The OBAA Standard for Developing Repositories of Learning Objects: the Case of Ocean Literacy in Azores

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Abstract

This paper describes the existing web resources of learning objects to promote ocean literacy. The several projects and sites are explored, and the shortcomings revealed. The limitations identified include insufficient metadata about registered learning objects and lack of support for intelligent applications. As solution, we promote the seaThings project that relies on a multi-disciplinary approach to promote literacy in the marine environment by implementing a specific Learning Objects repositories (LOR) and a federation of repositories (FED), supported by a OBAA, a versatile and innovative standard that will provide the necessary support for intelligent applications for education purposes, to be used in schools and other educational institutions.

Keywords: Learning objects repository, Ocean literacy, Intelligent applications.

Título: O padrão OBAA no desenvolvimento de repositórios de objetos de aprendizagem: o caso de literacia dos oceanos nos Açores

Resumo: Neste artigo descrevem-se os recursos existentes na Web para promoção da literacia oceânica. São descritos diversos projetos e sites e são realçados pontos fortes e fracos de cada um. Dadas as limitações identificadas, que incluem metadados insuficientes sobre os objetos de aprendizagem registados e falta de suporte para aplicações inteligentes, sugere-se o projeto seaThings como solução. Este projeto apresenta uma perspetiva multidisciplinar para promover a literacia oceânica, implementa um repositório de objetos de aprendizagem e uma federação de repositórios, todos baseados em OBAA, um padrão

versátil e inovador que vai permitir a construção de aplicações inteligentes com fins educacionais, para serem utilizadas em escolas, centros de ciência e outras instituições educacionais.

Palavras-chave: Repositório de objetos de aprendizagem, Literacia oceânica, Aplicações inteligentes.

1. Introduction

Oceans cover 71% of our planet's surface, and are the source of most life on Earth, offering a major contribution to the regulation of weather and climate, driving the water cycle that dominates land and atmosphere, providing most of our oxygen, and feeding much of the human population. Pollution, habitat degradation and overexploitation of natural resources, lead to climate change and ocean acidification and threaten the health of the ocean in unprecedented ways (NMEA, 2013). Considering that the ocean is the defining feature of our planet and that our lives depend on its health, understanding the ocean is essential to understanding and protecting our environment.

Despite the consensus in the need to acknowledge the importance of the ocean in people's life, ocean topics are not clearly included in the current regional/national curricula and only punctually are considered in some projects on the responsibility of more interested teachers. Moreover, better public understanding of the ocean is an important part to acknowledge and guarantee a better and healthier planet as the more people know, the more they are willing to support policies to keep the ocean healthy (Steel *et al*., 2005). So, this knowledge should be provided somehow throughout the public teaching/learning educational process.

Engaging learners in experiences focused on the ocean helps them build personal connections to the ocean, coasts, and motivate them to become ocean literate and to act on behalf of the ocean. By ensuring that ocean sciences concepts are available and more prominent for young education purposes, those who are concerned about science education and about the future health of our ocean planet will actively promote the implementation of high-quality science learning objects related to the ocean. This was intended by several international and national initiatives to promote ocean literacy - the understanding of the ocean's influence on people and the one's influence on the ocean. It is aimed that more and more people would understand the Essential Principles and Fundamental Concepts about the ocean; could communicate about the ocean in a meaningful way; and would be able to make informed and responsible decisions regarding the ocean and its resources.

For leveraging the literacy about marine environment among students and the society in general, first a state of the art panorama is stablished and then we propose the construction of a new repository with sound scientific learning contents on ocean knowledge by providing resources online using Learning Objects Repositories (LORs) and the agent-based learning objects (OBAA) a metadata standard. It will be, also, of major importance

the aggregation of the already existing resources through the implementation of a federation of repositories i.e. a set of repositories accessed using the same search engine. OBAA was developed for with this objective, which is the main difference from other standards.

With learning objects (LOs), digital contents related to the marine environment can be easily accessed, used and new contents can be proposed by teachers & students, researchers and other science promoters. The reusability along the ability to re-create new LOs i.e. to build new ones aggregating new objects with other LOs already present in repository, make them a suitable tool for learning in different learning contexts. Moreover, the use of innovative OBAA standard assures that advanced searching techniques using advanced semantic web technologies will be available. Using Artificial Intelligence, technology tools supporting the search, the creation and the management of LORs will be developed, extending the lifecycle of these repositories.

