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Virtual accessibility to enhance research efficiency: the case of Bolivia

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Abstract. The main objective of this article is to analyse how research management is carried out in some higher education institutions in Bolivia, based on the analysis of good practices developed. Furthermore, the virtual accessibility of the information and communication in research and science is carried out. Accessibility to digital information of the institutional Web contents of the higher education and research institutions in Bolivia were analysed to understand if they comply with the accessibility requirements contained in the Web Content Accessibility Guidelines 2.0 of the World Wide Web Consortium (W3C), as enshrined in the European Parliament Directive (EU) 2016/2102 and the European Standard EN 17161:2019. The final analysis revealed several weaknesses affecting users' interest and motivation and recommended to take certain steps to provide virtual accessibility of in HEIs in Bolivia.

Keywords: higher education institutions, research, research management, virtual accessibility.

1 Introduction

The role of higher education institutions is crucial to develop a cutting edge research and contribute to the science development. Thus, HEIs invest strategically in developing and producing high-quality research and disseminating it across the globe (Quitoras

& Abuso, 2021). Rapid evolution of technology, its wide use worldwide challenges educational institutions to provide virtual learning environments and ensure accessibility of research information on the websites of HEIs. In fact, higher education institutions in Latin America are faced with the challenge of taking some steps to raise awareness of the importance of virtual accessibility in managing research and ensuring digital accessibility for all (Hernández & Hilera, 2014). Therefore, this article has twofold objectives: 1) to present research management good practices of selected HEIs in Bolivia, as well as 2) to investigate the digital adaptation resulting from the technological innovation, to help the academic managers in formulating research policies and enhancing research culture. This paper is organised as follows: the second section is a brief contextualization on the issues covered; the third section presents the method and data collection; the fourth section presents the results and, finally, the discussion and conclusion.

2 Contextualization

Research performance and productivity is relevant indicators in higher education institutions. It is a fundamental part of their mission together with teaching (Bonaccorsi & Secondi, 2017). Academics role at the HEIs is in teaching, conducting research, transfer and dissemination of knowledge *(*Haque et al., 2015). Rapid evolution of technology, its wide use worldwide challenges educational institutions to provide virtual learning environments and create accessible web content. Since ICT tools facilitates quick search process, information access and retrieval, as well as interaction among users (Haque et al., 2015). In this context, websites of the universities providing relevant information for academic community should fulfil accessibility standards and be accessible to all (Agangiba et al., 2017). In the case of Latin America, Hernández & Hilera (2014) showed concern regarding the need to increase awareness at the HEIs about the importance of website accessibility and take certain steps to facilitate the use of the websites by the academic community.

For a website to be considered accessible, text-based alternatives must be provided for any non-textual content. This allows for adaptation to each user's needs, such as large print, Braille, read-aloud, symbols and plain language. All content should be adaptable, discernible and keyboard accessible. It is also important that there is a help option, and multimedia elements should provide content and texts properly identified, with subtitles or audio description (https://www.w3.org/Translations/WCAG20-pt-PT/).

3 Method and Data Collection

3.1. Case study methodology: good practices

For the identification and exploratory analysis of the good practices in research management in higher education institutions in Bolivia, the case study methodology is employed. Selection of the case studies is assorted according to the criteria such as relevance within the context of Bolivia, scalability in terms of viability of the transposition

of similar schemes to other institutions of the consortium and cost-effectiveness. The coordination of this task was carried out by the Portucalense University together with USFX, Bolivia in the scope of the work package "Needs analysis" of the Innova project. To collect more detailed information about good practices in the most efficient and effective manner, semi-structured interviews are used and applied to responsible person in each university. The information related to the selected good practices is presented in the table 1 and detailed description of each case can be consulted in the section 4.

