Artificial Intelligence For Open Source Educational Resources

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Abstract

Artificial Intelligence (AI) is a field of very active and intense research worldwide. The whole field of AI has recently been revisited to provide critical functionality and significant enhancements in reasoning, decision making, filtering, personalization and adaptability, natural language understanding, deep learning, machine learning and data mining under the research and development pressure of the important and evolving new technological advancements of big data, smartphone and mobile software applications, Internet of Things as well as a vast range of application areas in all sorts of human activities and professions. As such, current related research includes efforts towards the efficient incorporation of AI enhancements into software. The goal is to develop algorithms, mechanisms, methodologies, and procedures that allow software to learn and evolve, i.e., to become better and more efficient at performing specific tasks, either on its own or with the help of a supervisor/instructor.

The Project in Artificial Intelligence and Educational Technology proposed has *four main research line*s, each of them comprising research themes that, together, reinforce the projects' main goals of promoting better education standards and expanding the education boarders to a

much larger portion of the population. The development of these actions starts in 2010 and, at this moment, some applications become used by researchers, teachers and students around the Latin America, Africa and Portugal. It is a long-term project for research, development and students formation. It is divided in sub tasks as **OBAA** - Learning Objects Standard-, **FEB** – Federation of Learning Objects Repositories -, **Cognix** – Learning Objects Repository - and **Heraclito** – Intelligent Tutor System - infrastructure for an intelligent environment for open source educational applications.

1. Main Project

In order to make efficient development and use of Artificial Intelligence-enhanced Software, further research is required. In the Educational context, this project focus on the Incorporation of AI enhancements into software as intelligent agents and softbots, development of AI-enhanced multi-modal interfaces, development of AI-enhanced user/student model, AI-enhanced technologies for web services, Learning Objects, Internet of things, ontologies, and Intelligent Tutoring Systems.

Objective: This project intends to foment research in Artificial Intelligence that enable the implementation of efficient solutions for learning applications as a way to provide cutting-edge results in employing more effectively and reusable computational learning systems. The specific goals are:

1.1. Interoperability of systems and contents

System interoperability relates to the ability to develop software components that can be used across different platforms and can be reused in different contexts. In Education, it relates mostly to the capacity of reusing instructional material in a different context from the one to which it was designed. One of the best examples of interoperability is probably the World Wide Web: through the use of the *http protocol* and a set of universal languages and patterns (html, css, javascript, etc), documents with varied styles can be seen with different computers, browsers, operating systems, etc. Now, Internet of Things provide a good protocol for interconnection among thins and software. It is an important step for development of new educational software.

In the field of Artificial Intelligence applied to Education, interoperability is crucial, as it is common that systems have to run in completely different computational environments. A British report stated, “in schools which already used a virtual learning environment, the ability to adapt contents to other systems was considered to be critical” (Scholzone 2007).

Although many significant results have already been reached in the field, as the definition of web standards and patterns for learning objects, the adoption of certain specifications depends to a large extent on the availability of well-documented open source implementations. A big effort has been made, for instance, by different virtual learning environments to provide good documentation and user support. Moodle, Sakai, Zoom or Meet is international examples of initiatives on tools that have already a large community of users following interoperability standards. However, there are no common patterns to enable easy and direct communication between the virtual learning environments. Besides, there are increasing requests for more complex features that complicate even more the creation of standards, as educators realize the needs and benefits that can be gained from student tracking, content organization, assessment, and other. Such functions already exist in some virtual learning environments, but they cannot be carried from one system to another for their lack of interoperability. The interoperability objective is to provide educational contend available at any time and any location as long as users have computer or mobile devices access.

This research line should therefore operate on the investigation of appropriate models and standards, as OBAA (Learning Objects Based on Artificial Agents) to enable broader diffusion and use of educational software, as well as on the testing and validation of novel patterns proposed by the international community. Having the social purpose of taking education to the largest possible number of people in the country, the institute would focus mainly in standards for open source and free software. This research should enable the attainment of many of our goals, such as the distribution of the software developed to many institutions throughout the country, the enhancement of teaching and learning practices in various educational levels through the production of digital educational material for different media, and the involvement of Brazil in current and future global initiatives regarding the use of technology in education. See Figure 1.

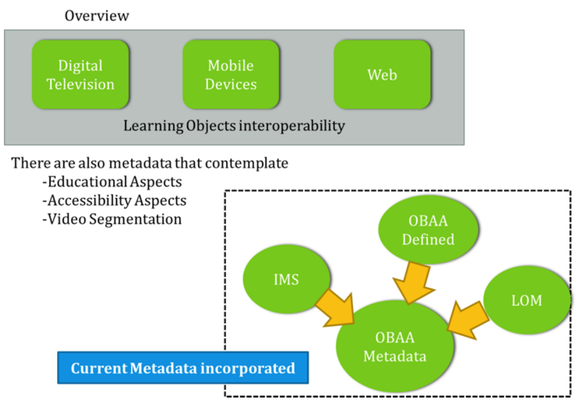


Fig. 1 Interoperability among devices and learning objects metadata

1.2. Pedagogical methodologies for new educational demands

Nowadays, computers have enabled a sought paradigm in educational practices: students can finally become more autonomous in their learning activities. They may find a vast amount of materials made available by the teachers in virtual learning environments, they may use intelligent tutoring systems to learn a new topic or to reinforce what they have already learned, they may assess their own knowledge through automated tests, or they may simply search for information in the internet and explore the incredible amount of information that is fed into the web everyday. However, to get the most out of each of these tools, new pedagogical methodologies have to be created and/or adapted to meet new educational demands.

The modern pedagogical methodologies that take into account technological resources as part of day-to-day practices encourage instructors to stimulate reasoning and learning instead of working as "information providers". In distant education in particular, an approach that has grown exponentially in Brazil according to the Statistical Brazilian Yearbook of Open and Distant Education (ABED, 2010), new pedagogical methodologies need to be exploited and diffused.

Many heavy investments have been made in distance learning to improve education in the country, as the Open Brazilian University (UAB), created by the Educational Ministry in 2005 (UAB, 2016). The system, through federal, state and local partnerships, intends to take higher education to many Brazilian cities that do not have this level of education, or whose courses do not meet the demand. Preparing these teachers without taking them away from their work has been a challenge and one of the main goals of distance learning programs in the country.

By working in this research line, several goals of the project will be achieved, such as the contribution with significant results on the best uses of new technologies in education, the dissemination of knowledge and educational material as to assist other institutions in their pedagogical practices, and the training of elementary and high school teachers in using educational technology, as part of a continuing education program.

Besides the concerns regarding the methodological approaches to teaching/learning, questions are also raised about the traditional model of designing digital educational material, many times a process driven by software engineering methodologies. It is certain that good results in educational software design can only be obtained if accompanied by sound pedagogical theory to support content presentation, student/educator interaction, collaborative learning and other. Our next research line concerns the investigation of new methodologies for educational software development by taking into account pedagogical aspects in the design/development process.

1.3. Main research and development lines for the project

Learning objects offer a new concept for developing and combining learning materials by providing smaller, self-contained and re-usable units of learning (Beck, 2008). They typically have several different components that range from descriptive data to information about educational level. At their core, however, one will find instructional content and, most likely, assessment tools.

This research line has as a main focus to develop and test learning objects in different areas and teaching levels. These methodologies should support the design and development of functional features that have to be part of the learning systems, and also favor fundamental pedagogical aspects that are critical for the success of the software as an educational tool. This theme opens the possibility to investigate and discuss advances and limitations of technology in its use for the construction of computational learning environments.

This research line should also concentrate on the development/improvement of learning platforms exploiting different resources, such as storage and retrieval and communication tools, as well as novel interfaces to promote the interaction among students and between student(s)/educator(s).

For the next 2-year we intend to concentrate our research in the use of Ontologies applied in Learning Objects (LO) Repositories. Ontologies can be used to enrich the description of the LO metadata. It is also possible to use ontologies to cope with the interoperability among repositories. Along with user interaction, ontologies can improve recommendations, both for cataloging and for LO (re)use, and an intelligent search can be leverage with ontologies. These situations are the scope of the project. For the applications under our scope, ontologies will improve OBAA in order to reason about the student learning and to evaluate the educational content of e-learning assessments. It also helps to the intelligent tutor abilities and facilitates decision making. Cognix will store the objects and will interoperate with a repository federation (FEB). Also, ontologies can be used for define aspects of LO authoring, recommendations, searching, and data analysis. To implement it we intend to use an agent-based architecture.

The new tendency for Educational software is ecosystems that include different applications as databases, repositories, smart books generation, intelligent systems, learning platforms, headphones, gasses, tiaras, etc. It is an actual open research line for our group.

The investigation of these topics should enable the achievement of many of the projects’ goals, such as the design and to production of digital educational material for different media; the evaluation of educational software and materials as to improve students’ learning; the operation in areas that may promote the development of new businesses, as in the production of distance learning material, digital television, mobile learning, among other.

The learning platforms and objects developed in the project should be enhanced by communication capabilities, which enable knowledge management and sharing. The next research line of this project investigates these particular themes. Its line finished in 2012. The **OBAA** Standard for Learning Objects is in used since them. OBAA project line was supported by FINEP (Brazilian Research Agency) project 01.08.0215.00 and FAURGS our university foundation. The infrastructure for Learning Objects development and storage is finished. The search engine **FEB**, supported by RNP (Brazilian Research Foundation), is also finished. An open intelligent repository was created. See **Cognix** subtask supported by Cognitiva Brazil.

Historically speaking, the concept of collective knowledge has been around since man started to communicate and to store information. But only now man is starting to be able to truly build a collective knowledge base, with the help of computers and the Internet. Wikipedia is one of the best examples, in which people from all over the world contribute with the creation and maintenance of a knowledge base in all areas, becoming one of the most accessed websites in the planet.

This line of research concentrates on the development of methodologies and models to store and manage knowledge that has been collectively built through the organized aggregation of many individual contributions. It is known that knowledge production and use is a collective activity, in which communication between its participants plays a central role. Some of the problems related to this task are the generation of duplicated work, slower productive processes, and misleading decision making because of lack or incomplete information. It is therefore necessary to invest on research that enables the development of appropriate knowledge management and communication tools that are able to minimize these problems and to make collaborative learning efficient.

It is also important to develop methodologies that encourage interaction and create a supportive environment, which fosters a real community and provides a lasting learning experience. While people collaborate and learn through the act of working together, they generate knowledge that is stored, shared and used by others. *This line is in development till this moment in a project supported by FCT (Portugal Research Agency) Portugal, in cooperation between Azores University, Lisbon University and Federal University of Rio Grande do Sul, Brazil.*

The development of methods for automatically identifying the quality of knowledge found in the Internet is another research theme that is extremely important, especially as the web becomes one of the main sources of information consulted by people. Identifying trustworthy sources and making dynamic connections with other information fonts is a challenging investigation topic with a great potential for delivering tools that can be useful for students in all levels, for scientists, and even for the average citizen that wanders through the internet without specific goals.

The min porpoise of this line is smart books generation on real time, for different educational platforms like Intelligent Tutor Systems and Learning Management Systems. This line is still open at this moment.

