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A TECHNOLOGICAL INFRASTRUCTURE TO CREATE, PUBLISH AND RECOMMEND ACCESSIBLE OPEN EDUCATIONAL RESOURCES

INFRAESTRUTURA TECNOLÓGICA PARA CRIAR, PUBLICAR E RECOMENDAR RECURSOS EDUCATIVOS ABERTOS ACESSIVEIS

INFRAESTRUCTURA TECNOLOGICA PARA CREAR, PUBLICAR Y RECOMENDAR RECURSOS EDUCATIVOS ABIERTOS ACCESIBLES

Silvia Margarita Baldiris Navarro[1], Cecilia Avila[2], Joao Sarraipa[3], Silvana Aciar[4], Ramon Fabregat[5], Elsa Marcelino-Jesus[6], Jorge Bacca[7], Ricardo Jardim-Gonçalves[8, 9]

[1] PhD in technology. Direction of Research, Innovation and Social Projection, Fundación Universitaria Tecnológico Comfenalco, Cartagena, Colombia. Professor, Universidad Internacional de la Rioja, Spain, Colombia. E-mail: sbaldiris@tecnologicocomfenalco.edu.co and silvia.baldiris@unir.net.

[2] MSc in informatics and PhD candidate in Technology. Institute of Informatics and Applications (IIiA), University of Girona, Girona, Spain. E-mail: cecilia.avila@udg.edu.

[3] PhD in industrial information systems. UNINOVA, DEE, FCT, Universidade NOVA de Lisboa, Lisboa, Portugal. E-mail: jfss@uninova.pt.

[4] PhD in information technology. Universidad Nacional de San Juan. San Juan, Argentina. E-mail: silvanav.aciar@gmail.com.

[5] PhD in information technology. Institute of Informatics and Applications (IIiA), University of Girona, Girona, Spain. E-mail: ramon.fabregat@udg.edu.

[6] MSc in Economy and PhD candidate in Electrical and Computer Engineering. UNINOVA, DEE, FCT, Universidade NOVA de Lisboa, Lisboa, Portugal. E-mail: ej@uninova.pt.

[7] PhD in technology. Institute of Informatics and Applications (IIiA), University of Girona, Girona, Spain. E-mail: jorge.bacca@udg.edu.

[8] PhD in industrial information systems. UNINOVA, DEE, FCT, Universidade NOVA de Lisboa, Lisboa, Portugal. E-mail: rg@uninova.pt.

[9] Endereço de contato dos autores (por correio): Av. de la Paz, 137, 26006 Logroño, La Rioja, Espanha.

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ABSTRACT

Open Educational Resources (OERs) should provide equal access for all people, independent of their particular needs or preferences. If an OER that does not comply with web accessibility guidelines, it will hardly address the diversity of students' learning needs. From a pedagogical and technological perspective various solutions have been proposed in an attempt to reduce inequality in educational settings. This article presents a technological infrastructure designed for supporting teachers in the creation, publishing and recovering of accessible OERs. The infrastructure was validated in the context of a training course offered to teachers from Latin America and results are promising.

KEYWORDS: Open educational resources; diversity; web accessibility; technological infrastructure; teachers.

RESUMO

Os recursos educacionais abertos (OERs) devem proporcionar acesso igual para todas as pessoas, independentemente de suas necessidades ou preferências particulares. Se um OER que não cumpra as diretrizes de acessibilidade da web, dificilmente abordará a diversidade das necessidades de aprendizagem dos alunos. Do ponto de vista pedagógico e tecnológico, diversas soluções foram propostas na tentativa de reduzir a desigualdade em contextos educacionais. Este artigo apresenta uma infra-estrutura tecnológica projetada para apoiar os professores na criação, publicação e recuperação de OERs acessíveis. A infra-estrutura foi validada no contexto de um curso de treinamento oferecido a professores da América Latina e os resultados são promissores.

PALAVRAS-CHAVE: Recursos educacionais abertos; diversidade; acessibilidade web; Infraestrutura tecnológica; professores.

RESUMEN

Los Recursos Educativos Abiertos (REA) deben proveer un acceso equitativo para todas las personas, independiente de sus necesidades o preferencias

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particulares. Si un REA no cumple con lineamientos de accesibilidad web, difícilmente atenderá la diversidad de necesidades de aprendizaje de los estudiantes. Desde una perspectiva pedagógica y tecnológica varias soluciones se han propuesto como iniciativas para reducir la inequidad en contextos educativos. Este artículo presenta una infraestructura tecnológica diseñada para dar soporte a los profesores en la creación, publicación y búsqueda de REA accesibles. La infraestructura fue validada en el contexto de un curso de formación para profesores de Latino América y los resultados son prometedores.

PALABRAS CLAVE: Recursos educativos abiertos; diversidad; accesibilidad web; infraestructura tecnológica; profesores.

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1. Introduction

The growth of Open Educational Resources (OERs) in the past years has demonstrated that there is great potential for learning processes. Existing research recognizes the critical role played by OERs (ANDERSON, 2013; KINSHUK; JESSE, 2013; MUÑOZ ARTEAGA et al., 2015; WILEY, BLISS, 2014). Moreover, OERs demand on their adopters a lot of time and effort to create and adopt them. Teachers as the main adopters of OERs should provide their students with mechanisms that create scaffolds for the achievement of learning goals. However, one of the biggest challenges teachers face is tackling the diversity present in all educational systems. Particularly in learning processes, diversity is related to aspects such as students' profiles, personal needs and preferences, learning styles, learning difficulties, and contextual settings, among others.

One way to address the diversity of students' learning needs is to provide accessible OERs. Accessibility, and web accessibility in particular, aims to provide equal access for all people to digital contents (W3C, 2005). Web accessibility appeared as a concept aiming to avoid content access barriers. Due to the fact that the majority of OERs are published online, their contents should always comply with accessibility standards (e.g. Web Content Accessibility Guidelines – WCAG 2.0). However, platforms and authoring tools used to create OERs need to be adapted to support the creation of accessible OERs.

On the other hand, the creation of OERs involves the participation of different actors working collaboratively. Thus, these actors have to apply strategies for sharing their ideas with others and complement their work by

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discussing with experts or other stakeholders. The Communities of Practice (CoP) concept can be adopted to support teachers and other stakeholders in the learning process that are willing to share information and experiences. CoP provides people with the opportunity to grew up at personal and professional level (LAVE; WENGER, 1991).

Another aspect to consider in the creation of accessible OERs is related to the way of retrieving the OERs. In this sense, the Learning Objects Repositories (LORs) seem to be one of the best options to publish and find OERs. Each LOR can have its own mechanisms to label resources and those labels or metadata information can make it easier to find educational resources. However, one of the main challenges for LORs is to provide users with better and customized options to retrieve and access OERs.

All the above mentioned challenges in the creation of accessible OERs led us to pose the following question:

- *How to support the creation of accessible open educational resources?*

To answer this question, this study presents a technological infrastructure able to support teachers in the creation, delivering, publishing and characterizing accessible OERs. This infrastructure was developed and implemented under the ALTER-NATIVA project ("Alter-Nativa Project", 2013) and consists of four parts: a LMS and an authoring tool to create OERs, a Repository to publish, label, deliver and recommend accessible OERs, a collaborative platform for the CoPs of the project, and a knowledge base to manage the information from users and OERs. The knowledge base comprises the knowledge areas (math, science, language) included as part of the ALTER-NATIVA project and information related to supporting tools, user profile, accessible OERs, and technologies.

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The Technology Assessment approach was used to validate the technological infrastructure. It included training sessions about the creation of accessible OERs with the use of the applications and services provided by the infrastructure. To conduct this validation we defined the following question:

- *How do teachers perceive the ALTER-NATIVA technological infrastructure?*

In this regard, a total of 61 teachers and pre-service teachers from different Latin American countries participated in the training sessions and in the activities related to the validation of the technological infrastructure. Results from the validation showed a positive perception of teachers and pre-service teachers regarding the technological infrastructure.

In summary, this article provides a description of the applications and services developed, adapted and implemented to create the ALTER-NATIVA technological infrastructure and it also shows the perceptions of teachers in terms of the level importance and satisfaction after using the technological infrastructure.

Section 2 covers the theoretical background and some related works. Section 3 provides an overview of the technological infrastructure describing all applications and services developed, adapted and implemented. Section 4 describes the steps followed to validate the technological infrastructure by applying the Technology Assessment approach. The results and discussion of the study are provided in section 5. Finally, conclusions and future work are presented in section 6.

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2. Background and related work

Different initiatives have advocated the development of tools and frameworks for providing teachers with more robust technological solutions to create educational contents that address the diversity of students' learning needs. Educational contents can be represented with different levels of granularity (WILEY, 2000): as single digital resources (images, videos, etc.), learning units or complete courses. Educational resources are also known as Open Educational Resources (OERs). Moreover, that concern of providing students with more accessible OERs has led research towards solutions that tackle not only issues related to web accessibility but also personalization and recommendations.