The following sections will present the state-of-the-art web resources for marine environment literacy and the OBAA standard for LOR are presented as well as the concept of federation. The innovative aspects of this technology are also presented and the impact of using Learning Objects on end-users by means of facilitators like science centers and teachers, using the concept of ontology and multiagent architecture for tools supporting the lifecycle of a LOR and of a federation. Finally, the last section centers on the proposition of the seaThings project for a new LOR and a federation.

2. Web Resources for Ocean Literacy

The ocean literacy framework was developed over seven principles: 1: The Earth has one big ocean with many features, 2: The ocean and life in the ocean shape the features of Earth, 3: The ocean is a major influence on weather and climate, 4: The ocean made the Earth habitable, 5: The ocean supports a great diversity of life and ecosystems, 6: The ocean and humans are inextricably interconnected and, finally, 7: The ocean is largely unexplored. Over these principles the Ocean Literacy project (http://oceanliteracy.wp2.coexploration.org/) constructed in US, organized learning contents according to these principles as well as school levels and respective curricula.

The ocean literacy framework has inspired the Portuguese project “Conhecer o Oceano” (http://www.cienciaviva.pt/oceano/home/). This project aims to stimulate citizen involvement in the themes of the Sea. It produced several learning objects in Portuguese language for all levels of primary and secondary school. Searching for resources in this site shows what are the usual challenges of this kind of resource structures: (1) it is impossible to identify the type of resource e.g. video, presentation, quiz, challenge, experimental activity; (2) there is no connection between users and resources *e.g.* it is impossible to identify who was the last school or institutions that used a specific resource and which resources are connected with other resources; (3) even if a school uses one of these resources there is no authoring system that will allow the school documenting an experience of using that resource or to report the results of an activity.

Other projects inspired by the American program of ocean literacy include the Atlantic Ocean Research Alliance (http://www.atlanticresource.org/) which has as objective to realize the Galway Declaration (2013), signed between the European Union, the United States and Canada, to promote cooperation in ocean scientific research. The area of Ocean Literacy is coordinated by Ciência Viva, understood as the ability to understand the influence of the ocean on our life and the impact of human activity on the ocean. This is a project oriented for meetings and events not for producing learning objects. On the other hand, Sea Change (http://www.seachangeproject.eu/) which involves partners from 9 European countries to change citizens' attitudes and behaviors and how they relate to the ocean, produced several learning objects in English language.

Besides this, the Escola Azul project (http://escolaazul.pt/) is a new project that intends to promote school's involvement on teaching sea related contents. This latter project is coordinated by the Directorate General for Maritime Policy with the participation of Ciência Viva, integrating different public and private schools. It challenges the schools to embrace ocean thematic, developing educational projects related to ocean and to support students' learning on ocean subjects, therefore enhancing ocean literacy of the youngsters. The "Escola Azul" program is being implemented at a national level by the Portuguese Directorate General for Maritime Policy. Some other international platforms disposing some marine based contents are usually in English but only seldom marine contents are available in Portuguese, except for Brazilian sites.

In relation with the marine related contends from the Azores, there are some web-based platforms that provide information about Azorean marine biodiversity e.g. Azores Bioportal (http://www.azoresbioportal.angra.uac.pt/), skaphandrus platform, imageDOP, or the archipelago's natural heritage (http://siaram.azores.gov.pt/). But it is not always easy to find these sites or even to select these resources or find contents adapted for classroom usage or adequately designed for specific teaching levels. Although the initiatives like the ones cited above, there is, still, scarcity and dispersal of the available learning objects in Portuguese language on marine subjects available in the web, not easily find by the usual searching platforms with tools for rich interaction.

The seaThings project builds on the latter projects. For instance, the learning objects should include the subjects identified in the ocean literacy framework, but, two projects are of special relevance: the Recursos Educativos Digitais e Abertos (REDA) platform (http://reda.azores.gov.pt/) and iLIT project (Faria *et al*., 2010) which establish the grounds for the answers of the most relevant questions we believe must be answered, in the context of a pedagogic and didactic perspective, i.e. what are the challenges concerning the active participation of schools, teachers, students and science promoters to foster knowledge using digital resources for one part, and what strategies to adopt to engage students in school and to improve knowledge in ocean literacy, for the other.

The REDA platform is a regional governmental initiative to promote the share of resources to teachers and students. It organizes the resources by area of knowledge for primary to secondary stages. REDA is a repository which supports authoring by registered teachers.