To close the cycle with other research *lines considered by the project, the investigation on knowledge sharing and management should consider interoperability properties, as to enable people to store and diffuse knowledge regardless of hardware and software platforms, for example as Fab-Lab. The use of these tools from the perspective of education and learning should also bear in mind pedagogical issues that are considered by another research line of the project.*

1.4. Development of Human Resources

The project envisages the development of human resources in all levels, through the articulation of students, researchers and professionals, engaging them in different projects stages and in various types of projects. At this moment, 6 students from Colombia, 1 from Chile, 7 from Mozambique and 1 from Venezuela are finished their MSc or PhD in the context. The study was supported by different agencies, as CNPq and CAPES (CNPq and Capes are Brazilian research agency) from Brazil, University Pedagogica de Mozambique, Colciencias (Colombia research agency) from Colombia and Conecity (Chile research agency) from Chile. In addition to foreign students, several Brazilian students have also developed jobs in the scope of this project. At this moment there are 4 Brazilian students working in their PhD projects. The work is concentrated in the PPGC – graduation Program in Computation and in a multidisciplinary program PGIE –graduation in Computer and Education. All research is in development in Artificial Intelligence in Education.

1.5. Transferring knowledge to society, government and startups

One of the main goals of the project is to transfer knowledge to society, as a way to return to the tax payers the financial investments made. The project will transfer knowledge to society in several ways:

- *Diffusing and distributing the results of the research carried out to other institutions without any cost;*
- *Organizing courses targeted to different public, from seminars to extension and specialization courses, as a way to provide continuing education;*
- *Capacitating human resources by involving students of all levels in the development of the research projects;*
- *Transferring technology to movement sector and to startups connected to the university.*

The project will also have an exhibition hall with the main purpose of showing research results produced by the participants, which may be of interest to the community. Elementary and high school visits are expected to the exhibition hall, which displays works that can be tested and experimented by the students. These works should be educational and entertaining – challenging researchers to produce tangible results that can be seen and tested by average students.

At now 23 institutions are using OBAA http://www.portalobaa.org/obaac standard and the Brazilian Ministry of Education adopt OBAA standard for calls in technology and education area.

A big number of users around the world are using FEB http://feb.ufrgs.br/, including CAPES (research agency of Brazilian Ministry of Education and UAB – Open University of Brazil.

At now, 12 Universities are using the Intelligent Tutor System – Heraclito http://labsim.unipampa.edu.br: 8080/heraclito/index.jsp – for teaching Propositional Logic.

All the AI technologies produced at now, was transferred for Brazilian Ministries and Cognix http://cognix-repo.inf.ufrgs.br/repositorio/documents to a startup called Cognitiva Brasil. All the products are freeware.

1.6. Expected Results and Impact

The evolution in research and development in the 21st century indicates that multidisciplinary teams are one of the most common forms of obtaining scientific results. This way, the main actions of this project aim, at least initially, to make the researchers and other people that will take part in the institute aware of the problems inherent to multidisciplinary research. For instance, the need for a common vocabulary and understanding of the methodological differences in the research in each field, the development of teaching models and "joint-venture" research among the areas, aiming at educating professionals and scientists who may work in this new world, with the emphasis in multi and inter-disciplinarily. Examples of multidisciplinary applications which could be used in this type of instruction could be in areas such as environment, public health, e-learning, digital entertainment, telemedicine, among others. Therefore, the success indicators of this proposal should consider:

- The integration with the industry: good quality research is reverted into social and economic benefits. Here, this integration will try to find technology companies working in Education. *At the end of the next three years we intend to have a consortium of startups associated to the project*. A brief search at MEC's (Brazilian Ministry of Education) Elementary and Secondary School showed that there are 133 startups operating in this area in Brazil.

- The publication of books presenting pedagogical proposals, evaluation forms and policy propositions for the public sector. At now the project published 1 book in Brazil and 1 book in Colombia, all of them is free available ate web. A new book is expected for next year. Also the project produced 1 chapter in a free book available at web. For a complete list of the project publications see item 7 of this document.

- The development of specialization/capacitation courses for the use of technology in Education. A big number of in live courses was developed and new courses are under development. The foundation of a virtual community, autonomous and auto-sustainable for discussing and exchanging experiences in the areas of fundamental, elementary and special needs education, aiming to share expertise in using technology in educational practices. I'm taking part of UNESCO community.

- The possibility to integrate, into this project, new related interdisciplinary areas, such as cognitive neuroscience. After 2019 it was adopted.
- The setting up of a space to provide storage, management and pedagogical content retrieval services, such as learning objects, blogs, websites, and other, for the whole country. Cognix provides this service. Cognix is an open educational resource repository. At this moment, we need more memory space for support LO storage.
- The development of educational technology, software and other, that can be used in institutions nationwide at all levels. From elementary, secondary school, to universities and other educational institutions. These technologies should also be effective for the improvement of training programs in private companies as well as in government sectors. Hare the main objective in 2020 and 2021 is the development of a set of LO for teaching about the sea preservation. It is under development in cooperation with the University of the Azores, Portugal. Also the research members of this project are providing courses and videos at YouTube, to education about the conscientious use of IA in the day-by-day life.
- Include value alignment in the previous educational systems developed in this project. Ethical issues are always complex, mainly due to their temporal, cultural and context dependence, in addition to the subjectivity of judgments and multiple points of view. The lack of agreement among moral philosophers, on which theory of ethics should be followed, also may be considered an obstacle to the development of machine ethics (Bostrom 2014; Brundage 2014). Yet, it is not the intention of this paper to define which principles or ethical frameworks should be implemented in educational contexts, but to defend the need to have them. This need, in turn, is as true for human agents as it is for artificial agents. This action is under development. Firsts results are expected for 2021. It will be included in Heraclito system as a concept test.

1.7. University

The main location of the project is the Federal University of Rio Grande do Sul (UFRGS). From the offices and laboratories set up at the university, the joint research with other partners all over Brazil will have to be coordinated by Rosa Maria Vicari.

UFRGS is a centenary nationally and internationally recognized institution. It has courses in all areas of knowledge, in all levels, from fundamental school to postgraduate courses. The excellence of its instruction, research and extension, making available several activities and services directed to the community, enables UFRGS to be ranked as one of the best universities in Brazil. In a recent ranking presented by the Ministry of Education and Culture (MEC), the university was ranked as the 1th in the country fin the lets 3 years (2018-2020).

UFRGS possesses 27 units of undergraduate courses, of which 13 are central institutes, 10 faculties, 4 schools. Besides, the university has a technical school and a regular school for elementary and secondary education. The university has 67 academic Masters courses, 9 professional Masters courses, and 61 PhD programs. Besides, the university always has a large ongoing set of graduate courses. At the end of 2006, for instance, UFRGS had 126 latu-sensu graduate courses, demonstrating its vast capacity to form human resources at postgraduate level.

In computer in education area, UFRGS has been the first institution in the country to create and offer specialization courses in informatics in education. In consonance with the goal of setting up a Graduate Course Program in Informatics in Education at UFRGS, the Interdisciplinary Center of New Technologies in Education (CINTED) was also created, as a way to guarantee the institutional assistance and support to interdisciplinary actions, requiring the interlacing of different units. Its purpose was to create co-participation spaces, offering support to actions of interdisciplinary character in the context of research, of teaching and extension, aiming to develop or improve these same educational functions of the university, making use of the new technologies of information and communication. CINTED hosted an UNESCO chair in Communication Information and Technology.

PGIE-Informatics in Education PhD Program- has become a renowned program, attracting students from all over the country and from Latin America. PGIE has also obtained prestige nationally and internationally, with prizes awarded to research works from students and professors in many events. It is also important to emphasize that in the last evaluation (2017), the program has obtained mark 7, the highest in Brazil for multidisciplinary courses, confirming the excellence of the program.

2. Sub Projects

This section described all the sub-projects that implement the man objectives of this proposal. All the sub-projects already has some results, in different laves of implementation. Some of them have objectives under development in 2020 and for 2021. OBAA standard is the base for all the other projects in use or under development.

2.1. Project Goal 1 - OBAA Standard Metadata

The Learning Technology Standards Committee (IEEE LTSC, 2003) defines a Learning Object as “any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning”. These learning objects require metadata in order to be indexed, retrieved and reused in repositories, the Learning Object Repositories. The learning object metadata consists in a specification describing the educational content in terms of technical and pedagogical aspects. Wiley (Wiley, D, 2009), considers that metadata are formed by a set of information to describe a resource using a standardized structure, making possible the retrieval and access of the learning object, i.e. data about the data.

Several authors use metaphors to explain metadata, Silva (Wiley, D, 2009) for instance, compares it to labels identifying the contents of a learning object, describing how, where and by whom they were developed, which public it is intended to, its size, (Vicari et al, 2009) emphasize that the storage and utilization of learning object in different learning environments require the description of its content in a standardized way, which allows the exchange of information.

Agent Based Learning Objects (OBAA) proposal include all metadata from the previous standard as LOM and DublinCor. See Figure 2. This approach permits the interoperability among different standards.

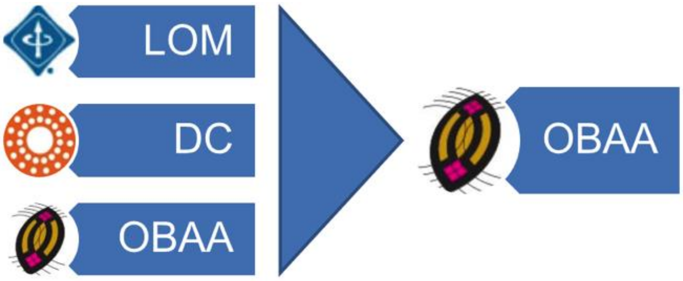


Fig. 2 OBAA standard conception

In Brazil, the first initiative towards a standard for learning object was the project OBAA. The name means that OBAA tools are composed by a set of AI software. Those technical and functional requirements are aligned to specific Brazilian demands, restrictions and context, such as, the fact that the vast majority of the population has a TV in their homes but only a minority has access to a PC and even less to the Internet.

OBAA is grounded on the learning object metadata standard, with all its categories and extra metadata, complementing the technical and educational categories and including two new categories representing accessibility and segmentation aspects. Such modifications and extensions to learning object metadata are proposed to structure a Brazilian standard for learning object. We are going towards a standard because the efforts to compose the documentation in fact represent an agreement among several Brazilian communities (education, culture, science and technology). Thus, according to a broader perspective our characterization of the metadata proposal as a standard reflects a strategy to disseminate learning resources inside Brazil in an interoperable and inclusive fashion.

Although such extensions and modifications could be formalized simply as specific learning object metadata profiles, we feel that such approach would diminish the acceptance of the proposal difficulty the utilization of the metadata by Brazilian developers. Following that approach, due to backwards compatibility with the original LOM, we should restrict ourselves to using learning object metadata’s extensible metadata, which does not allow providing all the required customizations.

