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# Heráclito: Learning Environment to Teach Logic

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**Abstract.** The present paper aims to present the Heráclito environment. The Heráclito is an Intelligent Tutoring System focused on teaching Logic and assists students in solving exercises that ask them to calculate the logical value of a formula, going through truth table exercises, and even doing argument-proof exercises through rules of Natural Deduction. In order to do so, it provides the Electronic Logic Exercise Notebook - LOGOS<sup>1</sup> [1] (with two different test editors) that allows creating and editing formulas, truth tables and proofs of Natural Deduction to Propositional Logic.

## 1 Introduction

The subject of Logic [6], addressed in higher education, is a basic and compulsory subject for all courses covering computer science and informatics [2]. Fundamental to the training of undergraduates, the Logic discipline enables the development of the skills of logical analysis, formalization and problem solving. These skills, in turn, are necessary for the understanding of the several contents and activities found in the curricular components of computer science and informatics. A statistical survey [5] conducted in the last ten years pointed to very high rates of fail and dropout, leading to higher retention of students. These dropouts, in particular, tend to occur at the beginning of the subject, especially when the contents of Natural Deduction began to be addressed in the context of Propositional Logic. In practice, the difficulties begin when concepts such as formula, rule of deduction and formal proof begin to be presented. In order to improve the presented indexes, a dialectical teaching method was used, associated to a sociohistorical approach, and a model of computer mediation, modeled in an Intelligent Tutor System (ITS), which was called Heráclito Environment.

The Heráclito environment is an ITS and can be termed as a learning object that aims to support the teaching of Logic. Its test editors have the main functionality of assisting the elaboration of exercises and to calculate the logical value of a formula, truth table exercises and proofs of formal arguments through the rules of Natural

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<sup>1</sup> Free to use at <http://obaa.unisinos.br/heraclito/>

Deduction in Propositional logic. Its focus is associated with the use of agent technologies with pedagogical characteristics that make use of teaching-learning strategies, seeking to help the student in his reasoning process in solving a problem in the form of exercise [4].

The current version has the support of a tutor (online) in the process of resolution of exercises and its access is via Web Browser, which has made the tool adaptive. Associated with this responsive characteristic, its recent reprogramming, using the Prolog language, standardized the set of pedagogical agents (students profile, mediator and specialist) that work together with the specialist system, also developed in Prolog.

The Heráclito environment is part of the OBAAMILOS project [7], and its software architecture is compatible with the MILOS<sup>2</sup> agent infrastructure. To facilitate interoperability between devices and the reusability of the Heráclito environment, it is encapsulated in the form of a Learning Object (LO) and is part of the OBAA Educational Content Repository, at Federal University of Rio Grande do Sul.

## 2 Main Purpose

Developed in 2011 and updated since then, the Heráclito environment [5] has gone through versions for Desktop and Mobiles until arriving at a graphical interface that uses Web Browsers for access with responsive characteristics, combining technologies that comprise HTML 5, CSS 3, Java and also JavaScript.

The environment can be used in two ways: offline, as a visiting user, but without tutoring services; and online, with the support of the tutoring service, being necessary to log in to access the resources. The procedure for log in and access to the system in online mode is through a simple registration, where it requires minimum user information such as: email, name and a password. After registration, to log in the environment requires email and the password that were previously registered.

The Heráclito environment was developed through the use of agent technology for pedagogical purposes, responsible for student interaction with the system and also access to the intelligent tutor that assists in the development of the resolution of the exercises indicating correct, incorrect and not recommended paths during the course of the proof. This tutorial service aims to help the student in the step by step of solving the exercises, playing the teachers role. As a student interacts with the environment, the agents are monitoring their actions, ready to assist in case of need. If the student is unable to advance in a test, the student can also ask the tutor for tips or suggestions through the Help button (which can also be activated at any time during the exercise). This tutorial service uses a set of learning strategies, developed specifically for Logic, based on classroom experiences that help the student perform, for example, a Natural Deduction test.