The resources are organized by subjects in context of different areas of knowledge. It provides not only resources but also it keeps information (metadata) about resources stored in other repositories.

Although the REDA platform is a quite recent initiative it already provides insights about main challenges to provide supportive platform with open digital resources. There are technological challenges, such as making available the contents in different hardware equipment's (e.g., desktop computers, laptops, mobile devices), incorporating facilities that target a new perspective to the classroom (e.g. bring your own device initiative - BYOD). There are also sociological challenges, such as the fact that students and teachers are engaged in an old fashioned and outdated model of classroom, where the technology in use is usually restricted and where the creativity are constrained, with the different students' learning necessities forgotten (Conselho Nacional de Educação, 2016, Becker *et al*., 2017).

The project "Between tide marks: integrating literacies" (iLit), shows the importance and need of creating curricular resources that promote students engagement with science classes, and, at the same time, that are easily accessed and appropriated by teachers (teacher's ownership), according to their interests and needs, and so easily implemented in the classroom (Faria *et al*., 2011, Faria *et al*., 2015, Jesus-Leibovitz *et al*., 2017, Boaventura *et al*., 2013, Boaventura *et al*., 2016). The activities supported assumed an investigative nature, involving very diverse strategies such as experimental work, problem solving, discussion and decision-making, promoted not only the acquisition of scientific knowledge through the exploration of real data, in particular on adaptation, biodiversity, climate change and its effects on the oceans, but also the development of complex skills such as reasoning, decision making capacity, and inter-relationship skills of cooperation, perseverance and autonomy. (Faria *et al*., 2015).

3. The Need for LOs and the OBAA Standard

3.1. The impact of LOs in learning contexts

In general, the LOs are considered beneficial tools for learning and some authors defend them as scaffolding resources to understand concepts (Li & McCormick, 2005). The results about preferences indicate that organizing, structuring, and guiding processes of the course are crucial. Kay and Knaack (2007) pointed out that students may benefit from LOs "if they are comfortable with LOs offering good learning control, useful content, and clear instructions" (Raspopovic, 2016).

In a more general view, the impact of Information & Communication Technologies (ICTs) in education is usually discussed without considering the role of teachers training activities. Moreover, the concept of training doesn't consider the fact that in schools and other educational institutions (e.g. science centers) the professionals of education act as in a "community of practice" (Wenger, 1998) where the collaborative self-learning is central in their activity. Niza (1997a and b) and also Arends (2008) and Nóvoa (2009) argue that a shift in the learning paradigm must be supported precisely by the practice of a self-training

collaborative work among teachers. This self-training activity is usually achieved by sharing practical activities in workshops and in other meetings where pedagogical strategies, the contents as well as the materials, are presented and discussed based on the teaching experiences. As an extension to this practice Niza (2015) used the concept of "isomorphism" to justify the importance of a collaborative environment in the classes to foster the learning at classroom, where opened communication channels promote the sharing of ideas at school and within the community and the embracing of creative activities promote the use of ICTs to search, to learn and to communicate. So, these authors, when referencing to the use of digital tools in a classroom, are in tune with the perspective of project-based learning activities which supports students' cantered activities and the exploitation of multidisciplinary problems contexts usually in connection to their local communities.

Additionally, the necessity to promote teacher training in a student's cantered practice implies the preparation of materials and the reorganization of contents to support these interactions. The LOs in the context of LORs have these features i.e. to introduce materials of different types, to provide the opportunity to challenge teachers to promote activities in classes that implies the use of documents usually multidisciplinary and in connection to local problems and to provide the opportunity to build new materials and to add them into the repository.

3.2. Learning Objects and the OBAA Standard

One of the much-cited definition of a Learning Object was introduced by the Learning Technology Standards Committee (2002). This committee was committed by the Institute of Electrical and Electronics Engineers to define a new standard for the Learning Objects, named IEEE Standard 1484.12.1. In this standard they opt for a minimal definition of a Learning Object as any entity, digital or non-digital, that may be used for learning, education or training. But this definition is complemented by the following key features: reusability – a single learning object may be used in multiple contexts for multiple purposes; self-contained – each learning object can be taken independently; aggregation – learning objects can be grouped into larger collections of content, including traditional course structures; tagged with metadata – every learning object has descriptive information allowing it to be easily found by a search (Vicari *et al*., 2010).

The principal feature of a LOs is its reusability. The reusability of a LO is supported by its modularity i.e. the self-contained degree of a singular object, its interoperability i.e. its capacity to be used in different technological platforms such as tablets, laptops or smartphones and finally its retrieving ability i.e. to be easily found by search based on its properties and functionalities (Vicari *et al*., 2010).