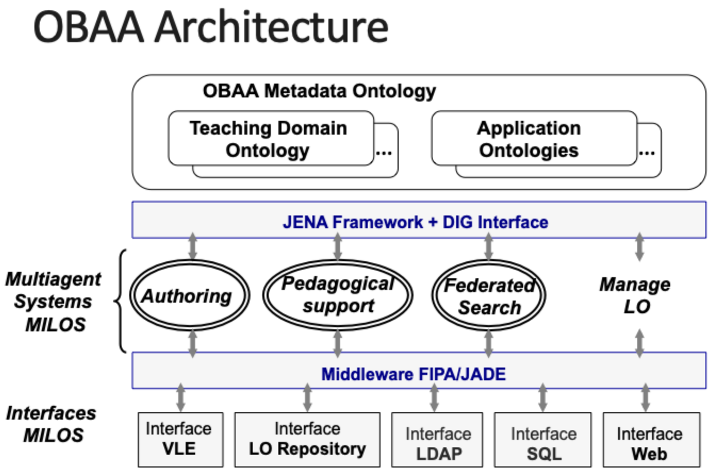


Fig. 3 OBAA infrastructure architecture

OBAA architecture is composed by 3 layer: the 1º one includes the ontologies about OBAA metadata, and also about educational dominium, as language, physic, history, etc.; the 2º one is composed by OBAA infrastructure for uses, as LO editor, LO pedagogic support, search and retrieval LO (FEB System) and Heraclito), and management LO system. At now only de editor is open. The connection between layers 1 and 2 occurs through JENA framework. Layer 3º one is composed by facilities laky Learning Management Systems, Repository as Cognix, for example, Data Base, Web connection and Web Services. The connection between layers 3 and 2 happens through Middleware FIPA/JADE (am agent development platform. All systems at layer 2 are intelligent agents.

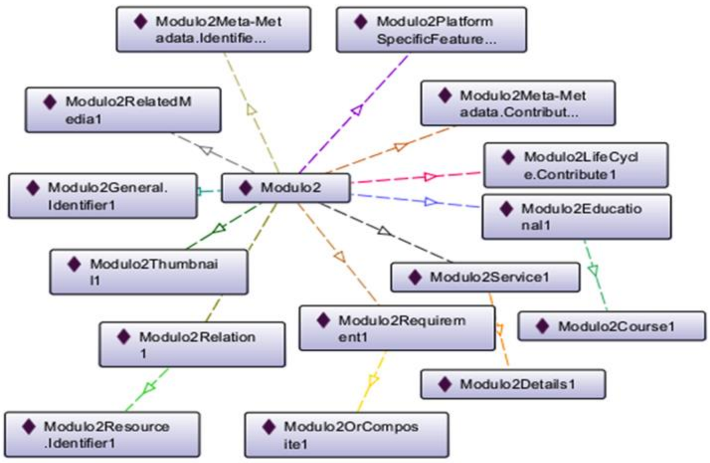


Fig. 4 OBAA metadata ontology developed by Prótegé

2.1.1. OBAA Metadata Proposal – new aspects

The Web's ubiquity and the perspective that this environment is also available for Digital TV and mobile devices motivated the proposal of a new standard for learning object. Thus, the proposed metadata standard intends to give enough freedom for the developers of pedagogical contents so that such professional faces no technological restrictions.

Before the definition of the OBAA standard, of internationally recognized learning object metadata specifications were studied, namely IEEE LOM (IEEE LTSC, 2003) IMS (IMS, 2008) and DC (DCMI, 210). The study was complemented with the specifications for cataloging media files and Digital TV (ISO/IEC, 2005), MPEG -7 (MPEG-7, 2008) and SBTVD (TELECO, 2008) (ABNT-NBR, 2010).

The choice of extending IEEE LOM came from the widespread acceptance of it in the academic environment and the ease of adjusting its metadata, allowing the insertion of new categories and items in existing categories. Figure 5 illustrates the categories that organize the metadata. The new elements aim to meet Brazilian requirements in terms of technology, education, accessibility and segmentation. In the next sections are described the categories of metadata that constitutes the OBAA specification, which differ from the IEEE LOM, modified or created.

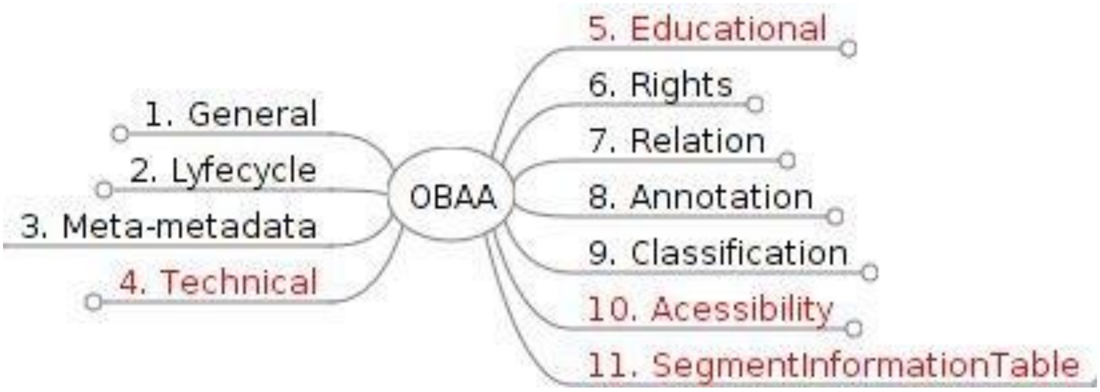


Fig. 5 OBAA metadata categories, with the proposed extensions are highlighted.

The proposed set of metadata establishes a wide structure for cataloging, enabling different uses according to the needs of each learning object designer. The set extent is due to its completeness in relation to objectives of interoperability and adequacy to the Brazilian educational scenario.

2.1.2. Technical Metadata

Multiplatform technical metadata define the technical information and requirements to use learning object in Web, digital TV and mobile device platforms, enabling construction of interoperable learning objects. Although in the ideal situation all produced content or media could be transmitted and executed exactly in the same manner in any type of device or digital platform, some characteristics are specific, preventing such ideal to be achieved. Therefore, these metadata particularly aim at dealing with the additional requirements of multi-platform interoperability. In addition, aiming at a compatibility with the Semantic Web (Berners Lee, 2001), metadata were established to define which services, ontology, content languages and interaction protocols are associated with the object. Instead of making changes directly to the existing metadata of the Technical group, our choice was to extend it, including new metadata and maintaining compatibility with the IEEE LOM standard. Figure 6 presents OBAA Technical metadata.

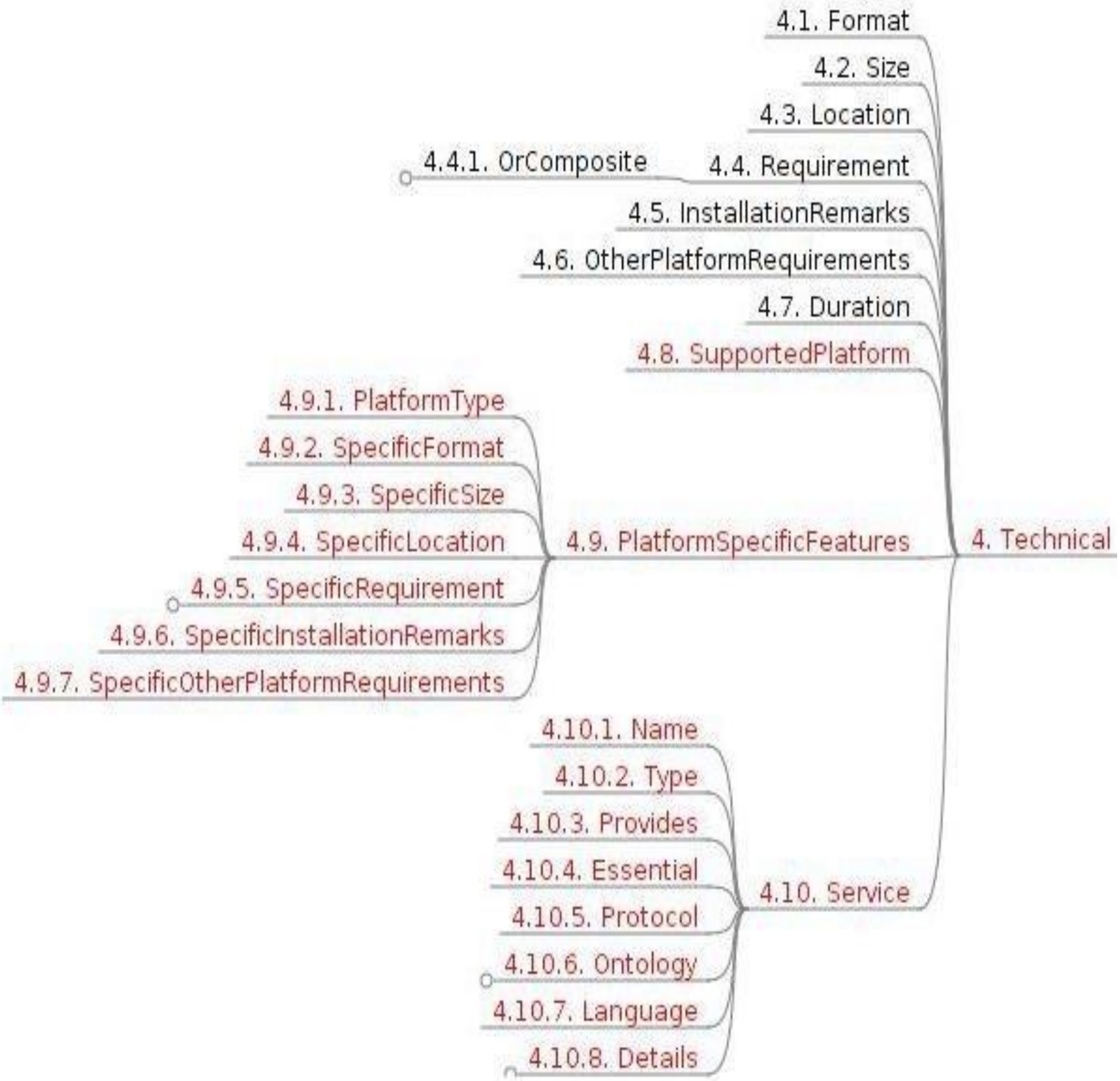


Fig. 6 OBAA Technical metadata.

Below, we describe the elements added:

- Supported Platforms (4.8): specifying the three basic types of digital
- PlatformSpecificFeatures (4.9): defines the technical information about the media applied to each one of the platforms for which the learning object was developed.
- If a platform is informed in the item SupportedPlatforms but there is no respective PlatformSpecificFeatures IEEE LOM Technical category also apply to the platform. For each platform represented by this category, there should also be specific information about its media: format, media size, shape, access, skills needed, installation instructions and software requirements;
- Service (4.10): This set of metadata allows the developer to associate services to a learning object. Here the specification of metadata models

the service access, allowing a flexible definition of the required services, regardless of the technology, with no significant restrictions on how it can be implemented. To do so, the items are specified as name, type, service definition, protocol, ontology, language and details. This definition of the service may be mandatory or optional, seeking the correct execution of the object.