Table 1. Good practices on research management in Bolivia

Title of the good practice	University
Construction of the university's lines of research through a participatory methodology	USFX
Registration and Copyright Management in compliance with Bolivian regulations	UAGRM
Integration of New Researchers into the Research Programmes	UCB
Aire Limpio -RED MÓNICA	UPSA

3.2. Methodology for analysing the websites

The methodology for website analysis is based on a selective sample of 11 websites, being 4 universities and related research units' homepages in Bolivia. In addition, the MINEDU - Ministry of Education of the Plurinational State, the Vice-Ministry of Science and Technology and INNOVA Project websites were also studied. We prepared observation grids for compliance with the requirements of virtual accessibility and, after collecting the URLs, quantitative and qualitative analysis of the information disclosed on the respective websites were conducted. Regarding the quantitative analysis, the degree of compliance with the recommendations of WCAG 2.0 was verified, currently implemented by AMA - Agência para a Modernização Administrativa, I. P. - Accessibility.gov.pt project (https://www.acessibilidade.gov.pt/), and we used the automatic validator AccessMonitor Plus, version 2.1. This software is an automatic validator of Web accessibility practices (WCAG 2.1) that checks the application of accessibility guidelines in HTML contents, on a scale of 1.0 to 10.0. The three types of results are stratified by three priority levels ('A', 'AA' and 'AAA').

Contrary to what we have been developing in other papers (Silva & Borges 2020; Pinto, et al., 2020; Borges, et al, 2020; Costa et al., 2020), we do not privilege quantitative analysis. We only verified the A, AA and AAA level errors, regarding accessibility and warnings (Table 3). The elements chosen for the qualitative analysis were the following: existence of the accessibility symbol or reference to the accessibility of the website, existence of search functionality and the languages in which it is presented.

4 Results and discussion

4.1 Good practices in research management

4.1.1. USFX: Construction of the University's lines of research through a participatory methodology

In 2008, the Business Administration Department of the USFX promoted the construction research lines at the university level through a participatory methodology. Work

was carried out in all areas of knowledge with a team of teaching moderators and systematisers, and with actors from society who expressed their research demands and interests in working groups. This initiative obtained a support from the Strategic Research Programme Foundation in Bolivia (PIEB). The purpose of this initiative was to determine and characterise the demand for research fields relevant to the development of Chuquisaca region.
In order to identify research lines several round tables were organized with a varying number of 4 to 6 leaders per roundtable, including moderators, systematisers and support staff. The research team's working groups were held once a week during the 8 months of the project. Roundtables organised with actors from civil society, public institutions, and the private sector. The results were a set of research lines by areas of knowledge on the basis of which further research can be carried out. The results of the roundtables to determine the lines of research were disseminated through a publication entitled "Universidad y sociedad- Agenda universitaria para la investigación en Chuquisaca" (University and society - University agenda for research in Chuquisaca) http://www.pieb.com.bo/anterior1.php?id=2478.

4.1.2. UAGRM: Registration and Copyright Management in compliance with Bolivian regulations

The creation of the Intellectual Property Unit within the Department of Knowledge Technology Transfer at the UAGRM has been recognised as a fundamental unit in knowledge management within the university, since by obtaining intellectual property, the results of research work are disseminated, knowledge that can be used in different social sectors. Other contributions are the obtaining of Patents in favour of the University and registrations of Copyrights and Distinctive Signs and Trademarks, being a national reference for having the most Intellectual Property registrations in the Bolivian University System, being a representative of the Intellectual Property Network at the Bolivian University System level.
Main activities carried by the unit are techno-legal assistance to the university's academic research units with the aim of safeguarding the ownership of the innovations, promotion of innovation and creativity at the service of the economic and social development of the community through a system and its regulation of the patent, application of national regulations and the university's internal regulations on legal procedures for copyright and intellectual property patents, training in intellectual property with the aim of informing the beneficiaries of the benefits of registration and their property rights obtained at the time of registering the patent, among others. The unit organises 10 trainings per year for the university staff, and if any faculty requested specific training in their area, it is also provided. The participation rate in the Intellectual Property training courses is 60%.

