...etc).
- Progress: modeled by using the knowledge level of the learners and test results, we will use overlay model

6.1.1. Overlay Model

This model associates to each concept a binary value (0, 1) or a qualitative measure (weak, good, very good, excellent ...etc). We use a numerical numbers to indicate the courses and the valuated concept. For example: (p1c1, 1): means that the level of the student is 1 (initial value) for the first concept (c1) of the first course (p1)

Remark: The initial state for every student is 1, and then we change it when they perform a test.

6.2. The Content Model

A student learns a set of concepts to reach certain objective of the content. The content is organized using several layers related to each other.

- **Module:** the whole content is a set of modules.
- **Chapter:** the set of chapters forms a module.
- **Course:** the chapter is formed by a set of courses.
- **Pedagogical object:** the course is divided into pedagogical objects. There are three types of the pedagogical objects: prerequisite, familiarization, and reinforcement objects.
- **Concept:** The pedagogical object contains a finite number of concepts.
- **Basic unit (BU):** We divide the concept into basic units that are elementary parts of the course. We have two kinds of BU: 1) Main role (MR): at first, these units will be displayed to all learners; 2) Reference role (RR): these units will be used after reading
- the PR units in some cases :
- If the learner fails in the exam (test).
- If the learner succeeds but he needs reinforcement.
- If the learners asks for references to understand MR units or to enhance his knowledge.

Figure 1 shows the organization of our pedagogical content.

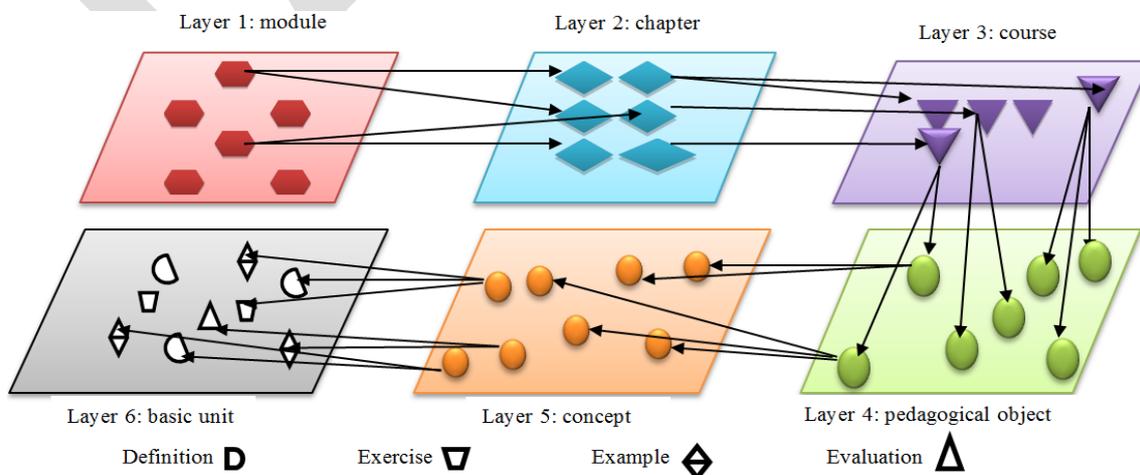


Figure 1. Content model.

6.3. General Architecture of our System

Our system provides the opportunity to the learners to acquire knowledge using the adaptation of content and strategies. Three main actors exist in our system: Learner, teacher, and administrator. To meet the needs of those actors, we propose the following global architecture.

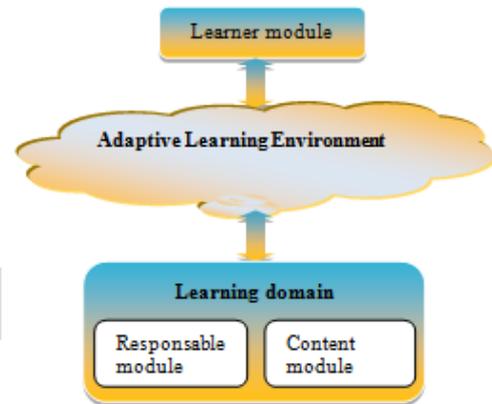


Figure 2. General architecture of the system

We identify the different parts of our system in Figure 2 and the following sections.