The elements SupportedPlatforms, PlatformSpecificFeatures and Service follow the same definitions and rules of the category 4 of the metadata standard, however, applied to each platform used.

2.1.2.1. Educational Metadata

The Educational category also received an extension, increasing the amount of items it contains. Based on the interactions model, with the premise that the subject knows the world through interaction with objects of knowledge.

The pedagogical model is composed of a pedagogical architecture and a pedagogical and epistemological conception of the teacher. Figure 7 shows educational elements.

Fig. 7 OBAA Educational metadata.

It was created the element LearningContentType to represent this pedagogical model, specifying the content type of the learning object.

This content can be classified as factual, concept related, procedural and attitudinal (Wiley, D. 2009).

The interaction between the learning object and the user concerns the behavior of people in relation to other people and systems. It is assumed that a meaningful learning experience can be provided only if the educational solution was designed as interactive. The metadata Interaction was proposed to define this interaction. It consists of the sensory mechanism used to transmit information; following the interaction between user and object, mechanisms to inform the co-presence of other users in the environment and the type of relationship between users, mechanisms to inform the co-presence of other users in the environment and the type of relationship between users, necessary to the functioning of the learning objects. Reciprocity is a way of related to others in which all have the same opportunities for participating and interacting in the group. It is hoped that this operation can assist students in cooperative and collaborative learning, where, through exchanges, it is possible to learn and teach.

A teaching strategy is defined as a set of actions planned and conducted by the teacher to promote the involvement and commitment of students with a broader set of activities. By specifying the pattern, it is possible to indicate the most appropriate teaching strategy to be adopted in using the learning object, as conceived by the author.

2.1.2.2. Accessibility Metadata

Nowadays the subject accessibility is acquiring an increasing importance. Accessibility is the ability that a learning environment has to adapt itself to the needs of each user/student. It is determined by flexibility of the educational environment (regarding presentation, control methods, access modality, support to students, and availability of contents, alternatives, and equivalent activities). To deal with accessibility issues, it was created a new category, shown in Figure 8.

Fig. 8 OBAA Accessibility metadata

The basic elements of this category come from the IMS AccessForAll (IMS, 2008). The intention here is to store information about student accessibility, defining the settings for users accessing the learning object, allowing the execution of the object to meet requirements such as audio for the blind, hearing-impaired subtitle, language and other important specifications seeking inclusion and access to the LO by people with special needs. In this metadata category it is discrebed the requirements for the utilization of the resources, by means of specifying if the display and control can be modified at runtime and if there is an equivalent alternative.

Besides that, language references for Assessment and Reporting, as defined by W3C (W3C, 2008), were included. They are applied to express and compare tests and results, transformability, control, and flexibility of the resources.

The ability to point to a resource equivalent to the feature described, or parts of it, was captured. In the same item, it is possible to indicate access learning facilities that are or will be contained in the LO, as one or more support tools. Some possible values for this metadata are: dictionary, calculator, notetaking, peerInteraction, abacus, thesaurus, spellChecker, mindMappingSoftware and outlineTool.

For the specification of an alternative visualization, it can be indicated if it will be through audio, alternate text – in the specified language for the primary resource referenced – and description of how colors should be used. Some examples of possible values of this vocabulary are: avoidRed, avoidRedGreen, avoidBlueYellow, avoidOrange, avoidRedBlack, useMaximumContrast and monochrome. It is also possible to define whether the described resource contains graphic and/or visual alternatives for parts of the main text, with an indication of content translated into sign language, or in one of its particular dialects, being faithful to the main contents of the resource. In this case, some examples of possible values are ASL American- British-BSL, Brazilian-BRA, Native-GUA Guarani, Spanish-SPA, French-LSF and Japanese-JSL.

2.1.2.3. Segmentation Metadata

Sometimes it is necessary to logical segment an object, allowing its organization in modules or by subject matter. A segment is a continuous fragment of an object. A particular segment may belong to a single program but can be a member of several groups of segments, characterizing, in this case, a collection of segments that are associated with a particular purpose or due to a common property. Figure 9 presents segmentation elements.

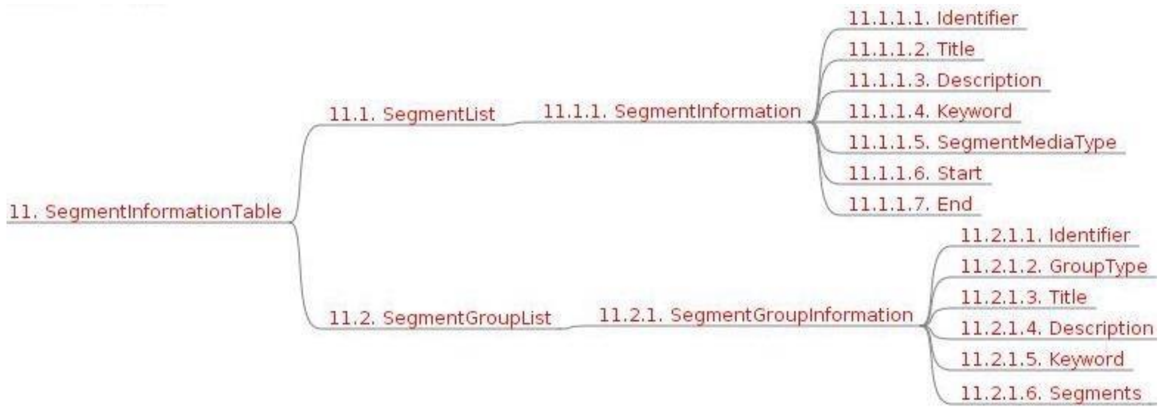


Fig. 9 OBAA Segmentation metadata.

To meet the needs of segmentation, we added to the standard an adapted version of TV-Anytime – European DTV standard. Therefore, to support segmentation of learning object and also groups of segments it was created as a new category called SegmentInformationTable. This category contains identifiers, title, description, keywords, type of segment (text document, hypermedia, multimedia file or other) and indicates the beginning and end of the segment in the learning object. Internally, each segment is defined by metadata and rules specified in the standard.

2.1.3. Syntax and Semantics of Metadata

During the conception of the OBAA proposal, one of our guiding rules was that the standard should lead to technological independence. Our perspective on technological independence is on the broadest possible sense, meaning that our proposal should not depend on any specific technology for set-top-box, nor Web browser, nor mobile platform and even less Web standards such as XML, HTML or RDF. Thus, our specification allows us to formalize its meaning according to state-of-the-art technologies and, most importantly, evolve with the technology. This is the case with our approach to implement the standard semantics under a computational representation.

We could use any language expressive enough, but we choose to implement a prototype with OWL (Web Ontology Language) due to its visibility, broad audience and W3C sponsorship. Besides, OWL also is the most expressive language to represent resources compatible with the semantic web. Another related issue is that, in the next five or ten years, OWL as it is today will not be the state-of-the-art anymore. In this case, as stated earlier and if necessary, we are able to migrate to a new, more expressive language. Of course, such flexibility might lead to several different implementations (concretizations) of the standard, which one should the application developer adopt? Our answer to that is: the one that best fits his requirements and that is formalized as candidate implementation of the standard. Such approach will lead to several different concretizations of the standard, and it is desirable in our case, since it will lead to further adoption of the standard, with the consequent cost of analyzing and approving the candidate implementations.

The approach described in this part of the paper represents the semantics specified in the metadata proposal and in the technical reports that grounded the proposal. This combination was necessary because, in some cases, what a metadata means is not fully described inside a traditional metadata table. Our goal is to achieve a full account of the metadata semantics and also the associations with a systemic view of the learning process (e.g. its connections to community issues).

So far, we developed an OWL-DL representation of the metadata proposal described in Section 2, which is available at: <web link omitted to support blind review>. Usually, each metadata is represented as an OWL Class or directly as an OWL property. For instance, the metadata for technical properties and is declared by the following OWL code:

```
Class(Technical) OWL:
<Declaration>
<Class URI="&obaa;Technical"/>
```

Given an OWL class definition we are able to associate different kinds of knowledge to it, specifying restrictions, relations between domains and specific uses of the metadata. Next, we present the OWL code for the metadata representing a platform's specific information (from the domain of technical metadata). This part of the definition specifies that the technical information associated to a learning resource must be specified as a requirement (which is also a property) and that it must be inside the technical domain. According to this approach, we ensure that the technical requirements specified for the learning objects must follow the axioms specified for the technical domain:

```
hasPlatformTypeSpecificInformation domain Technical OWL:
<ObjectPropertyDomain>
<ObjectProperty
URI="&obaa;hasPlatformTypeSpecificInformation"
/>
<Class URI="&obaa;Technical"/>
</ObjectPropertyDomain>
hasRequirement domain Technical * OWL:
<ObjectPropertyDomain>
<ObjectProperty URI="&obaa;hasRequirement"
/>
<Class URI="&obaa;Technical"/>
</ObjectPropertyDomain>
hasTechnical range Technical OWL:
<ObjectPropertyRange>
<ObjectProperty URI="&obaa;hasTechnical"/>
<Class URI="&obaa;Technical"/>
</ObjectPropertyRange>
```

Our concretization of the standard in OWL-DL allows the specification of learning objects as individuals of OWL ontology. In fact, this approach goes towards a next generation of learning objects. Considering the wide spread of OWL representations in the semantic web, our concretization may be used to describe LO inside any kind of semantic web content. This view can be achieved by importing and associating

OBAA properties to the already defined resources (semantic annotating). Thus, our OWL concretization of the standard can be used as a mid-level ontology to describe learning content, like the GUMO (Heckmann, D. et al., 20010) ontology is applied to describe users. Another important aspect of using this kind of representation is that it does not interfere with domain-specific knowledge and applications. It is simply used as a learning extension to knowledge-based applications.

2.1.4. A Case Study on Interoperable Learning Object

With the goal of testing the standard, we developed a few case studies that verify the practical use of the standard as the grounding for interoperability. Aiming to prove the items described in OBAA fulfill the requirements established, we present here two learning objects used as test bed. In this section, we describe two of our case studies.

The first learning object is a video that explains the origin of TV, including a little of its history. It explains how is the operation of broadcast TV nowadays and also provides the student a broad context of the functioning of this important media. In the original format, this video is in WMV format and 320x240 pixels, in the repository SACCA (Automated System for Cataloging of Audiovisual Content).

Seeking interoperability, the video was converted to the format H.264/AAC LC and encapsulated in a file ".Mp4". This format allows video play in Ginga-NCL Virtual Set Top Box (for Digital-TV) and on the Web. The video was also converted to the encoding H.263/AAC LC, using file format ".3gp" for execution on mobile devices. Therefore, we have a video in two different formats, allowing the contents to be visualized in the tree environments studied (Web, Digital-TV and mobile). Figure 10 shows the video on the three platforms. Note that it can be use in very poor equipment's and, even in smartphone.

Fig. 10 Learning Object, *"Where does the TV come from?"* on the three platforms.