4.1.3. UCB: Integration of New Researchers into the Research Programmes

The implementation process related to the Research Initiation Programme has a strategy based on the interest and impulse of the Regional Rectorate started in 2016 to promote the generation of research at the Bolivian Catholic University, in compliance with the

universal mandate of the university, towards the generation of knowledge. The initiation of students to research began in 2018-2019, through the promotion and call for students. Research management process is carried out by the Research Coordination, which is a unit in charge of promoting research among teachers and students and fulfils all the tasks related to the academic, administrative, and technical issues. To facilitate the student's involvement, the Student Scientific Society (SCE) was created. The management of the Student Scientific Society is done by a Guiding Teacher from the Environmental Engineering department. The students are invited to participate in the activities of the research centre in Water, Energy and Sustainability (CINAES), which is part of the Environmental Engineering department. Creation of the SCI, assigning a guiding teacher, and link to a specific research centre are positive factors contributing to new researchers' motivation and involvement in research activities. Students in the Student Scientific Society are motivated to continue their research and to apply for the arising scholarship opportunities.

4.1.4. UPSA: Aire Limpio -RED MÓNICA

The UPSA, in agreement with COSUDE (the Swiss Foundation for Technical Development Cooperation) through Swiss contact and the Municipal Government of the city of Santa Cruz, developed this project with the objective of installing and maintaining an air quality monitoring programme in the city of Santa Cruz, a municipality sensitive to air pollution from vehicular traffic and industry and vulnerable to forest fires, logging and burning. The management of the project has been done by carrying out permanent measurements and coordinating and sending the information to the Municipal Government, which by law is in charge of air quality in the cities.

Products of the Project are implementation of the MoniCA Network (Air Quality Monitoring Network) with measurement points according to WHO and validation of the pollutants to be measured, local and departmental air quality reports in Santa Cruz de la Sierra, national Air Quality Reports in Bolivia by the Ministry of Environment and the National Institute of Statistics (INE), international publication of data in The Clean Air Institute (CAI) magazine and Clean Air Initiative for Latin America.

Prior to this project, there was no information on air quality in the city. This project has served to raise awareness of the importance of air quality, both in social and climate change terms. A National Network has been formed with all the Municipal Governments of the departments involved and is based on the experience gained from this project.

4.2. Accessibility of websites

Given that the websites are constantly being updated, the validity of the analysis is relatively short, so the tests carried out on the pages under analysis in access Monitor version 2.1 were only compiled on two days, 24th and 26th January 2022. The target audience is higher education students and teachers or candidates, as well as researchers from various research areas.

One of the objectives is to carry out a summary qualitative analysis from the user/consumer perspective. The elements chosen for the qualitative analysis are shown in Table 2, Fig.1. Although we have selected only basic elements for analysis, these do not always exist on the webpages, namely the basic search functionality. Regarding the placement of the accessible website symbol or reference to the accessibility of the website, this presence is zero. In terms of the languages available, we can see that Spanish is the main language. Only the UPSA website provides information in English. Although internet functionalities allow automatic translation, if the website is built in other languages, the level of accessibility in terms of usability is significantly higher.

Table 2 – Characterization of some elements of the analysed websites according to the Web accessibility practices report (WCAG 2.1 do W3C).

WEBSITE OF THE INSTITUTION/RESEARCH UNIT	**Index *accessmonitor plus 2.1***	**Accessibility symbol or accessibility reference**	**Search functionality**	**Languages**
Universidad Privada de Santa Cruz de La Sierra – UPSA - https://upsa.edu.bo/es/	4.2	No	Yes	2
UPSA – Research - https://upsa.edu.bo/es/investigacion-en-la-upsa	5.5	No	Yes	2
Universidad Católica Boliviana – UCB - https://lpz.ucb.edu.bo/	6.0	No	Yes	1
UCB – Research - https://lpz.ucb.edu.bo/investigacion/	5.5	No	Yes	1
Universidad Autónoma Gabriel Rene Moreno – UAGRM - https://www.uagrm.edu.bo/	5.6	No	Yes	1
UAGRM – Research - https://www.uagrm.edu.bo/unidades-administrativas/dicit	6.3	No	Yes	1
Universidad Mayor, Real y Pontifica de San Francisco Xavier de Chuquisaca – USFX - https://www.usfx.bo/	4.8	No	Yes	1
USFX – Research - https://dicyt.usfx.bo/	4.6	No	Yes	1
MINEDU - Ministerio de Educación del Estado Plurinacional de Bolivia - https://www.minedu.gob.bo/	4.7	No	No	1
Viceministerio de Ciencia Tecnología - https://www.minedu.gob.bo/index.php?option=com_djmediatools&view=category&id=61&Itemid=949	6.1	No	No	1
INNOVA project - https://www.innova-project.eu/es	7	No	Yes	1