The web accessibility emerged from the need of providing people with disabilities with better access to digital contents (W3C, 2005). However, people face a wide variety of barriers every day regardless of whether or not they have any disability. Thus, new conceptual and technological solutions have been developed and almost all these solutions have been built on top of standards such as the Web Content Accessibility Guidelines (WCAG) 2.0 (W3C, 2008). In the educational context, different efforts have been focused on the creation of digital educational contents and technological solutions that meet accessibility requirements to avoid content access barriers which might hinder the learning process.

Early examples of research into web accessibility in educational contexts include the improvement of educational contents for students who have cognitive and learning disabilities (ANDERSEN; ROWLAND, 2007), web accessibility evaluations in educational portals (THOMPSON; BURGSTAHLER; COMDEN, 2003), and training people (including academic staff) on web

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accessibility (AMADO-SALVATIERRA; HERNANDEZ; HILERA, 2014; BENAVÍDEZ et al., 2006; KATSANOS et al., 2012), among others. Kelly et al. (2009) propose a framework for web adaptability that consists in going beyond web accessibility standards and considering other factors surrounding the web accessibility such as audience, use, resources, definition, innovation and policies.

Up to now, a number of international projects have also contributed to the educational field with the development of tools that support the compliance of accessibility standards. For instance, the AEGIS Project (AEGIS, 2013) aims to identify user needs and interaction models developing open source tools; the Fluid project (IDRC, 2014) provides different tools to make web environments more adaptable and personalized to the needs of the end users; the CLOUD4ALL project (CLOUD4ALL, 2014) focuses on the personalization and improvement of the web accessibility in products and services. Moreover, other research projects focus on giving teachers and other stakeholders supporting tools for the creation of OERs. For instance, the e-Access2Learn project (SAMPSON; ZERVAS, 2008) provides tools and services for the development and sharing of accessible eTraining resources, activities and courses that bare the potential to be inter-exchanged between eTraining platforms and programmes. Another example is the EU4ALL project (BOTICARIO et al., 2012), which promotes the development of inclusive learning systems by providing accessible services that address the personal needs and preferences for all people.

On the other hand, recent studies have been particularly interested in bringing the gap between web accessibility and OERs. For instance, MULWA et al. (2016) present a Web-based enhanced government learning platform which aims to provide the government administrators with the possibility to

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collaborate, search, learn and find other existing online OERs. Navarrete & Luján-Mora (2017) introduce a OERs' website which implements user experience functionalities that enhance its web accessibility. RODRÍGUEZ et al. (2017) present a framework for improving the web accessibility and usability of open courseware sites including the use of standards for the measurement of web accessibility and usability requirements.

All in all, these studies foster the need of providing supporting tools for the creation of accessible OERs which make students' learning experiences more bearable. Thus, although the creation of more accessible and personalized educational contents is a big challenge for teachers, initiatives such as the aforementioned provide different supporting tools for teachers in order to facilitate them the task of transforming and customizing the educational contents. This view is supported by TREVIRANUS and ROBERTS (2008) who state that:

"To a busy educator within a strained educational system, the idea of personalizing the learning environment for every individual may sound at worst, ridiculous and at best, Utopian; however, with the appropriate technical supports, personalization is feasible. The online system when designed correctly has the capacity to transform and customize educational content" (p. 789).

In summary, our study contributes to previous research on the development of technology-driven solutions to support the creation of accessible OERs by providing teachers with an integrated infrastructure that includes tools for the creation, publication and recommendation of accessible OERs. Furthermore, interactions among teachers are supported by a platform built based upon the CoPs approach. An additional contribution of this infrastructure is the intelligent support given by a knowledge base aimed to

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represent all the metadata needed for describing and characterizing the users, tools, and accessible OERs as well as to support the delivering of recommendations for the end-users according to their user profile.

3. Description of the technological infrastructure

The design, development and implementation of the ALTER-NATIVA technological infrastructure contributed to answer our first research question: *How to support the creation of accessible open educational resources?*

3.1. Overview of the technological infrastructure

The target group of ALTER-NATIVA project were teachers and pre-service teachers working in different educational levels. Thus, in this project the technological infrastructure was conceived considering that teachers are neither experts in web accessibility nor in the creation of accessible OERs, and that they are not always very familiar with publishing their contents in public repositories. However, teachers can provide useful information to facilitate the retrieval and recommendation of OERs according to the characteristics of the OERs and the end users. Thus, the ALTER-NATIVA technological infrastructure was designed to be easy to use for teachers and other stakeholders, with an intelligent support to represent the knowledge base of the project, with collaborative support for the interaction in CoPs, and with accessible tools and contents.

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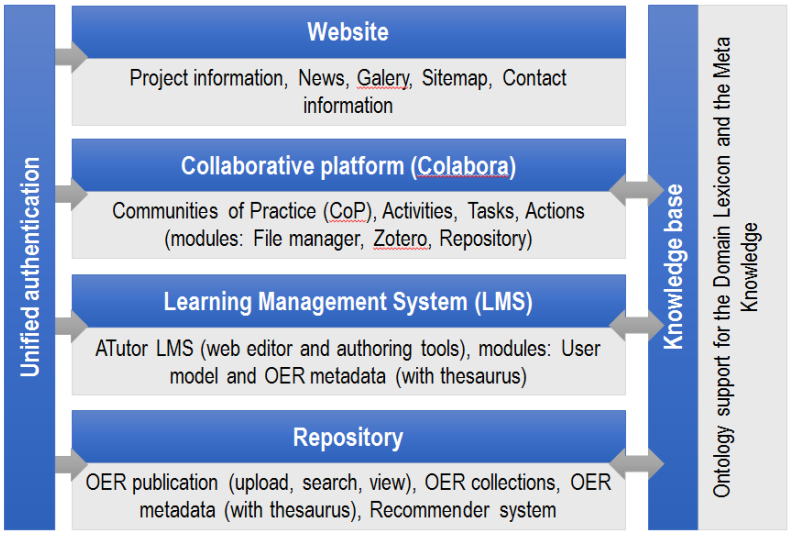

Figure 1: General architecture of the ALTER-NATIVA technological infrastructure

The technological infrastructure (depicted in Figure 1) includes a Unified authentication mechanism to access all applications using the same login information which is available through the Website of the ALTER-NATIVA project. The other applications and services developed to create, publish and retrieve accessible OERs are described as follows:

- Collaborative platform (Colabora): Colabora was developed as a virtual space for managing the Communities of Practice (CoPs) and the interaction of teachers working collaboratively in topics related to the diversity in educational contexts for the creation of accessible OERs. Colabora has three main components: Activities, Tasks and Actions. A group of Tasks defines an Activity and each Task consists of different Actions. Main Actions in Colabora are the File Manager module to upload files, the Zotero module to manage bibliographic information, and the

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Repository module to allow the searching of OERs with a connection to the Repository of the infrastructure.

- Learning Management System (LMS): the ATutor LMS was the platform selected for the creation of OERs. In ATutor teachers can create their OERs in the form of virtual courses by using the web editor of this LMS (TinyMCE) and its plugins as the authoring tools. New plugins and functionalities were added to the Web editor in order to provide a better support for the creation of accessible OERs. In addition, some styles were integrated into the TinyMCE web editor to improve the visual appearance in the contents of the OERs. Moreover, some modules were developed and integrated into the ATutor LMS. The User model module is based on the user model defined for characterizing the diversity profile of all end users (teachers and students). The OER metadata module allows teachers to provide essential characteristics of each OER in order to facilitate the searching and retrieval of OERs, this module also includes a connection to the thesaurus of the Knowledge base of the project.
- Repository: it is based on the Fedora Commons digital content repository and the Islandora framework as the front-end. Resources in the Repository are organized into three main OER collections: mathematics, science and language. Teachers can store small resources or complete OERs in the OER collections. Teachers can also create or upload the OER metadata of each OER. Moreover, the repository includes a recommender system, which takes advantage of the information provided by the Knowledge base.
- Knowledge Base: the Knowledge base of the technological infrastructure [REF-AUTHOR3] aims to represent the ALTER-NATIVA community

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knowledge in order to facilitate the development of services for specific educational recommendation commitments. Information in the Knowledge base is represented using an ontology, which has the metadata necessary to represent various elements (e.g. OERs, user profile, supporting tools, etc.).

Next subsections explain more details of each component of the ALTER-NATIVA technological infrastructure.