The second object is the learning object "Other Childhoods." This is a learning object, originally developed for the Web. Figure 11 shows the Learning Objects in the three platforms, demonstrating the interoperability of the standard. The original version of this learning object, which allows Web access, is available in http://www.nuted.ufrgs.br/objetos/ei2007/infancias/index.html. For text content it has been used XDHTML and CSS to adjust the images to view, following the recommendations of OBAA.

Fig. 11 Learning Object "Other Childhoods” in the three platforms.

Finally, the pursuit of the technological opening, using platform-independent generated the proposed standard OBAA for LO inter-operable among Web, TV-Digital and mobile devices. This allows adaptation of the existing platforms, as well as flexibility for new technologies.

A standard must be flexible and adaptable, which requires a comprehensive study of the characteristics of each platform. To address the particularities of the three platforms (Web, Digital-TV and mobile devices) - heterogeneous among themselves - in a unique pattern that reconciles, we needed to cope with the requirements and complexities of all of them. In addition, we need to promote such compliance, giving the maximum possible freedom to the developer of educational content, resulted in a broad set of metadata (not always required) and technical recommendations.

With this standard, we hope to allow a wide acceptance of OBAA by the education community and to allow the standard evolution considering the Brazilian education demands. We took into account the existence of a large amount of learning objects already developed in different standards that need to be adapted and/or converted.

One way to facilitate the use of the standard is the definition of metadata profiles (reduced sets of metadata), targeted for developers of educational content. Through the profiles, it is possible to meet different demands for specific niches in the educational community, while maintaining adherence to the standard and reducing its complexity. In the future, the profiles may be used to apply its settings to automatically classify the learning objects according to their degree of interoperability. Thus, it is possible to get an automated classification service, which can be used by authoring tools and content managers.

2.2. Project Goal 2 FEB- Brazilian Educational Federation

This Project describes an innovative retrieval system for LO, a federation of repositories of learning objects. FEB is the retrieval engine of OBAA, Los proposal. By learning object we mean any kind of resource that can be used in an educational context. Many groups in Brazil and in Latin America develop digital LO, but it is hard for a user (e.g., a school teacher) to find relevant material, because the LOs are scattered through multiple separate repositories. There is no single point-of-access. FEB provides a single point-of-access for as many individual repositories as possible, in the form of a web portal with search capability. To accomplish this goal we use a federated architecture, where we have a hierarchical structure of federations of federations (called a confederation). Each federation may have as children other federations or standalone repositories, and each federation is responsible for its own administration, i.e., ensuring LOs quality standard, deciding which repositories to include, specify metadata conversion, etc. This results in a very scalable administration process (see Figure 12). All software interfaces are in Portuguese at this moment. The idea is use part of this budget for translation.

Fig. 12 FEB main screen

One of the basic demands of LO technology is to provide efficient means of cataloging diverse pedagogical resources in a way that allows their reuse, even in different scopes than originally planned. A project that contributes to this goal is the OBAA initiative (learning objects supported by agents) (Vicari et al 2010). Its main purpose consists in establishing and specifying technical and functional requirements for LOs. OBAA provides a comprehensive metadata format and encourages content interoperability among web platforms, mobile devices and Digital TV, therefore supporting easy and widespread accessibility. FEB leverages OBAA technology wherever possible, but is also backwards compatible with other widespread metadata formats such as Dublin Core (DCMI 2012) and LOM (LTSC IEE 2002). To stimulate further adoption of the OBAA standard, we also developed an OBAA repository, which is fully compatible with FEB.

FEB use Artificial Intelligence technics, in particular Natural Lange Processing for search LO using LO's metadata. The base is Google search API. This options permits to FEB be language low depend. So, it works in different user language. Also, FEB internal architecture is a multiagent system composed by, a search engine agent, a database that store the LO's metadata, an autonomous agent (software robot) that seek in all of the repositories for some changes, like an brooked link, a new object, etc., and a management agent in charged of include our exclude repositories. It was developed in JAVA. FEB performance for parallel search is

$$f(x) = \begin{cases} 10{,}49\,x + 142{,}68 & 1 \leq x \leq 8 \\ 27{,}82\,x + 32{,}43 & 9 \leq x \leq 92 \end{cases}$$

Using Intel Xeon E5405 @ 2GHz QuadCore, 4GB de RAM in a net LAN 100 Mbps.

The robot time for actualization for 100.000 LO and 14 repositories can be seeing in Figure 13.

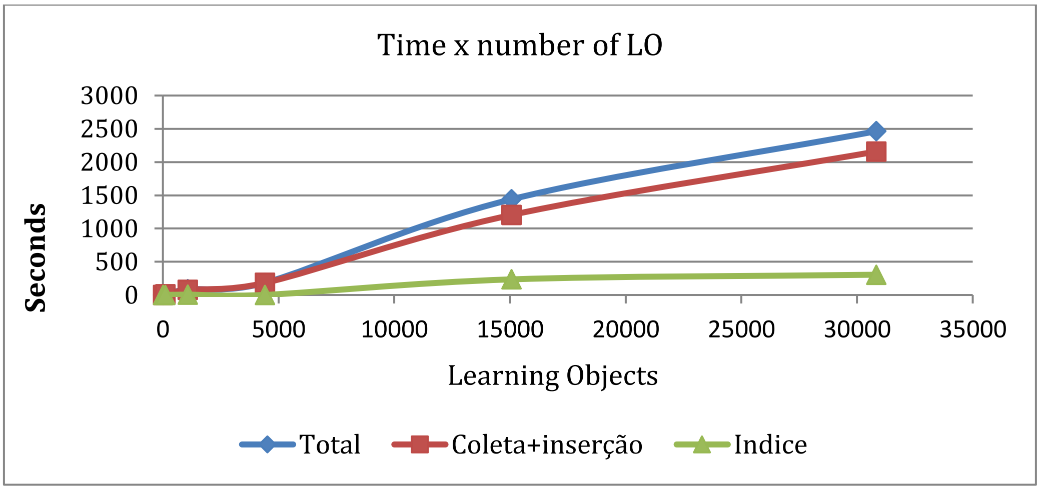


Fig. 13 Time for the federation repositories actualization

2.2.1. The LO Federation

The tree-based structure shown in Figure 14 depicts the overall federates structure envisioned in the project, which consists of several repository federations united by a central node in the top of the hierarchy. This root node is called the confederation. Each one of these federations represents a specific geographical or an institutional region that contains the belonging digital repositories.

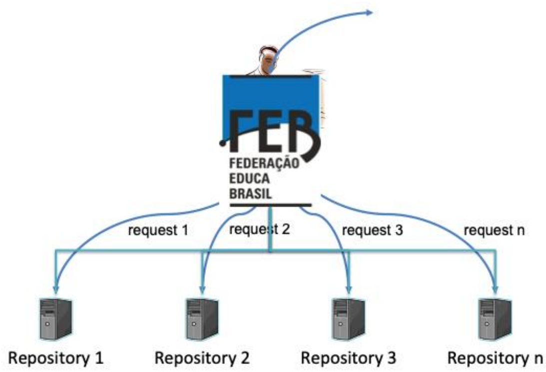


Fig. 14 Federation "Educa Brazil"

Currently there are 14 institutions supporting this project, mostly universities. The federated architecture is quite interesting for the institutions, because it allows them to provide a single point-of-access for their repositories, in their own web site and with corresponding branding. Besides that, being a part of the FEB confederation hosted by RNP

(National Research Net) greatly improves the visibility of LOs created by affiliated institutions. At now, 140.000 compose the LO federation.

FEB allows users to search for documents based on keywords or an advanced search, and allows administrators to perform all necessary functions in a simple web interface. A very important functionality for the administrator is the ability to define *mappings* between metadata formats, as many repositories don't quite follow it's metadata standard to the letter. It also gives an administrator the flexibility of indexing a repository that uses a novel metadata standard without changing source code. A full description of our implementation and architecture can be found in (Rossi et al 2012). FEB also provides many statistics (see Figure 16), such as most often searched terms, relative sizes of repositories, most accessed LOs, etc. Figure 15 presents the management agent.

Fig. 15 Administration Agent Interface

The FEB software is production-quality and is provided free of charge. In order to be a part of the FEB confederation hosted by RNP the interested party should contact us at feb@rnp.br. The system can be tested at the following URL: http://feb.ufrgs.br/feb

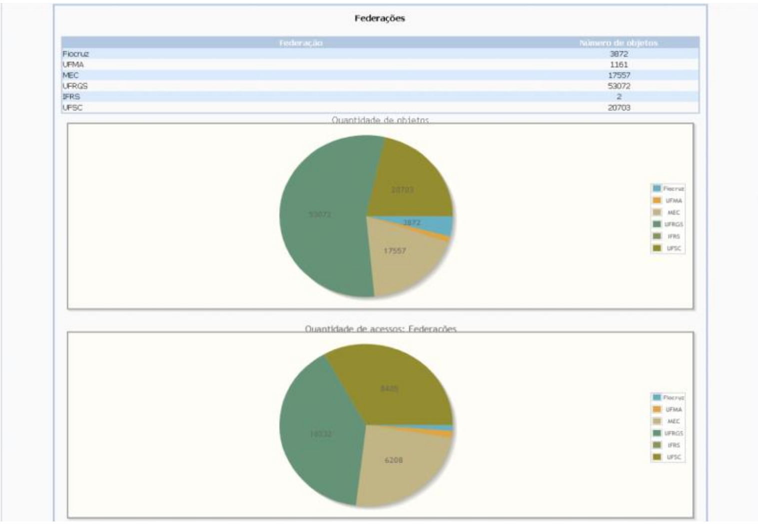


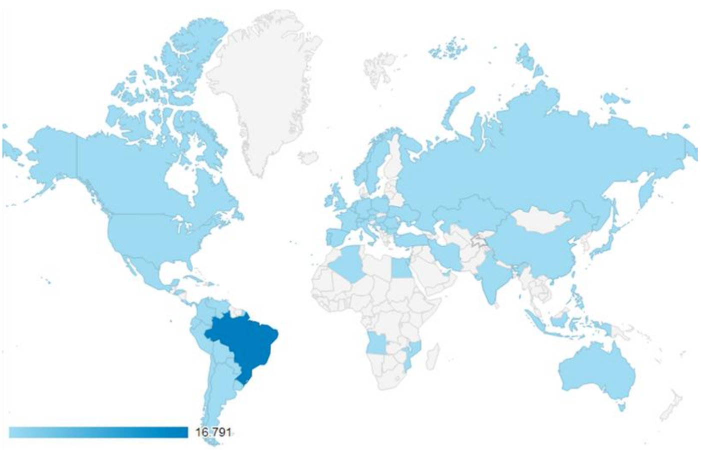
Fig. 16 Statistics View of FEB

The efficiency and precision of any retrieval system for LOs is bounded by the quality and granularity of its metadata. For example, in order to find LOs suitable for teenagers, age-range information has to be available. While FEB does not *require* LO metadata in OBAA format, is does support it fully, and will be able to provide a much improved retrieval experience for LOs with OBAA metadata.

To ease adoption of the OBAA standard by repositories, we created OBAA Repository (Cognix), a LO repository built from the ground up with OBAA metadata in mind. Cognix is the OBAA official repository. It simplifies the process of cataloging LOs with OBAA metadata by inference information wherever possible, providing an intuitive wizard for the process, and providing context sensitive help.