The learning object metadata consists in a specification describing the educational content in terms of technical and pedagogical aspects. Widely used metadata standards were created with the IEEE-LOM, IEEE 1484.12 Learning Object Metadata, the IMS-LOM, and the Dublin Core (DC). IEEE LOM is usually considered to be a complete model, representing the set of metadata organized in nine categories. Notice that the fields in the

metadata are usually optional, "so that in practice application profiles are used to specify which elements and vocabularies are relevant for particular communities of practice" (Freire & Fernández-Manjón, 2016). One important step for a LOR is precisely to specify profiles concerning data to be added to repository.

Based on IEEE LOM standard, the OBAA (OBjetos de Aprendizagem baseados em Agentes) standard was proposed in (Vicari *et al*., 2009) extending metadata but still compliant with the IEEE-LOM standard (see Figure 1). The main reasons for that extension on metadata were to add support for multiple platforms devices (such as digital TV and mobile devices platform) enabling construction of interoperable learning objects; to include new fields to the educational that promotes the collaborative experience of using LOs; to add accessibility, covering most requirements for the use of different devices for citizens with special needs; and, finally, to add segmentation information table, making possible to index segments of a learning object by subjects, highlights or activities (Behr, 2014).

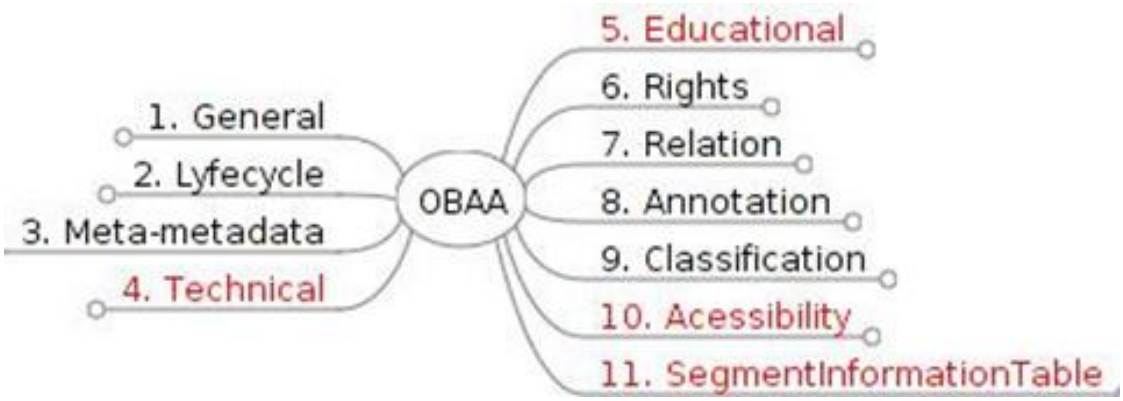

Figure 1. OBAA extending LOM metadata. In red new categories or extension of previously accepted categories in LOM (Vicari *et al*., 2009).

OBAA was designed using OWL ontological language allowing the description of the metadata, not to be dependent of a specific technology. Moreover, OBAA has been created as supportive to agents' technology, meaning that the types of services to support the life-cycle of OBAA compatible LO, including localization, authoring, use, management, content adaptation, and conversion for different devices, can be used within this technology (Vicari, 2010). The different tools that supports the use and implementation of LORs are very important to the lifecycle of a repository. The table 1 depict different types of tools and presents a small description of each one.

Table 1. Tools that support the implementation and the use of a repository.

Type of tool	**Description**
Localization / Search	A tool that allows a user of a LOR to find a specific LO or a set of LOs. To support the search, it uses the metadata information. The profile defined with the creation of LO is critical for the type of the search. The user interface must be adapted to the user *e.g.* a teacher or a student.
Authoring	Tools used to add LOs to a LOR. The profile will define the fields in the metadata that must be included in each LO that is added to a LOR. Moreover, when considering specific themes related to a knowledge area, an ontological description should help to provide accurate information in the content field. These tools must be adapted to the user.
Management	Management is a task for the providers of the LOR. Usually a team that is responsible for the repository uses appropriate tools.
Content adaptation and conversion to different devices	For metadata like in OBAA, it is possible to identify not only the devices but the type of accessibility. The tools that perform these adaptations are useful for an automatic procedure.

