Abstract—This paper describes a new learning-teaching model, ILEM (Intelligent Learning Environment Model). This model allows to design instructional programs oriented to maximize the balance of the student’s intelligence skills in a blended learning. The fundamentals of our learning-teaching model are sustained on the main principles of the Triarchic Theory of (Successful) Human Intelligence conceived by the psychologist Robert Sternberg. This author claims that there are three branches of Intelligence (analytical, practical and creative), all of them being necessary in different moments of one’s life. ILEM comprises an online and a face-to-face components. The former is supported by an adaptive hypermedia application whereas the latter, the presentational one, is based essentially on group work.

Keywords—Blended Learning Environments, Human Intelligence theories, Adaptive Hypermedia Systems, AHA!

I. INTRODUCTION

In the last decade, user-adaptive systems have known a huge interest by several research groups worldwide. One of the most prominent application domain of user-adaptive mechanisms is in the educational environments. Here the student’s knowledge has been the most common student attribute used to accomplish personalized content and views. Most recently, learning styles (LS) have been incorporated in several adaptive applications [1][2][3][4] aiming to satisfy the student’s learning preferences. Shortly, LS can be described as the way a student prefers to learn.

Our goal is to design a learning-teaching model oriented to maximize the balance of the students’ intelligence skills in a blended learning. This user-adaptive approach is the main goal of ILEM (Intelligent Learning Environment Model). These principles are sustained in the Triarchic Theory of (Successful) Human Intelligence (TTI) [5] which constitutes the theoretical foundation of ILEM.

This paper is organized as follows. Section II provides the theoretical background of our research, section III describes ILEM, section IV presents the adaptive hypermedia application built to put forward our model, and finally, the conclusions and future work are presented in the section V.

II. THEORETICAL BACKGROUND

The TTI has its origins in the 1980s [11] and, as others recent theories of human intelligence, presents a different perspective of this issue. His creator, the psychologist Robert

Sternberg, claims that there are three branches of Intelligence, analytical (conventional one), practical and creative intelligence, and that all of them are required in different moments of one’s life. Furthermore, the author argues that these intelligences should be trained in the classrooms from the very first school years [7].

Those claims contrast with the early idea of intelligence as a single ability. Contemporary experts in this research field [12] [13] [14] refute the idea of the indivisibility of the intelligence arguing it is rather a composite of multiple intelligences that can be changed and taught as well.

According to R. Sternberg, the three (triarchic) subcategories feed into successful intelligence. Analytical intelligence is applied to the abilities of analyzing, evaluating, judging, comparing and contrasting. Creative intelligence is related to the ability to design one’s own ideas to those of others, or to entirely devise a new concept. Practical intelligence relies on the intellectual capacity of the individual to make informed decisions. R. Sternberg also describes successful intelligence as the ability to balance analytical, practical, and creative intelligence and to use these intelligences effectively. Moreover, the author concluded [8] that both the triarchic teaching and evaluation contribute for improving students’ learning when compared with the traditional teaching model.

Our research has been conducted with the TTI theoretical basis together with user-adaptive models supported by computer.

In the next section, we introduced the main features of ILEM model.

III. ILEM DESCRIPTION

The ILEM model includes several modules. Fig. 1 visualizes the schema of the learning-teaching model.

Figure 1. ILEM model architecture
On the base (the conceptual level), we have three modules: the triarchic subject material developed by the teacher/author; the set of attributes needed to the algorithm for student’s adaptation; and the adaptive mechanisms defined by the teacher/author. On the top (the implementation level), there are also three modules: the online, the presential and the assessment modules. The adaptive hypermedia application comprises the online component of the model, whereas the group work belongs to the presential one. The two complementary learning scenarios in the classroom aim to improve the student’s learning achievement. This way, we can combine a more individual student’s pace with the benefits of a group’s rhythm. An assessment component was added. This component provides the necessary data to update the student model in the hypermedia application. Furthermore, the teacher needs also to plan the student’s triarchic assessment to be performed in the classroom.