Repository is currently in beta stage and under constant development, but is already deployed in two installations. It will be provided with a free software license in http://www.cognitivabrasil.com.br/repositorio/.

The map presented in Figure 17, shows FEB use in different countries.



Source: Google

Fig. 17 FEB Dissemination

2.3. Project Goal 3 COGNIX – OBAA Repository

Cognix is a new learning object repository with easy installation and material handling. The today market products are extremely bureaucratic, requires a considerable work of cataloging, not focused in the user experience. There are many ways making easy mechanical tasks with some intelligence and helps the user. *Cognix uses AI techniques as pattern recognition to infer metadata from the LO file.*

A digital repository is more than a portal or a way of accessing material. What makes a digital repository much more than a portal is the ability to discover a LO and reuse it. The purpose of a digital repository is not simply to secure storage and distribution, but to share and reuse digital content.

The great advantage of repositories is that they help institutions to develop coherent and coordinated approaches to the capture, identification, storage and retrieval of their intellectual assets. These intellectual assets go beyond normal publishing policies, and may include audiovisual objects, data sets, presentations, learning materials and research papers. Management that addresses these assets increases opportunities for efficient use of existing content, increases opportunities for improving learning experiences and encourages collaboration within and between different groups and disciplines.

Repositories offer a means by which institutions can break the cycle of individual sites of digital content by creating common storage, with access for all. This can guarantee the availability of content to improve the quality of the learning experience and address different learning styles. It can stimulate a culture change in teaching and learning, just as teachers can review the way they teach their courses and focus on how to improve the learning experience.

With the emergence of the Open University of Brazil, the incentive to create and share national educational content has grown, be it videos, texts, maps, infographics, etc. With all the heterogeneity of materials, combined with the large number of existing devices, it is necessary to store and disseminate this knowledge. Certainly, this need is universal and every day there is a demand for new solutions, mainly due to the growing supply of educational content on the WEB.

In order to catalog, store and distribute these education contents, educational repositories arise, which aim at the storage, preservation and dissemination of intellectual production (Costa and Leite 2006) and encompass a set of services that include: management, sharing, preservation, organization, reuse and access of its contents (Lynch 2003 and Duncan 2003).

The most widely used repository today is DSpace, a co-creation of Hewlett Packard (HP) with the Massachusetts Institute of Technology (MIT), which also maintains the rights to Fedora, both an open source initiative and strong worldwide adherence. However, this repository, although robust, is extremely complicated to install, configure, customize and maintain. As it aims to reach a very varied audience, it presents a generic design, from the set of metadata to the variety of interfaces, requiring major customization to satisfy the public in the educational area. Within this context, many institutions (mainly in Brazil) do not have either the human resources or the infrastructure to do so.

In addition, the work required of the author, who in general is a teacher, to register an LO is extremely large, and at times, repetitive. Our experience shows that much of the data that needs to be cataloged, in the repository, could be inferred from the LO file itself, such as, its size or format.

The Cognix is a new repository, focused on providing a satisfaction of use for the user, be it an administrator, a teacher or a consumer of educational resources. For this, Cognix has an easy installation system (at the second click), portability to different operating systems, has an interface for the use of direct objects and, where possible, portability for mobile devices, whether tablets or cell phones.

One of the points of greatest resistance in the adhesion to the existing repositories, on the part of the community that produces educational content, is the difficult work for the contents cataloging. Cognix repository, aims to take this point by changing the way this process is done in existing repositories today. So, the users upload the file at the beginning of the cataloging, and with that, much of the metadata can be automatically inferred by the cataloging service of the repository. Another factor that can make cataloging much easier is the creation of object profiles, for example, the goal is to catalog lesson plans, from mathematics, for elementary school, the target audience for this content is teachers, the format of LOs is text, the theme is mathematics teaching, etc.. This information allows the creation of a common profile to all these LOs and, with that, there will only be a small set of metadata for the user to fill in, which could not be inferred and nor belong to the outlined profile.

In addition, a major problem pointed out in the existing repositories (DSpace and Fedora, which was acquired by DSpace) is the difficulty of controlling versioning, a problem that has persisted since the design of the first repositories (Matkin, 2002). A great success in versioning control is the Git standard, a tool used in distributed version control development, in which it is possible to create forks from a source code, modify it and then create: or a new different version in a new life cycle, or make an update request (pull-request). Much of this concept is applicable to the life cycle of LO, whose main characteristic is its reusability. The inclusion of this type of versioning control in the Cognix repository is useful in controlling versioning of LOs.

Another issue that is sometimes overlooked and that makes cataloging a lot easier is the creation of links for the generation of copyright with, for example, Creative Commons. Most LOs are designed as open source, and this type of link can make it easier to make your declaration at the time of cataloging.

On the other hand, the interface for the consumer of the contents of the repository also needs to be facilitated. The DSpace interface is complicated for users of this type of content (teachers and students, among others). Cognix reduces the number of clicks that the user needs to make, so that he is able to reach the desired LO.

Another Conix advantage is not restrict to metadata standards without hierarchy, the problem is not simply, but that the standards for more advanced LO that exist today, use this feature (such as IMS, OBAA and LOM), and if repositories do not follow these changes in metadata standards, this makes cataloging impossible, which can make it much easier, for example, people with special needs, or even to search for video content. This bet may lead to advances in the area of repositories, in addition to meeting demands, already existing, in the country. Figure 18 presents a Cognix scream.

Fig. 18 Cognix Repository screen

2.3.1. Partnerships

The project was carried out by the Institute of Informatics of the Federal University of Rio Grande do Sul, the research group in Artificial Intelligence, has a strong relationship with the area of educational technologies, working with intelligent tutoring systems, and which was the developer of the project Educa Brazil Federation (FEB), which was sponsored by RNP, and OBAA project which was sponsored by FINEP. The startup Cognitiva Brazil Technologies for Education was developed Cognix, in 2017.

2.4. Project Goal 4 - HERACLITO

Heraclito is an Intelligent Tutor System that is part of OBAA architecture. Heraclito is now in his 3th version.

The complete process involving the student's interaction with the environment and the agents together with the components that are part of the Heraclito environment is shown in Figure 19.

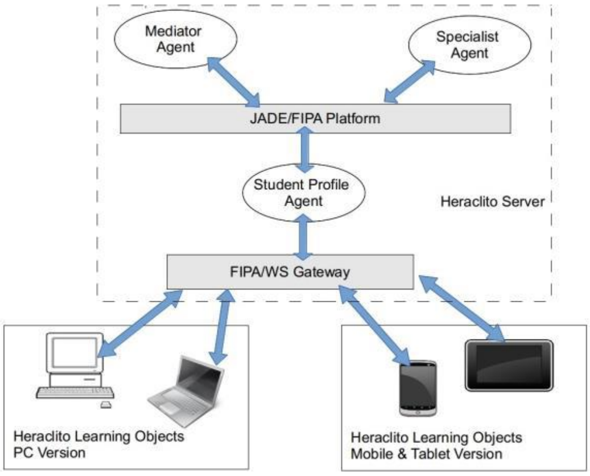


Fig.19 Heraclito environment.

Figure 19 shows all the components that involve the macro process, starting with the user performing an action, going through the 3 agents and returning with the response to the user action. The process begins with the student when interacting with the Heraclito environment through some device (Desktop, Notebook, Smartphone or Tablet). Each user action is informed to the Student Model agent.

Assuming the student is in the middle of a test and tries to apply a rule, the Student Model agent is informed, receiving the student's partial test as well as his/her last action. The information about its action is stored and inserted into the inference mechanism, which updates the student's knowledge. Once this process is completed, the Student Model agent forwards the information that they have to the Agent Mediator, which in turn analyzes their action plans and forwards the message to the Agent Expert. The Specialist receives the student's partial exam and its last step, assesses the status of that action and informs the Mediator about what it has discovered. With all possible information, the Mediator agent decides which learning strategy should be used and forwards the necessary actions to the Student Model.

If, for example, the attempt to apply a student's rule would result in a scenario where it would be impossible to complete the test, the mediator's action would be to inform the student of this situation and suggest to him that he would go back on his decision, undoing the application of the last rule (even if it is correct), since it would be from the behavioral point of view, prejudicial to the resolution of the exercise. Finally, the Student Model agent applies the action plan defined by the Mediator agent. This process repeats itself at each rule applied and is only terminated when the proof (or argument) closes to the end (successfully completing the exercise) or when the student gives up proving the exercise in question, closing the editor or initiating a new proof (the same or another of your choice).

There are several results up to now. The experiments had as target audience, students of the undergraduate courses in Computer Science and Software Engineering of our University. The experiment was carried out in the second semester of 2018, with the curricular component of Logic for Computing, comprising two mixed classes, and totaling 57 students. The experiment was composed of 1 pre-test and 1 post-test, and the application of a form to evaluate questions concerning the teaching environment and its functionalities. The pre-test was applied in the classroom while the post-test was applied in the computer lab. In both cases, the students had 1h and 15min to resolve a list containing 10 exercises. It should be noted that the exercises in the two lists were different, but equivalent, in order to allow a direct comparison between the exercises. Only at the end of the exercises did the students complete the environmental assessment form.

The experiments were started by evaluating the students' perception of the Heraclito environment, considering two main groups: Usability/Interface and Tutoring Service (teaching strategies). The Usability/Interface data are summarized in the following:

- 84% of the students are satisfied with the efficiency that the tool brings, speeding up and facilitating the test;
- 79% of students are generally satisfied with the interface;
- Over 90% are satisfied with the availability of basic rules and derivatives;
- 89% are satisfied with the demonstration format of the tests.

As we can verify, in general, the students were satisfied with the interface and operation of the environment. As for the Tutoring Service the mediator agent intervenes in the process when the student demonstrates that he needs help or trying to take action that will prevent the completion of the test. In addition, some motivational messages, stating how many steps are missing to complete the test (e.g. half the test, missing a few steps) are also forwarded. In this sense, considering generic messages, more than 75% were satisfied with the intervention of the tutor when they were in difficulties or trying to take an action that would prevent the conclusion of the test. However, with respect to the specific messages, according to a particular student profile, 47% and 44% declare themselves satisfied and indifferent, respectively. Some students pointed out that they were following a different flow of evidence from the tutor and, being informed that only X steps to complete the test were missing, they had to review the test from the beginning to be able to continue.

Next, it is sought to evaluate if there are significant differences between the accomplishment of the exercises in paper and the Heraclito environment. It begins by analyzing the data about the issues solved in

Table 1, which shows the number of theorems correctly proved on paper and in the Heraclito environment.

Table 1. Comparison between exercises performed on paper and in the Heráclito environment.

