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Computational organization of didactic contents for personalized virtual learning environments

Francisco Ramos de Melo [a, *], Edna Lucia Flôres [b], Sirlon Diniz de Carvalho [b, c], Ricardo Antonio Gonçalves de Teixeira [b, d], Luis Fernando Batista Loja [b, c], Renato de Sousa Gomide [b, c]

[a] Universidade Estadual de Goiás, Unidade de Ciências Exatas e Tecnológicas, Anápolis, GO, Brazil
[b] Universidade Federal de Uberlàdia, Faculdade de Engenharia Elétrica, Uberlândia, MG, Brazil
[c] Instituto Federal de Goiás, Goiânia/Luziania, GO, Brazil
[d] Universidade Federal de Goiás, Faculdade de Engenharia Elétrica e Computação/Faculdade de Educação, Goiânia, GO, Brazil

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ABSTRACT

This paper presents an organization model for personalized didactic contents used in individual study environments. For many students the availability of contents in a general form might not be effective. A multilevel structure of concepts is proposed to provide different presentation combinations of the same content. Our work shows that it is possible to personalize the didactic content in order to encourage students, by using proximal learning patterns. These patterns are obtained from the analysis of the actions of students with positive results in the individual content organization. The system uses artificial intelligence techniques to reactively organize and personalize content. Personalization is made possible by means of an artificial neural network that classifies the student's profile and assigns it a proximal learning pattern. Expert rules are used to mediate and adjust the contents reactively. Experimental results indicate that the approach is efficient and provides the student a better use of the content with adaptive and reactive personalized presentation.

1. Introduction

Since the dawn of mankind, acquiring and transmitting knowledge has been the element that distinguishes and instigates human development. Knowledge has been the instrument used to promote and ensure the survival of humanity, personal and social development and national sovereignty The oldest and most widely used method to transmit knowledge is still based on face-to-face interaction. In this mode, both teacher and student are in the same space and time. Along the presentation of contents, the teacher interacts with the student, mediating knowledge according to the student's development. The process is driven and controlled by the teacher in a dynamic and immediate manner. However, economic constraints of space and time have restricted the scope and availability of education for many students (Horton, 2000; Jonassen, 2001).

A recent teaching mode, called Distance Learning (DL), gave rise to a greater availability and scope of education, both socially and demographically. In this mode the interaction between teacher and student is asynchronous, not occurring in the same space at the same time. The teacher provides content that can be studied by students in a different time and place. The student takes charge of his or her own learning. When difficulties arise, the process may be blocked until the teacher's intervention takes place. The student's profile, discipline and persistence in the presence of difficulties will be crucial to sustain the learning process (Horton, 2000; Phelan, Mendoza-Diaz, & Mathews, 2002).

* Corresponding author. Rua Bernardo Sayão, 175, Vila Nossa Senhora da Abadia, Anápolis, Goiás, Brazil. Tel.: +55 (62) 9963 7437.
E-mail addresses: chicorm@yahoo.com.br, francisco.melo@ueg.br (F. Ramos de Melo), edna@ufu.br (E.L. Flôres), sirlondiniz@yahoo.com.br (S. Diniz de Carvalho), professorricardoteixeira@gmail.com (R.A. Gonçalves de Teixeira), luizloja@gmail.com (L.F. Batista Loja), renato.s.gomide@gmail.com (R. de Sousa Gomide).

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The organization and presentation of content have great relevance in the process of imparting knowledge. Its relevance increases in self-study learning environments. Several technologies have been developed to support Distance Learning. The introduction of electronic computers in the process revealed important solutions to aid the student's learning. Much of the developed computer applications consist of a sophisticated electronic version of books. The development of computer technologies that employ artificial intelligence (AI) provided important solutions for distance learning environments. Intelligent tutoring systems (ITS) are among the solutions that employ AI for educational applications. ITS was developed with the purpose of establishing links between the learning object and student's knowledge. A major effort in developing an ITS is the search for a mechanism that can compensate for the teacher's absence while the content is delivered (Horton, 2000; Viccari, 2005).

ITS research seeks to develop techniques for personalizing the presentation of content that is reactive to the student. The development of ITS usually utilizes symbolic AI techniques. In these techniques, knowledge processes are abstracted and organized into rules or equivalent structures that allow the system to automate the operation (Dastbaz, Mustafa, & Stoneham, 2006; Duque & Jiménez, 2006; González & Ruggiero, 2009; Vicari, 2005).