3.2. Creation of Accessible OERs

Some additional plugins and functionalities were developed and integrated into the TinyMCE web editor of the ATutor LMS with the aim of facilitating the creation of accessible OERs as a way to support the attention to the diversity of students' learning needs. The new functionalities developed for the TinyMCE web editor are described as follows:

- Plugin for dictionaries in indigenous languages: this plugin provides access to bilingual dictionaries of some indigenous languages with a translation into Spanish. The module allows teachers to use two dictionaries of Quechua language, one dictionary of Miskito and dictionaries of Mixteco and Zapoteco. This plugin is described in more detail in (REF-AUTHOR2)
- Plugin for grammatical number and gender agreement validation in Spanish language: this plugin was called Multilingual-Tiny [REF-AUTHOR2] This plugin aims to provide support in terms of grammatical number and gender agreement validation when indigenous teachers write sentences in Spanish.

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- Plugin for adapted content: this plugin takes advantage of the ATutor LMS mechanism for adapted content so that teachers can add content alternatives for images, videos and audio recordings. Thus, if a teacher includes a video with audio, the teacher can define a sign language video as a content alternative for the video so that deaf people can have access to the information of the video. The main improvement in this regard was the possibility to add alternatives in sign language for each country.
- Plugin for defining the language of parts in the text: teachers can write texts in different languages but the TinyMCE web editor does not provide a mechanism to properly define the language of parts of the text. The plugin developed allows teachers to define the language of parts of the text in their OERs. The benefit of this plugin is that assistive technologies can render the text or present the content to the user taking into account the changes to the language of the contents.
- Plugin for web content accessibility: with the aim of facilitating the automatic accessibility evaluation, a plugin called WCAP (Web Content Accessibility Plugin) [REF-AUTHOR 1] was developed and integrated into the TinyMCE web editor. This plugin supports teachers in the automatic accessibility checking process by using the API of the AChecker tool which provides a report with the possible failures or warnings about the web accessibility of the contents in the OER. This tool works with the WCAG 2.0 guidelines.
- Plugin for searching, retrieving and including learning resources from the Repository: this plugin allows searching contents such as videos, images, audio recordings or documents which can be integrated into the web editor. Teachers can search by the keywords contained in the OER

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metadata or by words that match part of the title or the description of the OER. This module was developed as a client of a REST (Representational State Transfer) web service. This web service is offered by the Repository of the technological infrastructure, and the result is received in XML. After that, the list of resources is shown so that teachers can select the new contents to include in their OERs.

3.3. Management of Accessible OERs

The Repository of the ALTER-NATIVA technological infrastructure was implemented with the purpose of storing OERs created by teachers in the ATutor LMS and other resources such as images, videos and audio recordings. The Repository has the following characteristics:

- Content organization: OERs and other resources in the Repository can be organized within OER collections.
- Metadata: the Repository uses the IEEE LOM (Learning Object Metadata) standard to store the OERs' metadata. Since the LOM schema does not provide metadata for accessibility, the AccessForAll IMS metadata (IEEE, 2009) specification was used together with LOM. AccessForAll IMS metadata schema tries to solve the shortcomings of accessibility defining metadata structures to indicate the characteristics related to the accessibility of the OERs.
- Objects retrieval: OERs can be retrieved from the Repository by using the automatic recommendations provided in the Repository according to the user's profile, using the search engine of the Repository or accessing the collections available in the Repository.

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- Recommender system: the recommendation algorithm in the Repository uses as input the user's profile and uses recommender methods such as demographic filtering, content-based filtering and collaborative filtering (BOBADILLA et al., 2013).

3.4. Intelligent support: User model and Knowledge base

The intelligent support of the ALTER-NATIVA technological infrastructure is based on the representation of the users' information in a User Model and a Knowledge base.

3.4.1. User model to support recommendations

Brusilovsky & Millán introduced the term user model, "a user model is a representation of information about an individual user that is essential for an adaptive system to provide the adaptation effect, i.e., to behave differently for different users" (2007, p. 3). The user model in ALTER-NATIVA Project was not created with the purpose of labelling people, but with the purpose of supporting the generation of recommendations to users. The methodology used to define the ALTER-NATIVA user model was as follows:

- Each ALTER-NATIVA CoP selected some members to be part of a multi-disciplinary team led by the technological CoP.
- Meetings were defined during 6 months to define the categories of the model. The categories proposed were also discussed during the weekly meetings by the team.
- A first version of the user model was sent to all CoPs so that they could send comments and recommendations about the categories.

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- The model was refined considering comments and suggestions received and then a new version of the user model was generated. This process was repeated until a final version of the model released.

Figure 2 presents the structural vision of the user model defined in the ALTER-NATIVA project which was divided in the following profiles:

- General profile: with the basic information about the user that permits unmistakably identifying the user within the joint components of the infrastructure.
- ALTER-NATIVA profile: with the user's information that differentiate the ALTER-NATIVA teacher from other actors participating in other projects (Figure 3). This profile is related to the information of teachers according to the areas of the project (language, science and mathematics).
- Accessibility profile: with the specifications of the technological accessibility profile that are related to the definition of user traits according to the type of diversity that the ALTER-NATIVA project aimed to address (Figure 4). It defines user characteristics related to three types of conditions: sensorial, linguistic and socio-economic.
- Preferences of access profile: with the information model defined by the PnP (Personal Needs and Preferences) section standard (ISO/IEC, 2006).

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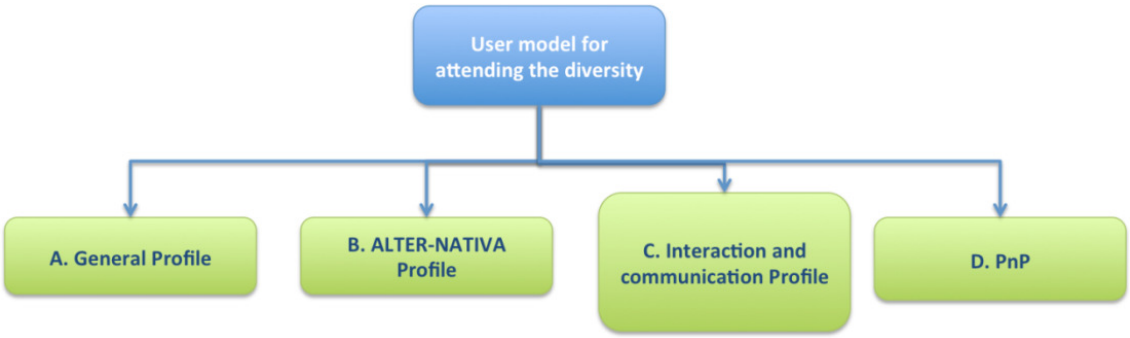

Figure 2: ALTER-NATIVA user model for attending the diversity

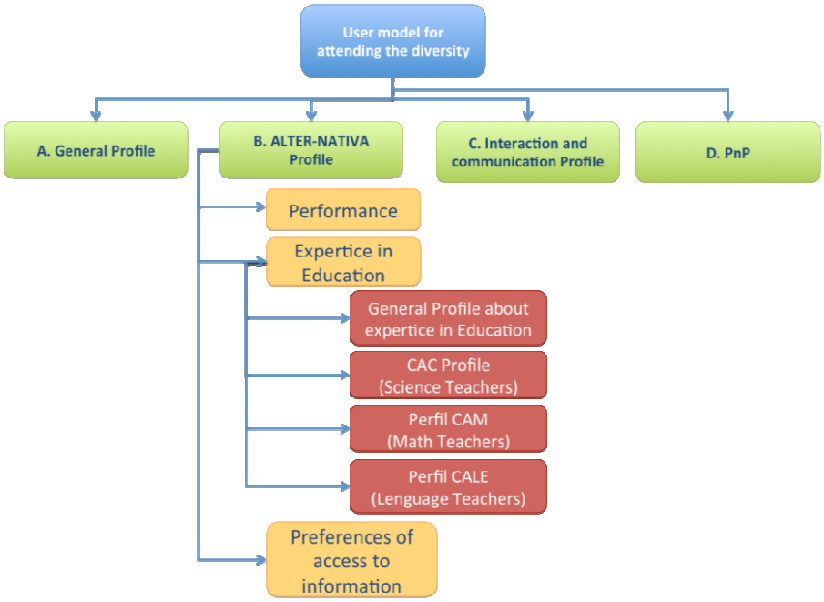

Figure 3: Detail of the ALTER-NATIVA profile

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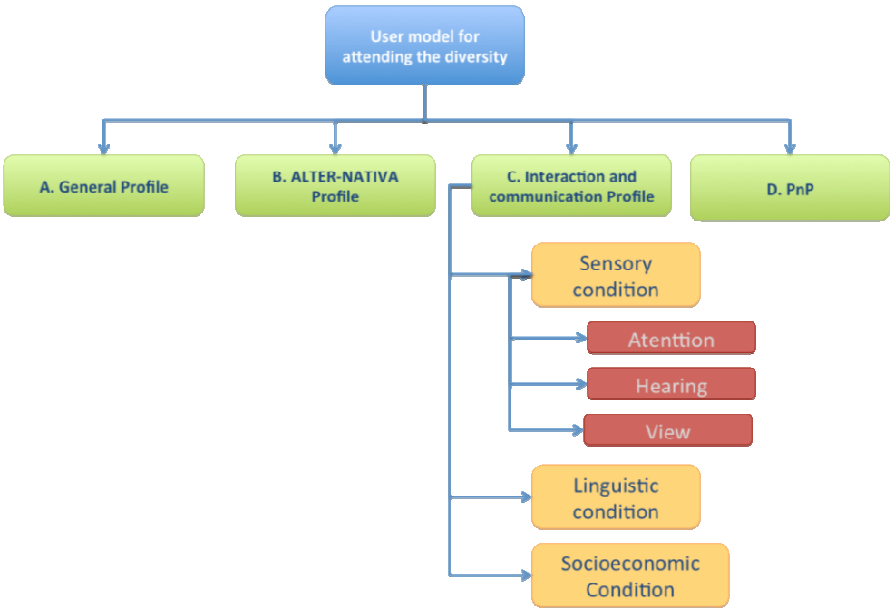