Method	Ex.1	Ex.2	Ex.3	**Ex.4**	**Ex.5**	Ex.6	Ex.7	Ex.8	Ex.9	**Ex.10**	Total
Paper	29	43	40	**8**	**7**	13	16	10	19	**44**	229
Heráclito	43	43	41	**47**	**0**	42	41	41	40	**38**	376
Average	36	43	40,5	**27,5**	**3,5**	27,5	28,5	25,5	29,5	**41**	302,5

It can be seen from Table 1 that the students performed more exercises in the Heraclito environment than on paper. When we observe the absolute quantities, it is possible to verify that only exercises 5 and 10 were more performed on paper. However, although it was more performed on paper, exercise 10 did not present a significant difference compared to the Heraclito environment (MW=1008; p=0.078), differently from exercise 5, where there was a significant difference (p=0.006). In contrast, when analyzing the others, it can be verified that the students performed more often in the Heraclito environment. Only in exercises 2 and 3 there were no significant differences (MW = 1152, p = 0.680 and MW = 1128, p = 0.500, respectively). In the other exercises, p values were 0.001 for exercise 1 and less than 0,000 for the others (exercises 4, 6, 7, 8 and 9), and the Mann-Whitney values were less than 1000.

Table 2, divided by basic rules (10) and derivatives (6), shows the students' perception, the percentage of correct answers and errors in the corresponding applications, and the average probability of the students knowing this rule (calculated by the agent).

Analyzing the logic rules that the students must use to solve a demonstration, it can be observed that 82% of the students pointed to the conjunction rule as being what they believed to be the easiest to use, which corroborates the fact that they have agreed to apply the rule in 86% of the time. In this case, the average calculated probability of the students knowing this rule is 80%. Another important fact is related to the rule Elimination of Disjunction, where few students pointed out facilities and some pointed difficulties, but students applied the rule correctly every time (7 times). Although they have always correctly applied the rule, the probability of students knowing this rule is only 73%, since this rule is associated with other rules, which these students did not demonstrate knowledge throughout the test. The same can be explained for the rule Elimination of Equivalence.

So, considering the derived rules, it can be observed that, unlike the basic rules, the students' perception of the difficulties and difficulties found in the application of derived rules, in some cases, does not corroborate attempts to apply the rules. Considering, for example, the rule Modus Tollens, 100% of the students indicated that it is easy to use the rule, but they miss their application 50% of the time. On the other hand, 56% of the students emphasized ease in using the rule Disjunctive Syllogism, and 79% of the attempts were successfully applied.

In addition, as additional information, it is worth mentioning that the correlation between the facilities and difficulties pointed out by the students and the average probability of knowing the rule is 0.61 and -0.21, considering the basic rules. As for the derived rules, the correlation is 0.56 and -0.12, respectively. It is worth noting that the correlation presented in the basic rules is stronger than the correlations obtained for the derived rules, which can be explained by the teaching domain. All theorems can be proved using only the basic rules of inference, as well as being taught before the derived rules. Nevertheless, when comparing the total applications of the basic rules with respect to the derived rules, we notice a greater number of attempts to apply the basic rules, which allows students to be clearer about the facilities and difficulties they are facing.

3. Objective to Use the Prize Awarded

We are currently involved in 4 objectives, so we intend to apply the value of the prize to achieve some of these targets.

- Divulgation and disseminate all technologies already developed for all countries;
- Change the technology used in the federation of Learning Object repositories (FEB) and in the repository (Congnix) for the use of Ontologies.
- Complete the Heraclito Intelligent Tutor System; incorporating an agent into the already existing nucleus, that generates the solutions through Genetic Algorithms. Heraclito also needs a new interface, which allows the use of pedagogical strategies based on example (learning by Examples). At now, we haven’t the financial support for the Heraclito system development.
- Published new papers.

4. Project Budget and chronogram

Services	Quantity (month)	Unit Cost	Total
Web Designer	4	$ 225.00	$ 900.00
Web Developer for Heráclito	9	$ 190.00	$ 1 710.00
IBM Watson Chatbot developer	9	$ 225.00	$ 2 025.00
Project Manager	12	$ 190.00	$ 2 280.00
		Total	$ 6 915.00
Scientific Divulgation	Quantity	Unit Cost	Total

International Conferences Registration	3	$ 500.00	$ 1 500.00
Air Tickets	3	$ 2 500.00	$ 7 500.00
Accommodation	18	$ 200.00	$ 3 600.00
		Total	$ 12 600.00

Hardware Acquisition	Quantity	Unit Cost	Total
MacBook acquisition	2	$ 2.300,00	$ 4.600,00
Server acquisition	1	$ 885,00	$ 885,00
		Total	$ 5 485.00
		TOTAL	**$ 25 000.00**

Some of the activities can be done in parallel because they are independent and focus on different applications.

Activities for Cognix and FEB	**Period**
Studied of an ontology solution for interoperability among LORs that employ distinguished metadata for LO description	3months – Starting in January 2021
Programing a selected solution	6 months
Enhancing Cognix (Learning Object Repository) with Ontologies	3 months
Testing the Cognix performance	6 months
Activities for Heraclito	**Period**
Studied IBM Watson chatbot interface	2 months
Development of a chatbot dedicate to Heraclito context	6 months
Integration and testing	2 months
Activities for products divulgation	**Period**
Project and development of a specific web site	2 months
Maintain the web site	During the project
Activity	**Period**
Paper publication	During the project

5. References

ABNT-NBR 15602-1. Associação Brasileira de Normas Técnicas. NBR 15602-1. Televisão digital terrestre – Codificação de vídeo, áudio e multiplexação, parte 1: Codificação de vídeo. Rio de Janeiro, April/2008.

Anderson, M., & Anderson, S. L.: Ethical healthcare agents. In M. Sordo, S. Vaidya, & L. C. Jain (Eds.), Advanced computational intelligence paradigms in healthcare-3. 233–257. Springer: Berlin (2008).

Aliman, N. M. and Kester, L.: Requisite variety in ethical utility functions for AI value alignment. In: Workshop on Artificial Intelligence Safety 2019, vol. 2419. CEUR-WS, Macao (2019).

Aliman, N. M., Kester, L., Werkhoven, P.: XR for Augmented Utilitarianism. In: IEEE International Conference on Artificial Intelligence and Virtual Reality 2019, 283 – 285. IEEE, San Diego (2019).

Allen, C., Smit, I, Wallach, W.: Artificial morality: Top-down, bottom-up and hybrid approaches. Ethics and Information Technology, 7(3), 149 – 155 (2005).

Arnold, T., Kasenberg, D., Scheutz, M.: Value alignment or misalignment-what will keep systems accountable?. In: AAAI Workshop on AI, Ethics, and Society 2017, AAAI Press, Palo Alto (2017).

Berners Lee, Tim; Hendler, James; Lassila, Ora. The Semantic Web. Scientific American 2001; 284(5), pg. 35-43.

Bostrom, N. Superintelligence: Paths, dangers, strategies. Oxford University Press: Oxford (2014).

Brundage, M.: Limitations and risks of machine ethics. Journal of Experimental & Theoretical Artificial Intelligence, 26(3), 355–372(2014).

Cervantes, J. A. et al.: Artificial Moral Agents: A Survey of the Current Status. Science and Engineering Ethics 26(2), 501 – 532 (2019).

Costa, A. R., Coelho, H. Interactional Moral Systems: A Model of Social Mechanisms for the Moral Regulation of Exchange Processes in Agent Societies, IEEE Transactions on 2018, vol.18, 60 – 66. ACM, New York (2018).

Cano, D.J., Cano, V., Cervera, M., G.: The Future of MOOCs: Adaptive Learning or Business Model? Revista de Universidad y Sociedad del Conocimiento, 12(1), 64 – 73 (2015).

Costa, Sely Maria de Souza; LEITE, Fernando César Lima. Repositórios institucionais: potencial para maximizar o acesso e o impacto da pesquisa em universidades, 2006. In 1ª Conferência Ibero Americana de Publicações Eletrônicas no Contexto da Comunicação Científica, Brasília, 2006, p.1-10. Universidade de Brasília.

DCMI. Dublin Core Metadata Initiative. Available in: http://dublincore.org/ Access in: 01/05/2010.

DCMI, "DCMI Especifications", http://dublincore.org/specifications/, September, 2012.

DUNCAN, Charles. Digital Repositories: e-Learning for Everyone. Presented at eLearnInternational, Edinburgh 9-12 February 2003.

Heckmann, D., Schwartz, T., Brandher, B., Schmitz, M., Vilamowitz-Moellendorf. Gumo - The General User Model Ontology. In User Modeling, 2005.

IEEE LTSC. Learning Technology Standards Committee. Available in: http://ltsc.ieee.org/wg12/ Access in: 01/05/2010.

IMS. IMS Global Learning Consortium. 2002. Inc. Available in: http://www.imsglobal.org/. Access in: 20/06/2008.

ISO/IEC 15938-5. Information Technology - Multimedia content description interface - Part 5 Multimedia Description Schemes, 2001.

Kim, T. W., Donaldson, T., Hooker, J.: Grounding Value Alignment with Ethical Principles. arXiv preprint (2019).

Giraffa, L, Móra, M., Viccari, R.,: Modelling an interactive ITS using a MAS approach: from design to pedagogical evaluation. In: IEEE Third International

Conference on Computational Intelligence and Multimedia Applications 1999, vol.3. IEEE, New Delhi (1999).

Lynch, C. A. Institutional repositories: essential infraestructure for scholarship in the Digital Age [Énlínea]. (2003). ARL: Bimonthlyreport, 2003, n. 226.

LTSC of the IEEE (2002). “IEEE. Standard for Learning Object Metadata”, http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf, September, 2002.

Matking, Gary. Learning object repositories: Problems and promise. The William and Flora Hewlett Foundation, Menlo Park, Calif. 2002.

MPEG-7. MPEG-7 Overview (ISO/IEC JTC1/SC29/WG11 N6828). 2004. Available in: http://www.chiariglione.org/mpeg/standards/mpeg-7/mpeg-7.htm. Access in: 01/06/2008.

Rossi, L. H. L. ; Nunes, M. F. ; Schreiner, P. ; Vicari, R. M. (2012) . A Federated Retrieval System for Learning Objects. In: International Conference on Internet Technology and Applications, 2012, Wuhan. Proceedings of iTAP 2012,

Silva, Maria da Graça Moreira. Novas Aprendizagens. In: Congresso Internacional de Educação a Distância, São Paulo, 2004. Available in: www.abed.org.br/congresso2004/por/htm/146-TC-D2.htm. Access in: 26/10/2009.

Thornton, S. M., et al.: Incorporating Ethical Considerations Into Automated Vehicle Control. In: IEEE Transactions on Intelligent Transportation Systems 2017, vol. 18, pp. 1429 – 1439. IEEE (2019).

TELECO. Informação em Telecomunicações. 2008. Available in: http://www.teleco.com.br. Access in: 15/10/2008.

TVA. TV-Anytime Forum. S3 metadata (normative) v1.2. TV-Anytime Specification, 2003. Available in: http://www.tv-anytime.org. Acesso em junho de 2008.

Vamplew, P.: Human-aligned artificial intelligence is a multi-objective problem. Ethics and Information Technology 20, pp. 27 – 40 (2018).

Vicari, R. et al. Padrão para Metadados de Objetos de Aprendizagem Multiplataforma. Porto Alegre: UFRGS, 2009.