As we could see in section 2 there are a large number of Learning Objects repositories. Some of them, like the ones used in the Portuguese Universities, are implemented using DSPACE software, which uses Dublin Core (DC) metadata standard. Other repositories are Ariadne in European Union using IEEE-LOM, Edna in Australia, using DC standard, MERLOT which has a specific standard and, finally, Cognix in Brazil using OBAA. Some of these are only metadata search interfaces, meaning that they don't have LOs but point to the LOs at different LORs. Others include LOs.

There is still another concept related to LORs which is the federation (FED). A FED gather a set of LORs from different repositories not all with the same standard. The concept is quite related to what is happens with MERLOT, in the sense that in a federation we don't have any LOs but only the metadata of the LOs belonging to the LORs that are part of the FED. If the FED uses an open standard like IEEE-LOM or OBAA, then it is possible to incorporate a large set of LORs based on these open standards. Otherwise to belong to a FED which has a closed standard, the LOs must follow the metadata features related to that standard, like in MERLOT and users usually pay for getting certain services (e.g. advanced search task). OBAA standard is an open standard, meaning that its replication can be made under the rules of Free Software Foundation, and it already proved its worth. At this moment OBAA supports de CAPES – (a Brazilian agency to support the educational effort, at https://educapes.capes.gov.br/) LO federation including 200.400 LOs.

3.3. Ontologies in the authoring and searching tools

Ontologies can be considered as the support for the web semantic, with the use of an expressive and formal language (OWL) for the concepts that can be interpreted by computers (Sandoval & Guilherme, 2014). The concepts are no longer just worlds in a document but connections with a meaning which can be used by software agents.
They enable the organization of materials around small pieces of semantically enriched LOs. These pieces can be organized into customized learning courses on demand by the users (Raspopovic, 2016).

Ontologies can be referred to the content-domain which solve to problems related to semantically identical concepts expressed in different keywords, to the content structure, defining a LO structure providing to an agent the explanation about the elements of a LO and facilitates the reuse of part of it and, finally, to the context, which specify the role of a content unit. Based on ontologies, several new services can be provided such as the automation of the selection of LOs for specific learning needs, the management of the LO metadata and the support to automatic authoring using multiagent architectures (Gluz & Xavier, 2011; Barcelos *et al*., 201; Gluz & Vicari, 2010).

A general multiagent architecture proposed by Sandoval and Guilherme (2014) entails the different dimensions of a complete design where agents, autonomous software entities, perform a complete set of tasks to support the management and the supply of LOs for the users. The agents interact to each other to perform a management of the LORs / FEDs. Other authors have been suggesting other approaches where the management of LOs covering searching over repositories and different approaches of recommendation systems use multiagent systems architectures (Azambuja *et al*., 2015).

The outreach of AI tools in a context of learning sharing LOs and using open standards is described in Coelho and Primo (2017) where it is presented an ecosystem for Digital Education with different tools using Artificial Intelligence techniques that automatizes the search and selection of LOs, making recommendations to teachers and students pertain certain topic to be discussed in class. Two important features sustain this proposal, the activity in the class, is measured by using data from performance of the students when selecting LOs along the process of learning activity; and the Artificial Tools recognize the difficulties and the patterns of activity and suggest LOs by using repositories of Learning Objects used by teacher and students. Naturally, the “challenges to accomplish such ecosystem reside in open architectures, metadata standards, communication protocols and policies regarding data privacy and security of students and teachers” (Coelho & Primo,2017).

The OBAA standard provides metadata and other essential resources for the tools enumerated in Table 2.

Table2. Different features in OBAA related to Educational container (Vicari *et al*., 2009).

Name	Description	Type of data
Educational	Describe the educational features of the LO	Container
Learning Content Type	Specify type of educational content	Fact, Concept, Procedure, Attitudinal values and norms
Interaction	Specify the type of interaction	Need for one user or more users for the LO.
Perception	Type of perception used	Visual, auditory, mix
Synchronization	Define the type of interaction	True if synchronized, false is asynchronous.
Co-Presence	Use of tools to identify others in the environment	True if there is co-presence tools; false otherwise.
Reciprocity	Type of relationship between the users when applying this LO	1 to 1, 1 to N or N to N
Didactic Strategy	Type of actions planned and proposed by teacher to foster the participation of the students.	Model construction, challenge, hypothesis and test development, case study, question & answering, problem solving.