We limit our summary analysis at the best performing websites. The website of the INNOVA project itself, although it is still under construction, is the only one that achieves the value of 7.0 of compliance with the requirements of virtual accessibility, so in the future it may reach the ideal value of 10, fulfilling the desired requirements of full virtual accessibility. All the other websites have lower values of compliance with the requirements of virtual accessibility, the lower limit being 4.2 (UPSA) and the upper limit 6.3 (the page on research of the UAGRM), in addition to the 7.0 concerning the INNOVA Project website.

We therefore conclude that the compliance of the websites analysed with the different levels, although variable, presents average and weak values, with none of them reaching the value of 10 or even close to it.

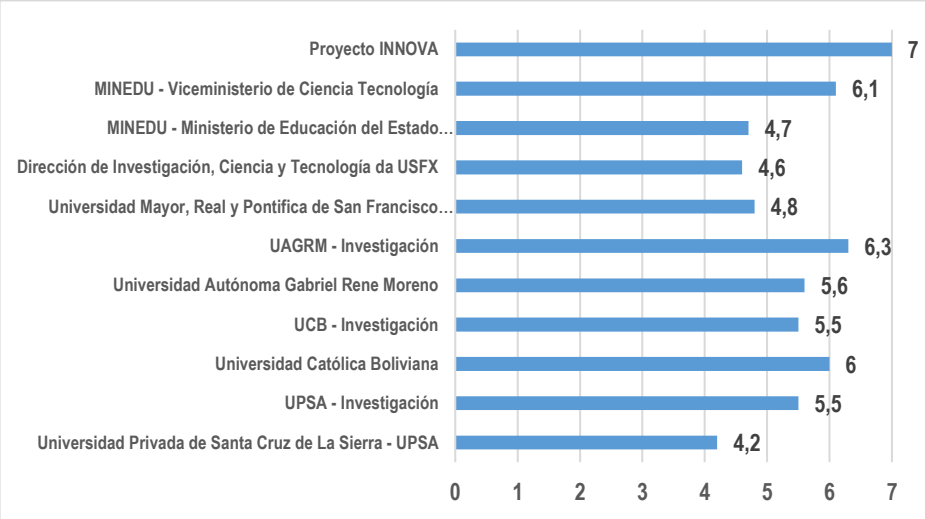

Fig. 1 – *AccessMonitor Plus 2.1* indexes of the websites analysed.

Given the constant changes in the websites, improvements are naturally taking place, so we are pleased to see that the website of the UCB, already has a compliance index of 7. 1 (April 15th), as a result of having made available, given the pandemic situation by Covid-19, a virtual visit tab, accompanied by voice reporting in Spanish, allowing access by image and audition to a greater number of people, particularly those with sight problems, among others, as the simple search for information on the website. This virtual visit provides a range of information about the university campus, the central library and all the existing training areas, as well as the research centres associated with each area.

Although the general page about research in this institution is very poor, it presents in the tab Culture and Art, through the Centro de Edición y Escritura, interesting elements about scientific writing, highlighting the existence of a publication called Ciencia y Cultura which is the only magazine of Humanities indexed in Bolivia.

Unfortunately, the page of the Vice-Ministry of Science and Technology, hosted on the website of the Ministry of Education of the Plurinational State of Bolivia, has little information about the support for research, limited to three tabs related to calls, instructions, and resolutions. The scarcity of information regarding research and research management is a fact, as it was possible to verify in most of the websites analysed. As the virtual accessibility is also weak, users will find it difficult to find and, subsequently, to retrieve the information they need.