6.3.1. Learner Module

The main task of a learner in an educational context is the acquisition of knowledge to form and enrich his personal knowledge. The learner performs a set of actions such as: reading courses, tests and ask questions. Each learner has to follow distance training according to his specific characteristics (using the profile).

6.3.2. Learning Domain

The learning domain module manages the training ^{institution}. It is composed of two types:

6.3.2.1. Responsible Module

This module has the following roles:

- **The teacher:** Is one of the important actors in our system, his main role is to follow the learners and answer their questions.
- **Administrator:** He manages all the system: training process management, the learners' management, group management... etc. In addition, the administrator informs the teachers and the learners engaged in learning process on administrative innovations.

6.3.2.2. Content Module

It is one of the system components; it identifies what will be taught. It contains all the elements to be taught, an expert of the domain who creates the content module.

6.4. Detailed Architecture of the System

Our system is based on nine agents that cooperate with each other to guide the learner using a well-structured manner during his learning process.

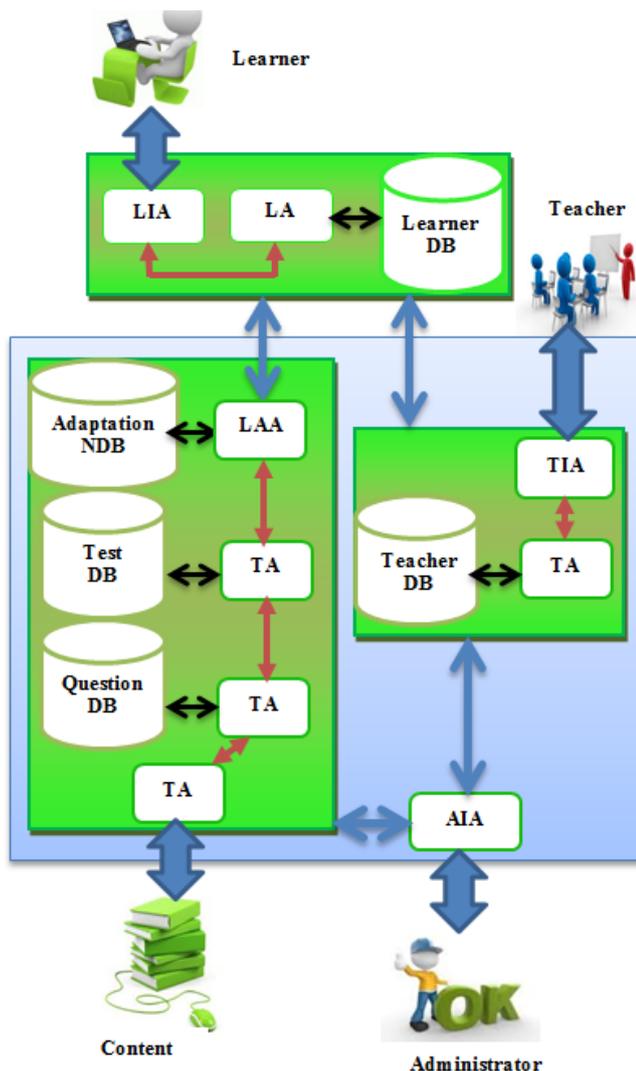


Figure 3. General architecture of the system.

6.4.1. Learner Interface Agent (LIA)

This agent allows the learner to react with the educational system. LIA is the intermediary between the learner and the system, it displays all the data oriented towards the learner and provides all what are displayed to the learner (courses, ID and password, questions, tests ...etc.). Also, it ensures the registration of new users; this agent is the gateway to the system, to which several tasks are assigned:

- It displays the courses and activities (Questions, tests, chat ...etc.) according to the level and preferences of the learner.
- It provides the learner registration form in our platform of E-learning.