Figure 4: Detail of the ALTER-NATIVA profile for accessibility

3.4.2. Knowledge base to support OER Recommendations

The ALTER-NATIVA knowledge base has two main components: the ALTER-NATIVA's "Domain Lexicon" and the "Meta Knowledge". These represent respectively the domain and the structure ontology as categorized by DICHEVA; SERGEY SOSNOVSKY; BRUSILOVSKY (2005).

The "Domain Lexicon", represents the lexicon of ALTER-NATIVA. It includes concepts from the addressed teaching areas, namely Languages, Mathematics, and Science. It also encloses concepts that are specific to pedagogics & teaching processes and that are related to e-learning supporting tools. This lexicon is represented in a set of thesaurus and general categories as illustrated in Figure 5.

The "Meta Knowledge" encloses six main classes: "Performance"; "Support tools"; "User profile"; "OERs"; "ALTER-NATIVA technologies"; and "Users". The "Users" class instantiates other classes to represent the users'

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profile including their interactions among the technological infrastructure (e.g. OER consulted). Through such recorded interactions, recommendations can be generated and represented in the "ALTER-NATIVA technologies" class. This class also represents the various OERs using both DRD (Digital Resource Description) and the LOM standards. Thus "ALTER-NATIVA technologies" class includes attributes such as: type of object, author, owner, terms of distribution, format or pedagogical attributes. It is from these metadata elements that concepts from the thesaurus are instantiated, also to characterize the OERs. This same class also includes a "Preferences" section, which encloses information about what and how users want to access the information.

The "User profile" class represents "General"; "Accessibility" and "ALTER-NATIVA" profiles. The "General profile" class represents some generic information of a user as his/her study degrees or belonging communities. The "Accessibility profile" class encompasses information related to the disabilities of the user (e.g. visual; hearing; physical; cognitive). The "ALTER-NATIVA profile" class comprises the information about the teaching profiles. The "Support Tools" class represents the tools able to be used in the learning executions and their characteristics. And, the "Performance" class represents the user's performance in interactions using the Colabora platform in different collaborations for the creation of OERs.

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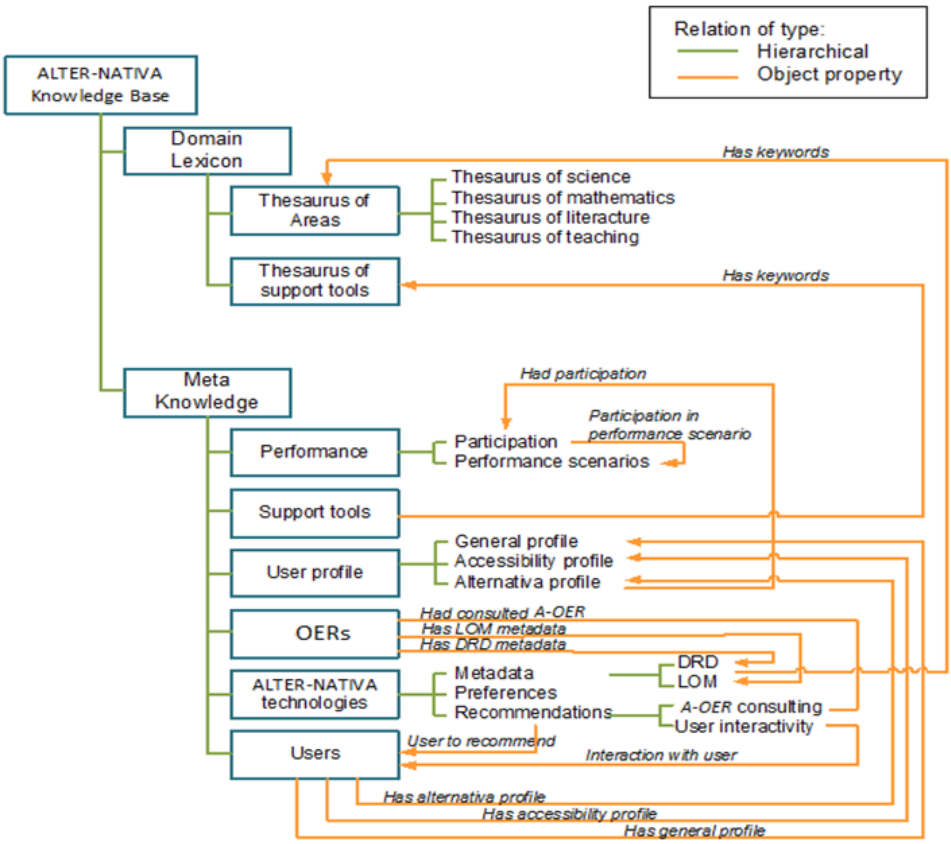

Figure 5: An excerpt of the ALTER-NATIVA KB [REF-AUTHOR3]

The Knowledge base developed in ALTER-NATIVA supports the recommender system included in the Repository to recommend OERs to users according their user profile. The recommendation function chooses the most appropriate item by calculating the number of similarities to the set of chosen target characteristics. The function calculates the strength of each item with a potential to be recommended by collecting the identifiers of all the OERs consulted by a user.

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4. Evaluation

To answer the second research question ("How do teachers perceive the ALTER-NATIVA's technological infrastructure?") a technology assessment procedure to validate the technological infrastructure was defined. This section describes the base framework of the technology assessment procedure, the sample and the instruments applied on the validation process.

4.1. Validation Framework

A validation process means that an object is acceptable for its intended use because it meets specified performance requirements (RYKIEL JR, 1996). In this regard, two types of validation can be defined: the empirical and the scientific. Empiric is the knowledge acquired throughout life, day by day and that is not based on any scientific evidence. The empirical validation relies on lived experiences and the observation of things. The scientific validation follows a scientific method, which establishes a set of methods and techniques that organize the acquired information through experience or introspection (PÉREZ; MERINO, 2009).

The evaluation of the ALTER-NATIVA technological infrastructure is based on the Methodology for Research Projects Viability Assessment and Analysis (MARCELINO-JESUS et al., 2016). This methodology (Figure 6) intends to be a guide in a formal and scientific assessment and validation of the implementation results of any research project. It is composed by the technical and conceptual validity. The conceptual validity encloses three steps: Study of Variants, Business Analysis and Decision. It should provide an acceptable scientifically explanation of the cause and effect relationship included in the model (RYKIEL JR, 1996).The technical validity implies that a concrete research

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result or object exists as conceptually defined and according to the requirements identified. It is also defined as the extent to which an assessment accurately measures (HURST, 2016) the level of accomplishment of a result or object. The steps are: the implementation step represents the phase of the project idea or solution development, and the Technology Assessment step which represents the evaluation of such results. If a positive evaluation score is reached, then the project progresses to the exploration stage that encloses a periodic maintenance control. If a non-validity result is got in one of such controls then the project either ends, or advances to an ex-post evaluation for a new reformulation of the idea. A technical validity of the project results means that such results are apt to be in the exploration mode.