Table 3. "A", "AA" and "AAA" level test results

Website	Index *accessmonitor plus 2.1*	LEVEL A				LEVEL AA				LEVEL AAA			
		Acceptable	No acceptable	Warnings	TOTAL	Acceptable	No acceptable	Warnings	TOTAL	Acceptable	No acceptable	Warnings	TOTAL
UPSA	**4.2**	3	1	8	12	0	1	2	3	0	2	1	3
UPSA - research	**5.5**	4	1	5	10	0	0	2	2	0	2	1	3
UCB	**6.0**	5	4	5	14	0	1	1	2	0	3	0	3
UCB - research	**5.5**	5	2	5	12	0	1	1	2	0	1	1	2
UAGRM	**5.6**	6	1	5	12	0	0	1	1	0	3	1	4
UAGRM-research	**6.3**	5	3	4	12	0	0	2	2	0	4	0	4
USFX	**4.8**	5	2	6	13	0	0	1	1	0	3	1	4
USFX - research	**4.6**	5	2	6	13	0	0	2	2	0	4	1	5
MINEDU	**4.7**	3	2	7	12	1	0	0	1	0	2	1	3
Vice-Ministry of Science Technology	**6.1**	4	2	5	11	0	0	0	0	0	1	0	1
INNOVA project	**7.0**	6	3	2	11	0	0	1	1	0	1	1	2
AVERAGE	5,48	4,63	2,09	5,27	-	0,09	0,27	1,09	-	0	2.36	0,72	-

Table 4 - Average number of acceptable and non-acceptable errors and warnings per level

A		AA		AAA	
ERROR	WARNING	ERROR	WARNING	ERROR	WARNING
6,72	**5,27**	**0,36**	**1,09**	**2,36**	**0.72**

Given the index results obtained through AccessMonitor Plus, version 2.1, the systematic quantitative analysis of these websites was not one of the main objectives of this article, so only the quantifiable results of level A, AA and AAA errors were chosen for analysis, regarding acceptable, not acceptable and warnings (Table 3). These errors refer, among others, to the tests on image captions, the use of multimedia, forms, menus, headers, main language indication, links, menus and link text, links to information block outlines, w3c standards and, finally, metadata presentation elements and attributes. The analytical chart is presented in the table 3 and the average number of errors and warnings in the table 4.

The quantifiable results of level A, AA and AAA errors, regarding the acceptable, not acceptable and warnings show very high values, especially in the results of level A errors, highlighting the not acceptable errors, as we can see in Table 3.

In this quantitative analysis of errors per level, we found high values and, as such, reveal the problems that the vast majority of websites have in terms of conformity with what is intended to be considered an accessible and inclusive website. The quantitative data thus corroborate the qualitative data.

The results obtained reveal that these websites are not prepared to comply with the European legislation guidelines, and the guidelines made public on 21 March 2019, enshrined in the European Accessibility Act and the Design for All Standard.

Naturally, Bolivia does not have to follow European standards or legislation. However, in the absence of others, it could be important to gather existing information towards

the improvement of existing websites, bringing them closer to the parameters that are intended for a more inclusive and accessible virtual information for all users.

5 Final considerations

The analysis of the results of the websites allowed us to obtain measurable data, which can enhance the qualitative analysis regarding the strengths and weaknesses and the needs for improvement that the websites analysed require, from the perspective of any user and also of those who present, permanently or temporarily, limitations of various kinds.

According to the data presented by Access Monitor Plus, the average compliance with accessibility requirements is 5.48, on a scale of 1.0 to 10, not enough to pass the level A of accessibility of online pages. For this reason, we found that none of the websites under study is considered accessible. The research revealed several weaknesses that affect the interest and motivations of users in the face of the many different offers that the websites of the universities and the ministry can provide.

This raises a high concern and need of taking certain steps to increase awareness about the accessibility as a virtual gate to search, consult and retrieve necessary information and data. In addition, given the best practices presented in research management, linked to cooperation with the community and society, which should always have immediate access to the requested information, the involvement of young researchers in the research activities of the various units, who should have access to information more convenient and easy way. Some specific research projects, such as "Red Monica", where cooperation with external experts is fundamental who should not experience barriers in accessing institutional and research units' websites. Thus, it is recommended to increase awareness regarding this issue among the HEIs and Ministries in Bolivia, and call to adopt web technologies and approaches, facilitating the interaction of diverse users with the web content, which in turn would lead to new possibilities and opportunities.

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