An alternative research line sought to simplify the knowledge representation using connectionist AI techniques (Carvalho, 2004; Martins, Melo, Meireles, Nalini, 2004; Melo, Flores, & Carvalho, 2011). In connectionist AI, knowledge is abstracted, organized and manipulated in the form of patterns.

This paper presents a mechanism for reactive personalization of didactic contents. The proposal is a way to restructure and formalize a given content in different presentation levels of the same subject. Thus, it is possible to combine these levels to produce a different content for each student. By using a mathematical formulation with partial derivatives, it is possible to represent the teacher/student interaction process, i.e., the didactic path of the contents presentation. The proposed method identifies the student's profile and establishes a relationship with a proximal learning pattern. From these patterns, expert rules complement the personalization, providing reactivity for the different moments of contents presentation. The model discusses and formally organizes the elements involved in the system.

This paper is structured as follows: Section 2 present the rationale for the process of contents personalization. The proposed method, the description of the experiment and the results are shown in Sections 3 through 5, respectively. Finally, conclusions are discussed in Section 6.

2. Concepts, environments and patterns

2.1. Transmission of knowledge

The process of transmitting knowledge can be represented by the combined actions of teacher and student, with the purpose of assimilating knowledge. Three elements take part in this representation: the teacher, the student and the delivered content. The student is the interacting part to which all the effort of the process is directed, in order to develop his or her skills. The teacher is the key agent of the process and is responsible for the direction and organization of the means that enable the student to assimilate knowledge from the content. The content is related to the knowledge that is conveyed (Fontenla, Caeiro, & Llamas, 2010; Patten, Chao, & Reigeluth, 1986; Phelan et al., 2002).

The success of a knowledge transmission process should take into account the organization and presentation of content (Patten et al., 1986). The content is an organization of ideas involved in the inception of the knowledge to be transmitted. Ideas are knowledge units called concepts. A didactic content can be understood as an element structured in such a way that the ideas constitute a whole.

Typically, for designing, selecting and implementing programs and procedures for teaching numerous classes, teachers shape the content in a single and general format for all students. This format assumes a student of average ability and skill. The content selected by the teacher is presented in the same way for all students. The learning process happens with the interaction of teacher, student and content. This interaction involves the mediation by the teacher in face of the student's reactivity to the content that is being presented. The reactivity is the reaction of the student to the content that is presented (good understanding, doubts, etc.). The perception of the student's reactivity enables the teacher to interact in the process, taking the necessary action in the study sequence. This action performed by the teacher while interacting with students and content is called mediation, and favors the development of knowledge (Fontenla et al., 2010; Jonassen, 2001).

In a face-to-face teaching environment, the teacher interacts with students during the presentation of the content, identifies their difficulties and offers options to conduct the learning process. This interaction between teacher and student occurs throughout the contents development process. In this kind of educational environment, the single format can deliver effective results, because the teacher interacts with students when difficulties arise (Horton, 2000).

In a distance learning environment, interactivity is a complicating factor. Considering the lack of mediation by an educator, single-format content may not meet individual learning situations. During the presentation of content, the teacher's pedagogic intervention towards the student's difficulty may take longer to be administered. General pedagogic interventions are made impossible by the unknown plurality of students and all the typical situations of a distance learning environment. Due to its asynchronous aspect, DL does not enable immediate interaction between instructor and student when problems arise. Thus, the student's learning may be jeopardized by the delay of the teacher's intervention (Fontenla et al., 2010; Jonassen, 2001).

2.2. Computers in education

The need to provide cost-effective education to increasingly larger and diverse populations brought forth the development of new instructional alternatives. The interaction between the different elements involved in a non-face-to-face education process has established disciplinary ties between the Exact Sciences and the Humanities (Horton, 2000). The introduction of electronic computers enabled the development of many technologies to assist in educational processes.

Skinner (1968) points out the importance and rationale for organizing the teaching sequence in order to transmit knowledge, which requires patterns for the systematic process. Skinner's work comprises definitions for format and presentation of the contents, which enable the mediation of knowledge using electronic devices.