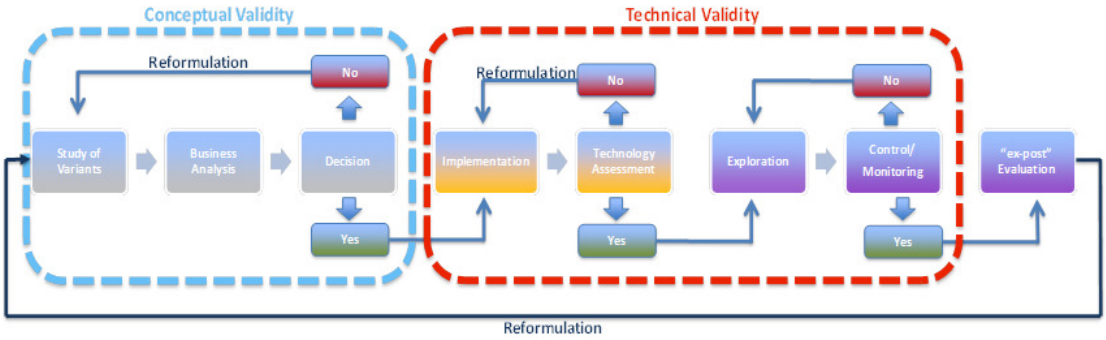

Figure 6: Methodology for Research Projects Viability Assessment and Analysis

Considering the technical validity, following subsections present the procedure, analysis and sample considered to evaluate the ALTER-NATIVA technological infrastructure.

4.2. Technology assessment procedure

The process of assessing the technological infrastructure of the ALTER-NATIVA comprehensively consisted of the following activities:

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- Defining the scenario for assessing the technological infrastructure. In this case it was a virtual course about the creation of accessible OERs.
- Preparing the instruments used to comprehensively assess the technological infrastructure.
- Defining the countries which participated in the course and sending the invitation to teachers, taking into account the technical requirements and the time needed to complete the course.
- Creating the course into the ATutor LMS and carrying out the registration of all participants with an instructor account.
- Delivering the course in each of the established countries including the application of the assessment instruments.
- Processing the data gathered about the assessment of the technological infrastructure in order to carry out the gap analysis.
- Writing the reports with regard to the assessment of the ALTER-NATIVA technological infrastructure.

4.3. Technology assessment analysis

The evaluation of the ALTER-NATIVA technological infrastructure focuses on a descriptive analysis by defining a series of variables that had to be measured and described. The analysis of the perceptions about the technological infrastructure in ALTER-NATIVA is based on the well- known theory of Gap Models proposed by Parasuraman, Zeithaml, & Berry (1985). The main aim is to gather the perception of teachers with regard to the main services offered by the technological infrastructure: creation of accessible OERs and the management of accessible OERs. The categories analysed were:

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- Correction: this means the solution developed meets all the initial requirements.
- Easy to use: this means teachers are able to use the solution in an easy and quick manner.
- Accessibility: this means all people can perceive, operated and understand the functionalities of the solution developed.

Main aspects to be analysed in the validation of the components of the technological infrastructure are:

- Attention to diversity
- Creation of accessible OERs
- Management of accessible OERs
- Recommender system
- Support to collaboration

4.4. Sample

Participants in this study included 61 teachers and pre-service teachers from Colombia, Nicaragua, Argentina, Germany, Bolivia, Chile, Cuba and Ecuador participating in the ALTER-NATIVA project and who also participated in the assessment of the ALTER-NATIVA technological infrastructure. Figure 7 shows a distribution of the sample by country. Participants from Colombia, Chile, Ecuador, Cuba and Germany belonged to the committee of the CLAVEMAT European project.

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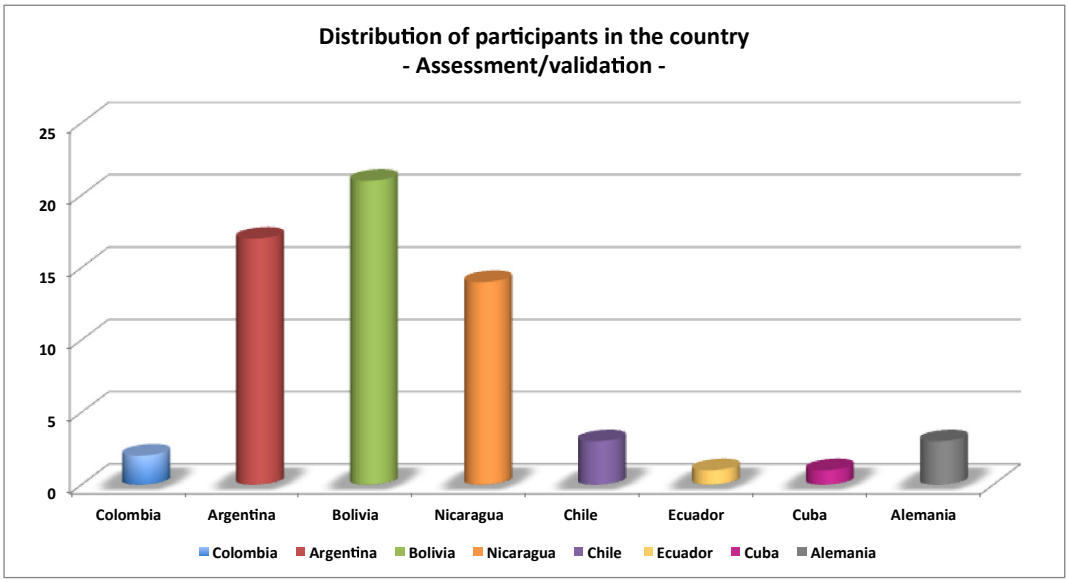

Figure 7: Distribution of participants in the country

4.5. Validation scenario "Course for Creating Accessible Open Educational Resources"

The scenario of validation for the technological infrastructure was a training course about the "Creation Accessible OERs". Its goal was to offer conceptual bases regarding the methodology and the tools to create accessible OERs by using the applications and services provided by the technological infrastructure. The course lasted five weeks including face-to-face sessions of three hours per week. The course was offered through the ATutor LMS, including weekly sessions supported by a video-conference tool. Activities in the course involved theoretical sessions, practical workshops sessions and individual tasks. Moreover, course contents were created considering orientation guides, supporting video tutorials, and the participation of experts in the creation of accessible OERs. Specific individual activities and conceptual bases in the course included:

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- A planning proposal for the creation of the accessible OER during the course.
- A didactical proposal for the creation of the accessible OER during the course.
- Selection of the learning contents to be included in the accessible OER.
- Checking the web accessibility of the OERs during its creation.
- Adoption of good practices in the development of the accessible web contents.
- Evaluation of the web accessibility of the OERs.
- Publishing the accessible OER in the Repository.
- Presenting to the other partners the final OER created.

The main aim of these activities was that teachers could identify and learn how to use the applications and services provided by the technological infrastructure (Website, Colabora, ATutor LMS, Web editor and authoring tools, and the Repository). At the end of the course each participant received a certification from the Institute of Informatics and Applications at the University of Girona.

4.6. Instruments

Five online questionnaires were created as the instruments to carry out the Gap Model Analysis. Participants were asked to answer those questionnaires by indicating the importance and personal satisfaction levels regarding the processes related with the use of the technological infrastructure developed. Appendix A contains the five questionnaires applied in this validation process. For each questionnaire the scale presented in Table 1 was applied. This scale

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was used to specify the level of importance and the degree of satisfaction perceived with regard to the components of the technological infrastructure.

Table 1: Scale of importance and satisfaction.

Not important / Not satisfied	Low importance / Low satisfaction			Important / Satisfied				Very important / Very satisfied		
0	1	2	3	4	5	6	7	8	9	10

5. Results and discussion

Although we could not present the results of all the countries participating in the validation process, this section presents results of participants from Bolivia which was the country with higher number of participants. This section also presents the consolidated results from all participants in order to give a general overview of the perceptions of teachers with regard to the ALTER-NATIVA technological infrastructure. Results are presented according to the aspects mentioned in subsection 4.3.

5.1. Results of the scenario in Bolivia

5.1.1. Attention to Diversity

The satisfaction level perceived by participants from Bolivia in the Attention to diversity, the Creation of accessible OERs and the Support to Collaboration is very close to the importance they gave to these processes and thereby the gap identified is small (Figure 8). This suggests a positive perception by the teachers regarding the support that the technological infrastructure provides. On the other hand, in the aspects of the Recommendations Support in the knowledge base and Attention to diversity concept, we can observe a slightly higher gap, which indicates that the importance the teachers gave to these processes is a little higher than the level

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of satisfaction towards the solutions offered by the infrastructure. Although the value of the gap is not higher than 0.5 points, it should be taken into account for improvement purposes.