6.4.2. Learner Agent (LA)

It is responsible for managing the learner profile. The main role of this agent is to check the correspondence between identification and password given by the learner and those saved in the learner database to decide if the system opens the learning session or not. In addition, it saves all dynamic information about the learner: the progress status, changes of the profile, test results, questions asked by the learner.

6.4.3. Teacher Interface Agent (TIA)

It is responsible for the presentation of all what are oriented to the teacher in the system such as: home page, registration announcements, check messages, and questions of learners. This agent interacts with the human teacher as an intermediary between the teacher and the system (interface).

6.4.4. Teacher Agent (TA)

The main role of this module is to manage the teacher profile and check the correspondence between identification and password given by the teacher and those saved in the teacher database. Also, it sends and saves all the information which concern the teacher: profile changes, the proposed tests, the answers of the questions...etc.

6.4.5. Administrator Interface Agent (AIA)

AIA interacts with the human administrator as an intermediary between the administrator and the system (interface). It is responsible to cancel the registration of a learner, add new learning modules, delete a learning domain, and accept or refuse the teachers' registrations. This module can access to all the databases.

6.4.6. Test Agent (TeA)

It prepares the tests for the learner and sends these tests to the learning and adaptation agent, this later send them to

the LIA to display them to the learners. It performs the evaluation of the tests and sends the results to the LA. The tests are Multiple Choice Questions that allow the automatic correction. The tests are stored in the test database with their answers. The learner agent (LA) saves the results of the tests in the learner profile; this will help the system to adapt the courses and styles according to these results. The test database contains the tests for each concept, as well as the answers of each test.

6.4.7. Question Agent (QA)

It is responsible for the management of the question database. This agent searches for the answers of the learner questions and saves the new questions and their answers. It receives the demand from the learner agent to search for an answer of a question; moreover, it sends the new questions (when the QA did not find the answers of these questions) to the teacher Agent to answer them by the human teacher.

6.4.8. Content Agent (CA)

It is responsible for managing the content database. It receives from the learning adaptation agent the requests of basic units of the course, and so it sends the BU which meets the needs of the learner (level, preferences, the appropriate learning style ...etc.).

6.4.9. Learning and Adaptation Agent (LAA)

This agent contains three modules: Learning module, adaptation module that adapts the process of our educational system, and communication module. The learning module indicates the following concept for each learner. However, in the case of adaptation (failed learner, reference, reinforcement ...etc), the adaptation module defines the appropriate adaptation using the knowledge database that contains all the rules of adaptation.

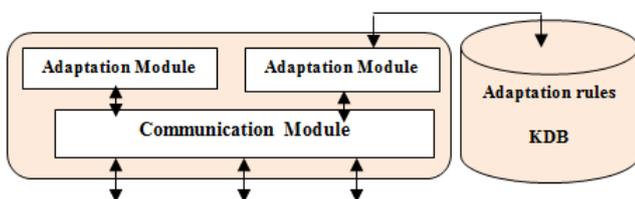


Figure 4. Learning and adaptation agent.

The adaptation modules Performs the adaptation process using the learner profile information, the rules of adaptation, the reference units and the different styles, these rules are used to personalize the learning path for each learner. To enrich the cases and rules of adaptation, we can add more rules in the rule database of this agent. Therefore, we present some rules of adaptation:

- The learner fails (less than 50%): here we seek for reinforcement basic units: examples, diagrams and exercises with solutions, use the auditory style.
- The learner fails (less than 25%): we seek for basic units: details, simple explanation, using auditory and visual style ... etc. If he does not follow the advice of teachers and the system we change his style to independent learners and so he will not receive the instructions (he will be free to choose the units of the courses).
- The learner fails (less than 10%): we return to the explanation of the prerequisites, seek fir the quizzes, and use the active style. If he communicates with his friends, then we use the works that require teamwork (collaborative style).
- For excellent learners, we search for basic units have more information, abstracts, articles, books ... etc.
- A learner who asks several questions on a particular course, we send him the basic units that contain more details, and we use the collaborative style for him.
- In the case when a learner fails and he was manipulating several activities and exercises (practice), we look for references that have the Detective style and we change the old style of his profile to this new style.
- If a learner fails, and he participates in forums: We change his style of participation to active style and we find courses that are oriented to active learners.
- If a learner fails using many adaptation rules, we return to prerequisites and we use the sequential style (very small steps or learning).