When developing the Web interface of the Heráclito environment, we choose for the client-server architecture. This choice was made due to the security and performance that this methodology, coupled with adequate programming languages, can offer to the system. It should be noted that this interface was also developed with the purpose of portability, *i.e.*, to be portable for different devices with different

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<sup>2</sup> More information at: [http://www.portalobaa.org/padrao-obaa/relatorios-tecnicos/copy\\_of\\_1o-relatorio-parcial-obaa-milos-comunidade-finep/AnexoA-EspecArqMILOSV10.pdf/view](http://www.portalobaa.org/padrao-obaa/relatorios-tecnicos/copy_of_1o-relatorio-parcial-obaa-milos-comunidade-finep/AnexoA-EspecArqMILOSV10.pdf/view).

capacities, screen sizes and different performances as well. With the use of the client-server architecture, it is possible to exchange messages between the interface and the system, leaving all the logical and the agents' part being processed entirely inside the server, which makes the system extremely light and portable for any device that has a web browser.

Aiming at increasing security, robustness, compatibility with various systems and screen sizes, was used to develop the Bootstrap framework. This framework provides a range of ready-made elements in HTML 5, CSS 3 and JavaScript that help in adapting the site to different screen sizes and several systems making them responsive, which means that the LO can be distributed, with only one version, to several different platforms reaching a greater number of users.

### 3 Demonstration

As mentioned before, the Heráclito environment uses the technology of pedagogical agents and is composed of a set of agents named: Students Profile, Mediator and Specialist. These agents are responsible for the interaction of the student with the environment and the specialist system, as well as the form of communication between these agents and the editor of formulas and proofs of the Heráclito environment. These agents are responsible for one or more scenarios and can be demonstrated at: <http://obaa.unisinos.br/heraclito/index.jsp>. Its organization is structured as follows:

- **Student Profile Agent:** This agent represents the student model, which in the Heráclito environment is based on the exercise resolution process;
- **Mediator Agent:** This agent represents the role of the teacher in his didactic-pedagogical function;
- **Specialist Agent:** This agent also represents the role of the teacher, but in his role of specialist in the field of teaching logic.

All agents of the Heráclito environment were developed in the Prolog language and have an interface in Java with JADE platform support for communication between them. This communication between agents in JADE is based on asynchronous messages, that is, an agent that wants to communicate must only transmit a message to an identified destination (or set of destinations), and there being no type of temporal dependence between the transmitter and the receiver.

The messages exchanged between these three agents must pass through the mediating agent, who mediates this communication between the student profile agent and the specialist agent. It is responsible for incorporating the role of the teacher or tutor within the Heráclito environment, the mediator agent provides pedagogical support to the student in its learning process. The main situations in which the Mediator agent will interfere through the application of some mediation strategy are:

1. When an incorrect insertion of hypotheses occurs;
2. When an incorrect deduction rule application occurs;
3. When a correct rule-based application occurs: in this case, even if the application is correct at the operational level, this rule can still be problematic at the behavioral level and can be categorized as useful, redundant, and harmful. The application of a useful rule assumes that the rule is correct (operationally) and contributes to the resolution of the exercise. The application of a redundant rule may be correct at the operational level, but it does not contribute to the resolution of the

exercise, and the student only increases the number of lines and rules applied without obtaining the expected result. The harmful rule, when applied, ends up leading the student to a path with no return, that is, with its application, the exercise can not be solved;

4. When the student is idle or does not advance in the resolution of the exercise;
5. When a significant percentage of the test is reached the student is informed and receives an incentive to continue;
6. When there is one step left to complete the resolution, the student is informed in the form of an incentive to finish;
7. When the student asks for help. The answers to the help requests can be three types: a tip, where the system provides the next step to be taken to continue in the resolution process; an example of an appropriate demonstration for the current situation of the student; and how much is missing. This option tells you the number of steps remaining for the end of the exercise.

## 4 Conclusions

The development and upgrade of the Heráclito environment, it is hoped that it will contribute, not only to a better understanding of the contents covered in the discipline of Logic, but also to reduce the number of dropouts and fails in this context. In relation to future work, the Heráclito environment has been developed in parallel with its current version, in order to identify the level of knowledge of a student within a specific context of logic, expressing mainly what occurs during the interactions with the environment between the student and the teacher (tutor). Using specific teaching-learning strategies for each student profile found.

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