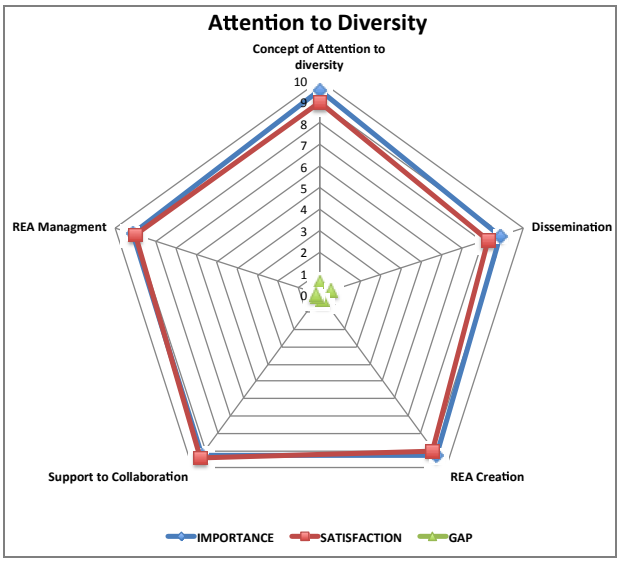

Figure 8: Attention to Diversity – Bolivia

5.1.2. Creation of accessible OERs

The satisfaction perceived by the participants from Bolivia regarding the importance defined in the aspects related with the usability, accessibility and correction in the Creation of accessible OERs (Figure 9). In the usability and the correction aspects gap is closer to 0. The accessibility aspect shows a little difference between satisfaction and importance, which suggests that this aspect should be improved. These results suggest that the technological infrastructure supports appropriately the creation of accessible OERs.

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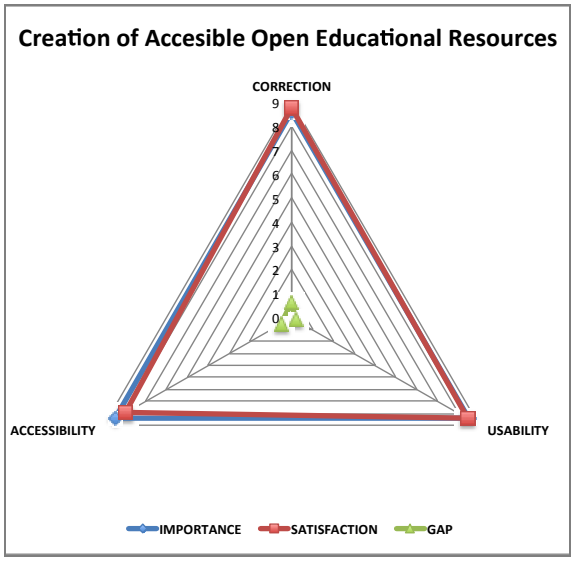

Figure 9: Creation of Accessible OERs – Bolivia

5.1.3. Management of accessible OERs

Figure 10 shows the level of satisfaction of the participants from Bolivia regarding the importance of the aspects related with the usability, accessibility and correction in the Management of accessible OERs. The chart shows that the teachers' level of satisfaction and the importance that teachers gave to this aspect is high. Thereby, the gap in this case is also close to 0 suggesting that the technological infrastructure provides good support for the storing and retrieving of accessible OERs from the Repository.

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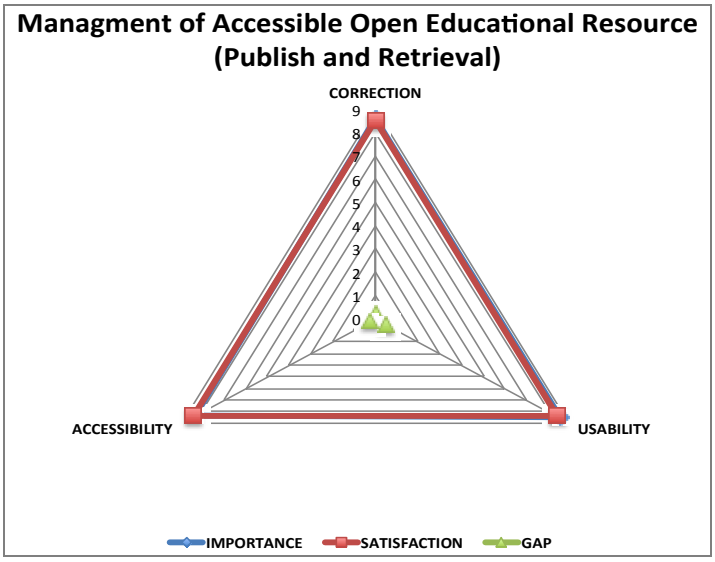

Figure 10: Publishing and retrieval of OERs – Bolivia

5.1.4. Recommender system

Figure 11 shows the results of the level of satisfaction of the participants from Bolivia regarding the Support to recommendations based on the recommendations they received when used the Repository. Such recommendations came from the service provided by the Intelligent support of the technological infrastructure. Results show that the level of satisfaction is high in almost all the aspect evaluated. However, aspect 4 shows a little gap. This aspect is related with completing the user model in the system, where we detected various opportunities of improvement. In general, for this process the gap is small, which allows us to conclude that the technological infrastructure provides adequate support to the teachers in this sense.

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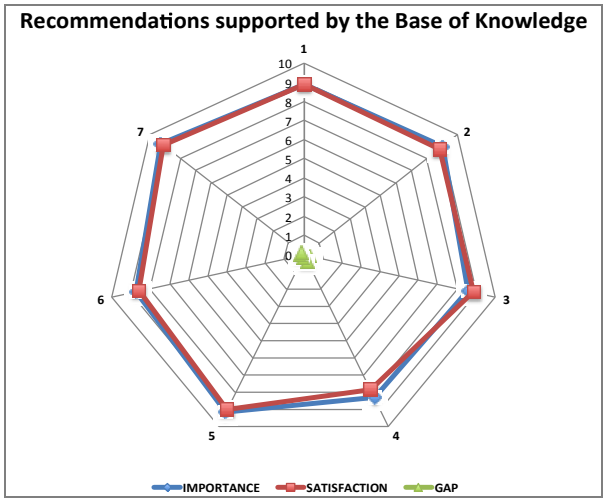

Figure 11: Recommendations supported by the knowledge base – Bolivia

5.1.5. Support to collaboration

Figure 12 shows the level of satisfaction perceived by the participants from Bolivia in the Support to collaboration offered by the technological infrastructure. Results indicate that the level of satisfaction is very close to the level of importance they gave to the five aspects evaluated. It is noticed a small variation in the gap (<0.5) in the aspect 4.

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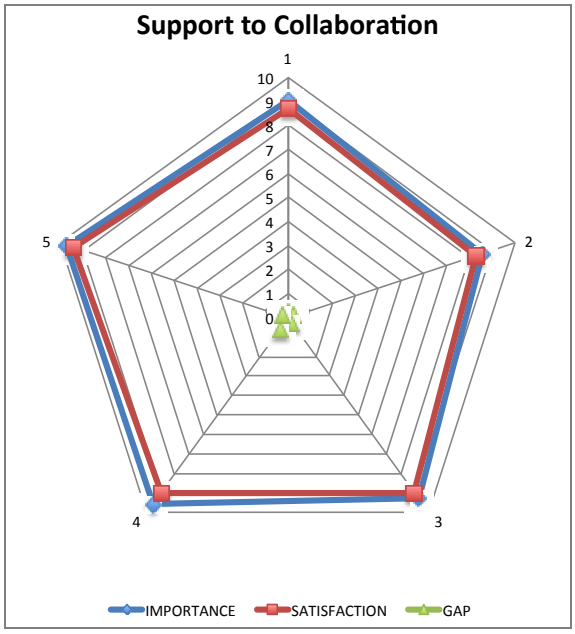

Figure 12: Support to collaboration – Bolivia

5.2. Overall results for all scenarios

This subsection shows the compiled results from the validation scenarios (Nicaragua, CLAVEMAT, Bolivia and Argentina).

5.2.1. Regarding the attention to diversity

Results with regard the Attention to diversity (Figure 13) reveal that teachers in all scenarios agreed with the components of the ALTER-NATIVA technological Infrastructure and they had positive perceptions about the concept of attention to diversity that the infrastructure implements. Teachers perceived the processes supported by the components of the technological infrastructure as important. They also considered that the applications and services provided were appropriated for supporting the creation of accessible OERs.