7. Functioning of our Approach

In this section we present some of scenario in our system to explain the functionalities of each agent in our system. When a new learner subscribes:

1. The LIA show the form of subscription, the learner provides the necessary information.
2. The LIA sends this information provides by the learner to the LA to create a new profile and save it in the learner database.
3. The Test agent (TeA) sends to the LIA a global test to show it to the new learner, the goal of the global test is to know the initial level of this learner.
4. According to the answers of the learner, the TA identifies the initial level of the learner, and sends this level to the learner agent to save it in the learner profile. In addition, it sends another request to LAA to identify the first UB ID according to the level of the learner.
5. LAA send this ID UB to the CA to send this basic unit.

When the learner connects:

1. The learning and adaptation agent (LAA) receives from the LA a request that contains the Learner ID and the ID of the basic unit that was read the last time.
2. LAA responds by sending a request to the CA to send the BU concerned. The learner reads the BU through three steps (prerequisite, familiarity or reinforcement).
3. After reading each BU, the learner performs a test (sent by TeA) to check the degree of his understanding.
4. If the learner succeeds in the test, then the learning and adaptation agent sends the test results to the LA to change the status of the learner. Thus, the learner passes to the next concept.
5. If the learner fails in the test, the learning and adaptation agent (LAA) applies the rules of adaptation (presented in 6.4.9). Then, the learner performs another test and so on.
6. If the LAA could not find another type of adaptation (using all kind of content adaptation and styles adaptation), the LIA sends to AIA a request contains the learner's ID to find an appointment with a teacher or to use a questionnaire form (contains a lot of questions to know the personality of the learner) to identify the appropriate style and strategy.

8. Conclusion

The success of web technologies has led to a growing attention on e-learning activities. In an education system, one must use several techniques and strategies to ensure that the learners will understand the different learning units in all formats provided by the system. Good guidance of the learner ensures the use of learner profile and adaptation techniques according to the characteristics of this learner (levels, preferences, degree of intelligence ... ect). Thus it is necessary to consider that learners have different intellectual abilities, backgrounds and heterogeneous levels. Consequently, we have focused on the guidance of learners in the education process (content adaptation and strategies adaptation) which is the essential element of our educational system to meet their needs.

In our system, we have used the results of tests to determine the learner's level and the type of adaptation that is relevant (in case of failure), we also provided an opportunity for learners to ask questions to clarify vague points.

For the implementation, we used the Java language, JSP, JADE and Eclipse environment. As results of our work, we mention:

- A platform that meets the needs of learners and ensures personal guidance, and keeps the learner motivated to learn.

- The use of the learner profile which helps the system to choose the content and the style according to the preferences of the learner.
- According to the test results, we can decide the level of the learner and the pertinent adaptation.
- The use of the paradigm agent which allows more flexibility and modularity to our system and facilitates the interaction of the community of agents.

9. Limitation and Future Studies

Our system offers a solid platform to ensure a good guidance of heterogeneous learners using adaptation of content and learning styles. However, the structure of the course and the learner profile is not appropriate for this aim (static representation). So, the lack of semantic representation of the courses and learners' profiles is one of the limitations of our work. Although, we used many tests of our work (some students of university), the practical use of our system (in a school of learning and on a sufficient number of learners for an appropriate period of time) was not done yet.

In future work, we aim to develop a semantic approach using ontology to represent the content and learners' profiles. This representation will facilitate the retrieval and reuse of the learning content according to many features. With the spread use of mobiles, we intend to develop an adaptive system on the mobile tools (smartphones, tablets... etc). Also, we will use our application in a whole school to present a solid proof of our approach.

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