As mentioned before, the main principle of ILEM is: “Balancing analytical, practical, and creative learning activities” both during students’ interaction with the adaptive hypermedia application and during the group work as well. By “learning activity” we mean “any online or presential analytical, practical or creative task”, for example, readings, evaluation tests, exercises. In our case, both the reading tasks and exercises fall into the online activities whereas the group work is linked to the presential activities.

In the next section, we describe briefly the main features of our adaptive hypermedia application which comprises the online component of ILEM.

IV. THE ADAPTIVE HYPERMEDIA APPLICATION

To develop our adaptive hypermedia application, the AHA! authoring framework was chosen as its functionalities fits to our goals. AHA! system is an Open Source Web-based platform [9]. It provides both adaptive presentation and adaptive navigation [15]. This framework provides several authoring tools. We emphasize the Graph Author Tool and the Test Editor tool [10]. The former is a high level tool that allows creating the domain knowledge and the concept relationships, that is, the domain model and the adaptation model. The latter is used to produce multiple-choice tests. One important issue about AHA! system concerns the creation of adaptation rules by the author. This way it is possible to create more specialized criterions to realize adaptation to the student.

In short, creating an AHA! adaptive hypermedia application consists of defining the domain model including the adaptation model, and the user model. Moreover, the content of the (X)HTML pages needs also some attention, specially whether fragments and objects are to be included in the content pages.

In an early experiment we have designed an instructional course at the Institute of Engineering, Polytechnic of Porto (ISEP) [6] for the 1st year undergraduate students. This course was related to basic concepts of Algorithms and VisualBasic Programming. Based on the adaptive hypermedia application developed for that purpose, we are going to describe the most relevant student-application interactions.

At first, each student needs to register in the application by filling out the presentation page (login, password, email are some of the required data). After that, the welcome page is showed (see Fig. 2). This page presents the subject matter and the main pedagogical goals. Moreover, there is a link to an online questionnaire. This questionnaire was conceived based on the information assembled in [7] author’s book.

![Image](image-url)

Figure 2. The hypermedia adaptive application interface

The results of the questionnaire aim to initialize the three student’s intelligence components (analytical, practical and creative one). In case of a student does not fill out the questionnaire, her/his intelligence components are set to zero by the adaptive application, which means that all three kind of activities will be recommended the first time s/he selects a content page with learning activities.

Concerning the adaptive presentation, the icon colours related to the content index indicate if a page/concept is suitable to the student. This decision depends on a predefined threshold. White colour means that a page was already visited; Green colour means that a page is suitable to the student; red colour means not suitable. A similar process happens with the link colours.

As mentioned before, the adaptive application suggests the most suitable learning activities to the student. These suggestions are spread through the content pages. In general, each content page should comprises a group of learning activities related to the subject studied. These activities consist of multiple-choice tests (AHA! presents only this type of interactive assessment) (see Fig. 3). The results of this test are used to update the student model, namely, the intelligence skills attributes of the student.

CONCLUSIONS AND FUTURE WORK

In this paper, we presented the learning teaching model, ILEM. This model aims to conceive instructional programs oriented to maximize the balance of the student’s intelligence skills in a blended scenario. It comprises both an online and a face-to-face components. We underline the fact that the adaptive application, which belongs to the online component
of the model, recommends those learning activities most suitable to each student based on the student’s intelligence grades. The overall model aims to both maximize the balance of the student’s intelligence skills and improve students’ achievements.

We also introduced the theoretical foundations, namely the main principles of the Triarchic Theory of (Successful) Human Intelligence. This way, we were able to implement a different kind of adaptive presentation proposal.

The overall results of an early experiment showed this model can answer positively to the questions investigated in [6], which gave us motivation to continue on this research direction.

Finally, our further research is twofold. Firstly, we intend to improve the functionalities of the adaptive hypermedia, namely, augmenting the diversity of means to assess students’ intelligence components. Secondly, we want to investigate pedagogical methods and techniques deeply, especially those that concern the creative field. We argue that the creative field has more and more importance in our day-to-day living and this way the creative competence, along with the two other competences, should be trained in the educational environments.

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