Recent initiatives in Europe have been working to the integration of repositories, using semantic web technology. Examples of these initiatives are the European (https://www.europeana.eu/portal/pt), a repository for art and literature (with an interface in Portuguese), the open-air (https://www.openaire.eu/) initiative that congregates the different repositories from universities in Europe (related to scientific production) and, finally, coar-repositories, an active confederation of repositories (https://www.coar-repositories.org/).

4. Conclusion and discussion

The importance of the marine environment for the Azores economy is obvious, as a major part of the local economy from primary sector to the tourism sector is based in marine activities. This importance of the blue economy is expected to grow continuously in a near future with new activities in consequence of the extension of the Portuguese continental shelf.

In this article we present the current state of web resources for sea literacy, the need for more literacy and the usefulness of learning objects in this subject, the OBAA standard and the use of ontologies for developing intelligent applications.

This work was developed on the context of the definition of a project, the seaThings project, that intends to provide the contents to fill the identified gaps by a design thinking approach that will meet the end-users needs and desires in a viable technologically based platform. The aim of seaThings project is to promote oceans literacy, supported by scientific basis, providing educational resources using Learning Objects Repositories (LORs) technology to arouse curiosity and increase the knowledge that will allow the

development of more informed, more responsible and more participative citizens, by raising awareness on the importance of the oceans and to develop tools for searching, authoring and management of these repositories.

To achieve this goal, this project uses cutting-edge technology of LORs, providing a federation of repositories related to the ocean literacy, creating a repository of marine environment with the contribution of local specialists, schools and other learning institutions connected to the project and congregating different resources from previous initiatives or active related projects. The two main concerns related to LORs implementation success e.g. the adequacy and visibility of contents and its lifecycle, are tackled by providing artificial intelligence tools such as intelligent search engines, authoring tools and adapted interfaces and the active participation of the schools and science promoter institutions along the project.

In Table 3 the SWOT analysis for seaThing is presented. Although, many projects have been developed in the context of general literacy or ocean literacy, but the seaThings project brings new concepts and new technologies to this field.

Table3. SWOT analysis for seaThings

Strengths	**Weaknesses**
- multi-disciplinary team, with competencies in the three areas involved in literacy: marine biology, education sciences and technologies; - collaboration with the end users (teachers and research centers) since the beginning of the project; - two full time researchers to be contracted; - server integrated in the data center of Azores University, which is responsible for all maintenance.	- big project, with some ambitious objectives; - time consuming operationalization of different collaboration meetings and management activities; - challenging new open source technologies with the need for many programming hours; - publishing fees not included in the project; we must apply to financing programs for that; - the project is dependent on bring in teachers to achieve some of the objectives.
Opportunities	**Threats**
- use of new technologies and standards now accessible; - collaboration with other ongoing projects like "Escola Azul" and REDA - Participation of science centers from Azores; - Interest on the federation from other countries; - The use of artificial intelligence and ontologies	- contracting PhD researchers in informatics can be hard, in Europe. - difficulties on visa permits for the researchers from outside Europe implying a late start of the project; - the abundance of repositories can lead to LORs be deposit in other platforms and not in seaThings.

The project defines priority of areas concerning marine environment and ocean based on the following criteria: Belonging to ocean / marine core thematic areas: biodiversity, ecology, underwater heritage, geology, oceanography; existence of particular

characteristics of the marine environment of the Azores; inexistence or scarceness of online information, on the subject, adapted to the current educational programmatic contents and to different educational levels. These directives are major guidelines but the specific subjects to include in objects and tools to be developed will be discussed inside the group of professors of several levels that will work together within the project.

To maintain a repository as an active source of knowledge is necessary to provide an engagement of the actors in learning institutions, considering their feedback in the management of LOs and LORs. To maintain this interest, a set of intelligent tools will be developed for: (1) helping the authoring process for seaThings LOR; (2) Recommendation for a better literacy on the oceans at FED seaThings repository: Based on previous research and use, the seaThings will create a recommendation system to help registered users to cover different topics for a complete understanding of the different dimensions of the ocean literacy; (3) On-time analysis of used LOs will provide data about the use of the federation search engine and about the use of the LOs as well as the number of new LOs to be added to the repository. This work will be integrated in a federation aggregating different repositories using a variety of standards and located in different geographies, with a common interface and search engine, which will potentialize the use of the LOs as well as the number of new LOs to be added to the repository.

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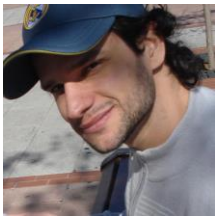

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