Vicari, R.M., Gluz, J.C.,Passerino, L.M. Santos, H.R., T. T. Primo, L. H. L. Rossi, A. Bordignon, P. A. Behar, R. C. M. Ferreira Filho, V. Roesler. (2010) “The OBAA Proposal for Learning Objects Supported by Agents”. In: Joint International Workshop on Multi-Agent Systems for Education and Interactive Entertainment MASEIE/AAMAS, 2010, Toronto. Proceedings of Joint International Workshop on Multi-Agent Systems for Education and Interactive Entertainment. p. 43-46.

Wallach, W. Robot minds and human ethics: The need for a comprehensive model of moral decision making. Ethics and Information Technology, 12(3), 243–250 (2010).

W3C. Mobile Web Best Practices 1.0, Basic Guidelines. W3C Recommendation. 2008. Available in: http://www.w3.org/TR/mobile-bp/. Access in: 15/06/2009.

Wiley, D. Connecting learning objects to instructional design theory: a definition, a metaphor, and taxonomy. 2001. Available in: www.reusability.org/read/chapters/wiley.doc. Acess in: 07/08/2009.

6. Global Project Results at Now

This section presents some project results. The results are concerning all de applications developed at this moment.

6.1. Publications Linked this Project

VICARI, R. M. Tendências em inteligência artificial na educação no período de 2017 a 2030. 1. ed. Brasília: Serviço Nacional de Aprendizagem Industrial. Departamento Nacional., 2018. 174p.

VICARI R. M. Inteligência Artificial aplicada à Educação. In: PIMENTEL, Mariano; SAMPAIO, Fábio F.; SANTOS, Edméa O. (Org.). Informática na Educação: técnicas e tecnologias computacionais. 1ed. Porto Alegre: CEIE/SBC, 2018.

MENDES, A. B. ; CASCALHO, J. M. V. R. ; **VICCARI, R. M.** ; COSTA, A. C. M. R. ; ROSSI, L. H. L. ; FARINA, C. ; BOTELHO, A. Z. C. ; CARDOSO, M. I. P. ; NEVES, P. N. . The OBAA Standard for Developing Repositories of Learning Objects: the Case of Ocean Literacy in Azores. REVISTA DE CIÊNCIAS DA COMPUTAÇÃO, v. 14, p. 51-66, 2019.

Behr, A ; PRIMO, T. ; **VICCARI, R. M.** . OBAA-LEME: A Learning Object Metadata Content Editor supported by Application Profiles and Educational Metadata Ontologies. In: CBIE 2014 - Workshop Brasileiro de Web Semântica e Educação, 2014, Dourados. Sexto Workshop Brasileiro de Web Semântica e Educação, 2014. v. 6.

GLUZ, J. C. ; **VICCARI, R. M.** ; VICARI, Rosa Maria ; PASSERINO, L. M. . An OWL Ontology for IEEE-LOM and OBAA Metadata. In: International Conference on Intelligent Tutoring Systems, 2012, Chania/Grecia. Lecture Notes in Computer Science. New York: Springer, 2012. v. 7315. p. 696-698.

Behr, A ; PRIMO, T. ; **Vicari R. M.** . An Ontology for the OBAA Metadata Standard. In: Simpósio Brasileiro de Informática na educação, 2012, Rio de Janeiro. sbie 2012, 2012. v. 1. p. 1-10.

SCHREINER, P. ; ROSSI, L. H. L. ; NUNES, M. F. ; **VICCARI, R. M.** . FEB + OBAA: Cataloging and retrieving Learning Objects effectively. In: Applications to Provide Learning and Teaching Support Workshop, 2012, Rio de Janeiro. Anais dos Workshops do CBIE 2012, 2012. v. 1. p. 1-10.

Gluz, J. C. ; **VICCARI, R. M.** . Uma Ontologia OWL para Metadados IEEELOM, DublinCore e OBAA. In: Simpósio Brasileiro de Informática na Educação, 2011, Aracaju. Anais do ... Simpósio Brasileiro de Informática na Educação, 2011. v. 1. p. 1-10.

VICCARI, R. M.; BEZ, M. R. ; SILVA, J. M. C. ; RIBEIRO, A. M. ; Gluz, J. C. ; SANTOS, É. R. . Proposta de Padrão de Objetos de Aprendizagem Baseados em Agentes (OBAA). In: Latin American Conference on Learning Objects, 2010, São paulo. Latin American Conference on Learning Objects, 2010. v. 5.

VICCARI, R. M.; RIBEIRO, A. M. ; SILVA, Júlia Marques Carvalho da ; SANTOS, É. R. ; PRIMO, T. ; BEZ, M. R. . Brazilian Proposal for Agent-Based Learning Objects Metadata Standard - OBAA. In: International Conference on Metadata and Semantics Research, 2010, Alcalá de Henares. Metadata and Semantics Research Conference - 4th International Conference, MTSR 2010. New York: Springer Berlin Heidelberg, 2010. v. 108. p. 300-311.

VICCARI, R. M.; GLUZ, João Carlos ; PASSERINO, L. M. ; SANTOS, É. R. ; PRIMO, T. ; ROSSI, L. ; BORDIGNON, A. ; BEHAR, P. ; ROESLER, V. . The OBAA Proposal for Learning Objects Supported by Agents.. In: Autonomous Agents and Multi-Agent Systems (AAMAS), 2010, Toronto. Ninth International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS) - Joint International Workshop on Multi-Agent Systems for Education and Interactive Entertainment (MASEIE), 2010. p. 43-46.

GLUZ, J. C. ; **VICCARI, R. M.** . MILOS: Infraestrutura de Agentes para Suporte a Objetos de Aprendizagem OBAA. In: XXI Simpósio Brasileiro de Informática na Educação, 2010, João Pessoa/PB. Anais do ... Simpósio Brasileiro de Informática na Educação, 2010. v. 1. p. 1-10.

Viccari, Rosa Maria; BEZ, M. R. ; SILVA, J. M. C. ; RIBEIRO, A. ; GLUZ, João ; PASSERINO, L. ; SANTOS, E. R. ; Primo, T.T. ; ROSSI, L. H. L. ; BORDIGNON, A. ; BEHAR, P. A. ; FERREIRA FILHO, R. C. M. ; ROESLER, V. . Proposta Brasileira de Metadados para Objetos de Aprendizagem Baseados em Agentes (OBAA). RENOTE. Revista Novas Tecnologias na Educação, 2010 (Revista (Journal)).

BEZ, Marta ; **Viccari, Rosa Maria** ; SILVA, J. M. C. ; RIBEIRO, Alexandre ; Gluz, J. C. ; PASSERINO, Liliana Maria ; SANTOS, Elder ; PRIMO, T. ; ROSSI, Luis ; BEHAR, Patricia ; Filho, R. ; Valter Roesler . Proposta Brasileira de Metadados para Objetos de Aprendizagem Baseados em Agentes (OBAA). RENOTE. Revista Novas Tecnologias na Educação, 2010 (Revista (Journal)).

VICCARI, R. M.; GLUZ, João Carlos . A Proposta OBAA para Padrão Nacional de Metadados de Objetos de Aprendizagem 2009 (course for secondary school teaching).

6.2. Technical Production

VICCARI, R. M.; Gluz, J. C. . OBAA. Standard 2010.

GLUZ, João Carlos ; **VICCARI, R. M.** . A Proposta OBAA para Padrão Nacional de Metadados de Objetos de Aprendizagem. 2009. (Curso de curta duração ministrado/Outra).

VICCARI, R. M.; GLUZ, João Carlos ; SANTOS, Elder Rizzon ; PRIMO, T. T. ; ROSSI, L. H. L. ; BORDIGNON, A. ; PASSERINO, L. M. . Relatório Técnico RT-OBAA-01 Proposta de Padrão para Metadados de Objetos de Aprendizagem Multiplataforma. 2009. (Relatório de pesquisa).

6.3. Conferences

XXX Simpósio Brasileiro de Redes de Computadores e Sistemas Distribuídos e no XII Workshop da RNP.FEB - Federação Educa Brasil. 2012.

6TH Colombian Computing Congress (CCC). OBAA - Padrao brasileiro de Obejetos de Aprendizagem baseado em agentes. 2011.

XXVIII Simposio Brasileiro de redes de Computadores e Sistemas Distribuídos.FEB Federação de repositórios Educa Brasil. 2010.(Simpósio).

Reuniao do Conicet Argentina.Febe - Federacao de Repositorios de Objetos de Aprendizagem. 2009.

Foro Latinoamericano de Ingenieria de Sistemas e Informática - Jornadas Nacionales de Telemática. OBAA project: An approach to interoperable learning objects based on Web and digital television. 2009.

André Rolim Behr. 5.3 OBAA-LEME : um editor de conteúdo de metadados para objetos de aprendizagem a partir de ontologias e perfis de aplicação. 2014. - Universidade Federal do Rio Grande do Sul.

6.4. Under graduation Student’s Scholarship

ADRIANO GUIMARÃES SOARES. WebService para acesso ao repositório OBAA. 2012. Iniciação Científica. (Graduando em Ciência da Computação) - Universidade Federal do Rio Grande do Sul.

Adre Rolim Behr. Projeto OBAA - Desenvolvimento. 2011. Iniciação Científica. (Graduando em Ciência da Computação) - Universidade Federal do Rio Grande do Sul, Conselho Nacional de Desenvolvimento Científico e Tecnológico.

Alexis Colombo Szpakowski. Versionamento das Ontologias do Padrão OBAA. 2010. Iniciação Científica. (Graduando em Ciência da Computação) - Universidade Federal do Rio Grande do Sul, Conselho Nacional de Desenvolvimento Científico e Tecnológico. Orientador: Rosa Maria Vicari.

Marcelo Horst Regina. Estudo de Caso para Validação de Ontologias do Padrão OBAA. 2010. Iniciação Científica. (Graduando em Ciência da Computação) - Universidade Federal do Rio Grande do Sul, Conselho Nacional de Desenvolvimento Científico e Tecnológico.

Gabriel Roleto Cardoso. Projeto OBAA - estudos dos metadados do LOOM. 2008. Iniciação Científica. (Graduando em Ciência da Computação) - Universidade Federal do Rio Grande do Sul, Conselho Nacional de Desenvolvimento Científico e Tecnológico.

Marcelo Horst Regina. Estudo de Caso para Validação de Ontologias do Padrão OBAA. 2008. Iniciação Científica. (Graduando em Ciência da Computação) - Universidade Federal do Rio Grande do Sul.

6.5. Human Resources MSc and PhD

Arlete Ferrão, 2018 - Mozambique

Cecilia Rafael José Tivir, 2017 - Mozambique

Daniel Cabrera, 2016 – Chile

Florêncio Extermo Maulano, 2016 – Mozambique

Luis Rossi, 2015, - Brazil

Julian Moreno Cadavid, 2010 – Colombia

Tiago Primo, 2012 – Brazil

Andre Behar, 2011 - Brazil

Néstor Darío Duque Méndez, 2008 - Colobia

Jovani Alberto Jiménez Builes, 2006 – Colombia