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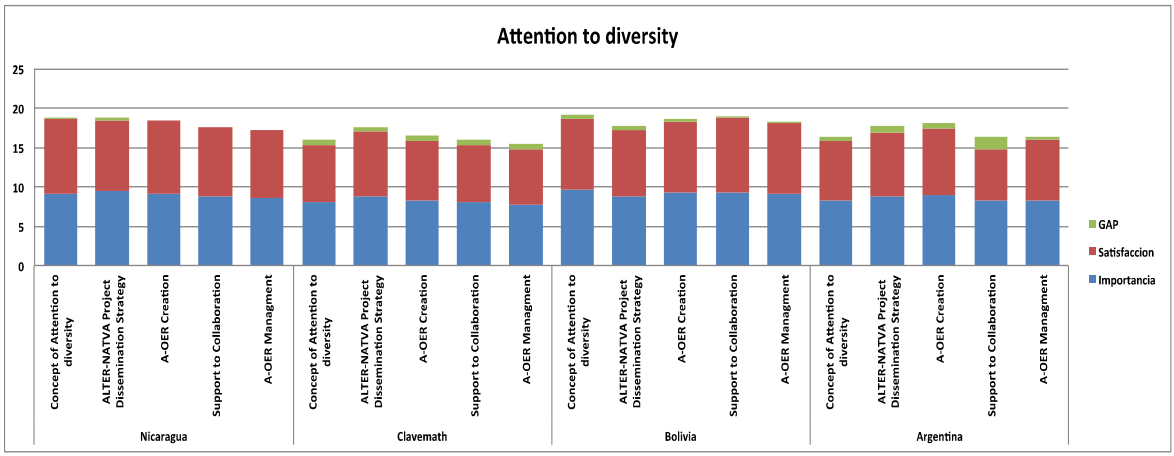

Figure 13: Attention to diversity – Overall results

5.2.2. Regarding the creation of accessible OERs

In the results regarding the Creation of accessible OERs (Figure 14) teachers considered this aspect as very important (8.87/10 points) and they felt very satisfied with it (8.69/10 points). The gap average was of 0.5 in all scenarios.

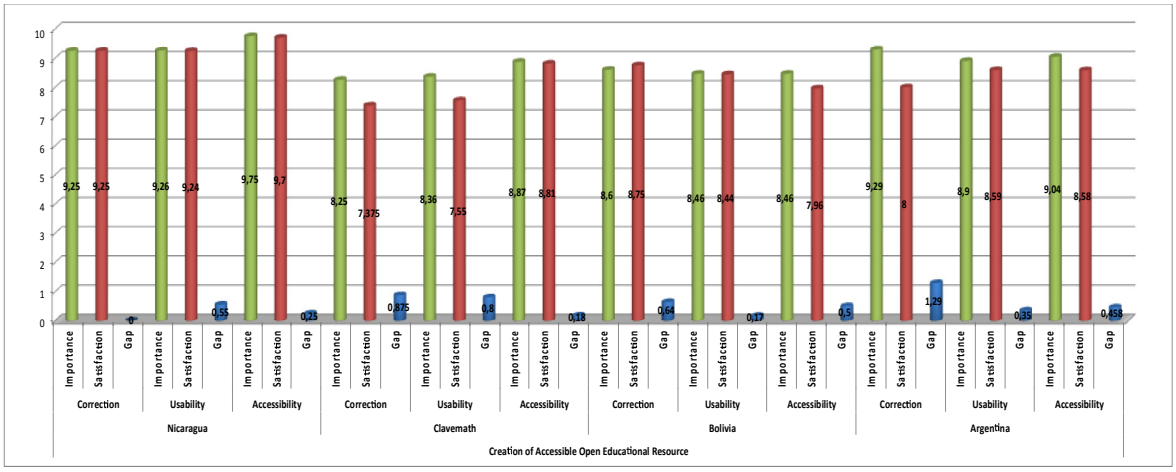

Figure 14: Creation of OERs – Overall results

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5.2.3. Regarding the management of accessible OERs

Consolidated results show that the Management of OERs (Figure 15) obtained 8.76/10 in the importance and 8.59/10 points in the satisfaction perceived by teachers. There was a small gap average of 0.25 in all scenarios. It is necessary to facilitate even further the process of recovering OERs by improving the searching mechanisms in the Repository in order to help teachers searching by other information contained in the metadata of the OERs. On the other hand, it is important that teachers can upload their own OERs directly from the LMS or the authoring tool to facilitate the process of publishing the OERs.

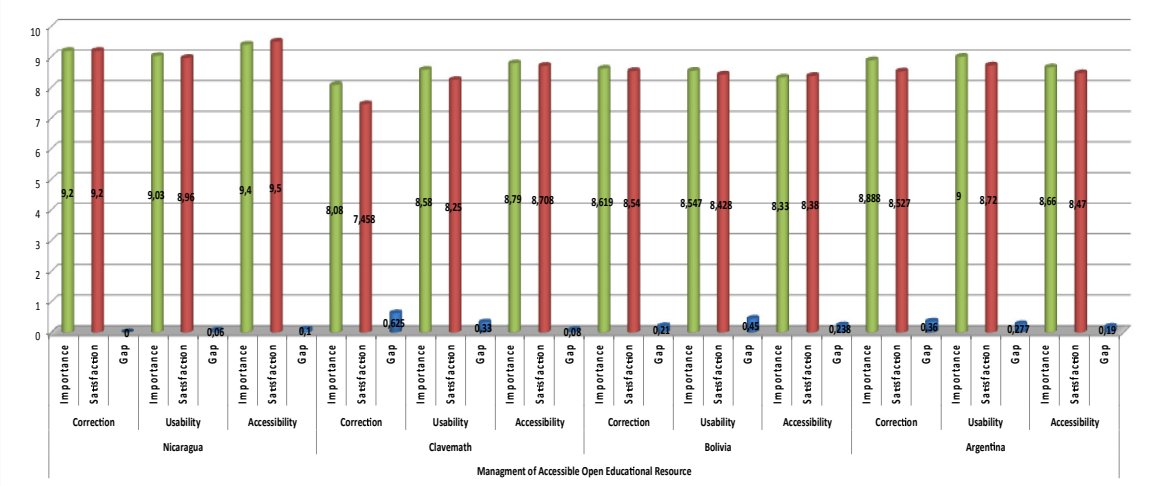

Figure 15: Management of OERs – Overall results

5.2.4. Regarding the recommender system

Consolidated results show that the recommendations supported by the knowledge base dimension (Figure 16) obtained an evaluation of 8.58/10 of importance and 8.20/10 of satisfaction with a small Gap of 0.41 over all scenarios.

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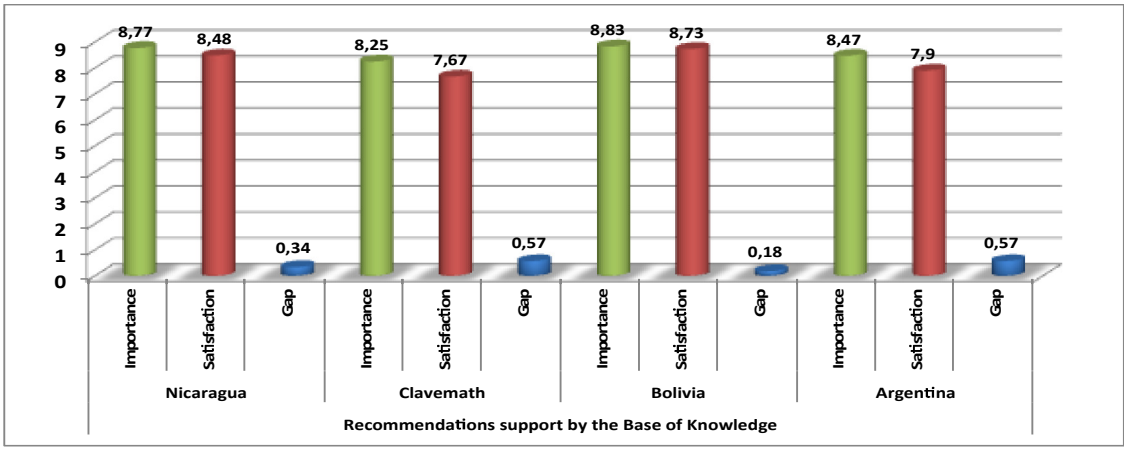

Figure 16: Recommendations supported by the knowledge base – Overall results

The components of knowledge like the ontology and the thesaurus can be used in the user to give more recommendations starting with all the rich and varied information captured throughout time. On the other hand, it is possible to obtain information about the OER user trends or to identify relevant information about the members of the community and their development throughout the process in order to improve the recommendations.

5.2.5. Regarding the support to collaboration

Consolidated results show that the support to collaboration dimension (Figure 17) obtained an average of 8.97/10 of importance and 8.58/10 of satisfaction with a small gap (0.42) in all scenarios. This suggests that teachers really find as important and satisfying the support provided in the Colabora platform for their interaction with other actors. In this regard, teachers considered necessary to improve the functionality for the management of bibliographical references and the connection with the Repository because its use was not intuitive enough. Moreover, other communication tools such as

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chat, forums, video-conference system, wikis or blogs could be integrated to improve the interaction with other actors in Colabora.

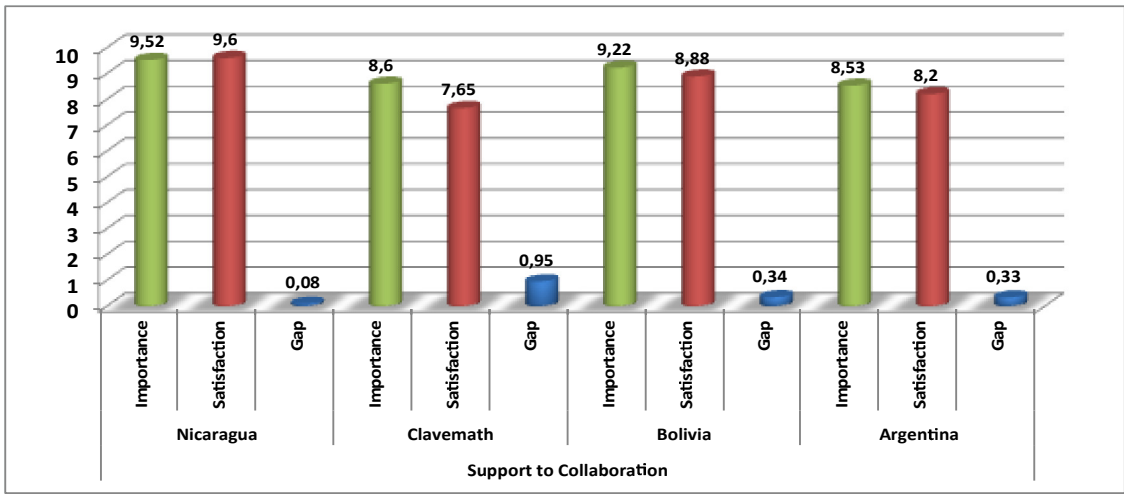

Figure 17: Support to collaboration – Overall results

6. Conclusion & Future Work

This article describes the technological infrastructure developed in the context of the ALTER-NATIVA European project. This infrastructure aimed to support teachers in the creation, publishing and retrieval of accessible OERs. The validation of this infrastructure was conducted during a course about the creation of accessible OERs in which teachers had the opportunity to use the applications and services provided by the technological infrastructure.

This study sought to identify the satisfaction and importance perceived from teachers with regard to the technological infrastructure. The evaluation of the infrastructure was conducted with 61 teachers and pre-service teachers from Colombia, Nicaragua, Argentina, Germany, Bolivia, Chile, Cuba and Ecuador. Results of the Gap Model Analysis showed a general positive perception of teachers towards the technological infrastructure. The gap between the

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importance that teachers gave to each aspect that was evaluated and their satisfaction was very small. This implies that teachers felt satisfied with each aspect covered by the technological infrastructure with regard to its perceived importance. From the results obtained we can observe that teachers in general are willing and eager to adopt the technology to create accessible OERs.

It is worth noting that the support given by the technological infrastructure facilitated teachers the creation of accessible OERs. Besides, for validating the infrastructure, teachers were instructed on how to use the technological infrastructure and how to apply the WCAG 2.0 when they create OERs. After that teachers were asked to answer the questionnaires related to their experience in the use of the applications and services of the technological infrastructure.

In terms of the management of OERs, teachers had a positive perception with regard to the use of the Repository. Pertaining to this, it is important to provide mechanisms that facilitate the processes of storing and retrieval of OERs including the possibility of searching in the metadata of the OERs.

Teachers also felt satisfied with the recommendations provided in the Repository which were supported by the Knowledge base. The recommender system could be improved with mechanisms to suggest other users to collaborate in the creation of accessible OERs based on the preferences and needs of teachers or their students.

Since teachers do not always work alone, it is important to create spaces for inter-disciplinary collaboration between teachers so that they can create accessible OERs in collaboration with others. The technological infrastructure included a platform for fostering collaboration between teachers. Teachers reported being satisfied about the use of the collaborative platform.

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Further research is needed in order to analyze benefits that the creation of accessible OERs, using the technological infrastructure, brings to the learning process of students in context of diversity. In terms of the knowledge base, the ontology and the recommendations could be improved to filter the information and improve the search taking advantage of all information provided through the metadata. Finally, the authoring tool could be improved to retrieve not only digital resources from the ALTER-NATIVA repository but also from other external repositories.

Appendix A

Evaluation instruments (EI)

Table A1: EI for the attention to diversity

Have the elements that constitute the ALTER-NATIVA technological infrastructure brought you more awareness regarding the diversity linked to the learning processes of your students?
Does the ALTER-NATIVA website provide a shared space for dissemination of the project's results?
Does the ALTER-NATIVA technological infrastructure give you adequate help within the creation of accessible OERs process, which is a fundamental process in supporting diversity in the educational system?
Does the ALTER-NATIVA technological infrastructure help you adequately in the collaboration process with the actors linked to the support process to the diversity of the educational system through Colabora?
Does the ALTER-NATIVA technological infrastructure help you adequately in the process of managing the OERs through the learning object Repository?

Table A2: EI for the creation of Accessible Open Educational Resources

CORRECTION
Does the web content editor ATutor help you in the process of editing OER?
Does the web content editor allow you to use resources like images, videos, audio recordings during the creation of accessible OERs?
Does the web content editor allow you to use styles to improve the visual presentation of the contents of accessible OERs?
Does the web content editor allow you to access dictionaries of the indigenous languages considered in the ALTER-NATIVA during the creation of the accessible OERs?
USABILITY
Do the symbols from the icons of the web content editor allow you to identify the function of each icon?
In the web editor, the name of each icon is adequate for the action it executes.
The language used in the tool for creating accessible OERs is simple and adequate.
The information from the web content editor is easy to understand.
It is not needed to have advanced knowledge of HTML (Hyper Text Markup Language) to create accessible OERs.

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Is the interface in the web content editor homogenous? Are the same styles being used?
Navigating the web content is easy to learn.
Are the figures, tables, links and active areas easy to relate with the action that is to be executed in the web editor?
When you select an icon in the web editor is easy to distinguish from the one that have not been selected.
ACCESSIBILITY
Does the editor allow you to create accessible tables that can be correctly interpreted by the screen reader?
Does the editor allow you to download videos and specify the audio-description and the subtitle, facilitating the creation of accessible OERs?
Do the colors of the font and of the color of the background allow the text to be read easily?
Does the web content editor allow you to define alternative equivalents to resources as images and videos?

Table A3: EI for the management of Accessible Open Educational Resource

CORRECTION
Do the services offered by the ALTER-NATIVA Repository correspond with the objectives of a Learning Objects Repository to store and recover OER?
Do the systematization of the accessible OERs in areas or sciences and types of objects allowed you to recover accessible OERs in a direct way (selective)?
Are the metadata from objects auto-descriptive? The ones that are not, do they have an adequate description?
Are the accessible OERs easy to find?
Are the search results shown in a comprehensive manner for the user?
Does the use of images of animations give some type of added value?
USABILITY
Does the repository's interface have coherence and homogeneity in all its structures and colors among all its pages?
Is the interface of the ALTER-NATIVA repository user friendly?
Is the language used in the Repository clear and concise?
Are the icons' titles meaningful?
Is the organization and navigation structure adequate?
Was the informational overcharge avoided?
ACCESSIBLITY
Is the font size adequate in making the text easy to read?
Is the type of font, line width and alignment used helpful in reading?
Are the colors of the font and the background color of the text helpful in making the text easy to read?
Is the ALTER-NATIVA repository easy to visualize with different navigators?
Can the user enjoy all the contents of the repository without downloading additional plug-ins?
Does the repository allow in the A accessible OERs labeling saving information about its accessibility? For example alternatives for the senses: sight, touch or hearing?

Table A4: EI for the recommendations supported by the Knowledge base

Does the thesaurus of the ALTER-NATIVA project clarify for you the semantics of the concepts used in your field of study?
Does the technological infrastructure of the ALTER-NATIVA project allow you to create and maintain thesaurus in your field of study?
Does the technological infrastructure of the ALTER-NATIVA project allow you to adequately classify the accessible OERs through the thesaurus?
Does the user model in the ALTER-NATIVA project adequately characterize the actors involved in the attention to diversity process and in the educational system?

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Does the metadata model defined in the ALTER-NATIVA project allow you to adequately characterize the accessible OERs developed in the project? Does the technological infrastructure of the ALTER-NATIVA project, that is making use of the ontology generated in the project, allow you to search accessible OERs? Is the process of recommendations of accessible OERs, which makes use of the ontology generated in the ALTER-NATIVA project, efficient and intelligent?

Table A5: EI for the support to collaboration

Does Colabora facilitate the joint processes of creating solutions for the attention to diversity in the educational system? Does Colabora provide a virtual space that allows the management of CoP? Does Colabora provide a virtual space apt for the reflecting about open and interesting topics in the context of the attention to diversity processes? Does Colabora provide a virtual space adequate for a joint creation of accessible OERs? Does Colabora provide a virtual space adequate for join reflecting and analyzing about bibliographical references?

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