

Designing of a Radio Link to Improve Web 2.0 and Internet Access in Rural Zones in Colombia. Case Study: E-Learning to the Indigenous Community of “Santander de Quilichao and Toribio Cauca”

Roberto Ferro^{1(✉)}, Ricardo González^{1(✉)}, Katherine Cuartas^{1(✉)}, and Yesid Díaz^{2(✉)}

¹ Lider Research Group, Universidad Distrital Francisco Jose de Caldas, Bogotá, Colombia
rferro@udistrital.edu.co, ricatv@hotmail.com,
kathecc91@gmail.com

² Axon Group CUN, Bogotá, Colombia
yesid_diaz@cun.edu.co

Abstract. In the Framework of the Community Program stations and internet access for indigenous people; this study introduces an overview of the feasibility studio and definition of technical conditions for the installation of a link between the broadcasting station of the municipality of Santander de Quilichao with a radial production center of Toribio’s municipality. The relevant aspects of the links design, as well as defining technical conditions to visit these areas, determining the location of the links, repeaters and some calculations made for this purpose and thus, how they can possibly access to e-learning Web 2.0 tools based on LMS basically in the area of indigenous communities of Toribio, Cauca’s County in Colombia.

Keywords: Data radio link · Indigenous communities · ITC · Web 2.0 · E-learning

1 Introduction

This paper was made in the frame of the community program between the Technologies of Information and The Communication Ministry. The Culture Ministry and the Financial Background of Development Projects Team, that supports the strengths, the recuperation and the conservation of the culture, its traditions, customs, languages and autochthonous life plans of Colombian Ethnic Minorities (indigenous people) [1], all of these through the provision of sound broadcasting infrastructure of public interest, whose operation is sustainable and guarantees the participation of the majority of sectors inside the ethnics groups. In this way, the link design and implementation for one of the stations between Santander de Quilichao y Toribio municipalities seeks to consolidate the above described project from Cauca providing an infrastructure that allows the foundation of the Radio Pañumat station that will have around 24.475 indigenous and benefits its population with a coverage of 16 reservations denominated “association of north zone of Cauca indigenous council” [2].

The purpose was performed by an inspection and visits of the involved zones in the project and to analyze the land conditions (surrounded areas, accessibility, transport, isolation, media access and development resources, for instance: electric energy and other services) after the parameter identification and the definition of the technical conditions of the link also, to make a comparison between the project techniques definitions and requests which can determine the feasibility of this link and after that, the results shown and the conclusion of this project.

1.1 Definition of the Technical Conditions and Studies of the Zone

To make a definition of the technical conditions it is necessary to evaluate some factors such as: location, height, antennas elevation, potency and frequency of the station operation for the zones involved which are divided in 3 links:

- Link 1: Toribio (Transmitting End) y San Julian's Hill (Repeater System)
- Link 2: San Julian Hill (Repeater System)–Pýumat Transmitting (Munchique's Hill)
- Link 3: Pýumat Transmitting (Munchique Pequeño Hill) (Repeater system) – Pýumat's studio (Santander de Quilichao) (Receiving End).

These conditions are summarized in the following tables (Fig. 1):

Link 1: Toribio studio (Transmitting End) y San Julian Hill (Repeater system)			
Location Toribio studio:	Indigenous House, Toribio.		
Coordinates Toribio studio:	Datum Level	X=818.630 m	Y=1'090.030 m
	Bogotá, ref. West	Lat. N 2°	Long. W 76°
	Geographical Datum WGS84	57°20.6"	16°4.15"
Field Height Toribio studio:	1697 m.a.s.l.		
Antenna Height Toribio Studio:	5 m		
Azimuth Antenna Toribio Studio:	315.6°		
Antenna Elevation Toribio Studio:	10.7°		
Gain and type of antenna Toribio Studio:	6 dBi, yagui		
Power Operation (ERP):	94.52 W		
Transmitter power:	10 W		
Link frequency:	It should be allocated by the technologies of information and communication ministry It worked in the band 335.4 - 343 MHz (339 MHz frequency)		
Coordinates San Julian Hill:	Datum Level	X=620.741 m	Y=1'087.942 m
	Bogotá, ref. West	Lat. N 2° 58'	Long. W 76° 17'
	Geographical Datum WGS84	29.4"	11.7"
Height field San Julian Hill:	2262 m.a.s.l.		
Antenna Height San Julian hill:	10 m		
Azimuth receiving antenna San Julian Hill:	135.6°		
Elevation receiving antenna San Julian Hill:	-10.7°		
Gain and type of receiving antenna San Julian Hill:	6 dBi, yagui		
Minimum receiver sensitivity:	1 mV, for composite signal		

Link 2: San Julian hill (Repeater system)- Pýumat transmitting (Munchique Pequeño Hill) (Repeater System)			
Coordinates San Julian Hill:	Datum Level	X=620.741 m	Y=1'087.942 m
	Bogotá, ref. West	Lat. N 2° 58'	Long. W 76° 17'
	Geographical Datum WGS84	29.4"	11.7"
Field Height San Julian Hill:	2262 m.a.s.l.		
Antenna Height Toribio Study:	10 m		
Azimuth transmitting Antenna San Julian hill:	250.7°		
Transmitter Antenna Elevation Angle San Julian hill:	0.65°		
Gain and type of transmitting antenna San Julian hill:	12 dBi, yagui		
Power Operation (ERP):	146.4 W		
Transmitter power:	10 W		
Link frequency:	It should be allocated by the technologies of information and communication ministry It worked in the band 335.4 - 343 MHz (339 MHz frequency)		
Transmitter coordinates Pýumat(Munchique Pequeño hill):	Datum Level	X=815.541 m	Y=1'073.016 m
	Bogotá, ref. West	Lat. N 2° 55'	Long. W 76° 25'
	Geographical Datum WGS84	40.3"	15.1"
Field Height Munchique Pequeño:	2462 m.a.s.l.		
Height Receiving antenna Munchique Pequeño hill:	10 m		
Azimuth Receiving Antenna Munchique Pequeño hill:	70.7°		
Receiving Antenna Elevation Angle Munchique pequeño hill:	-5.7°		
Gain and type of receiving antenna Munchique pequeño hill:	12 dBi, yagui		
Maximum sensitivity receiver:	1 mV, for composite signal		

Fig. 1. The relationship between Links 1 and 2.

The considerable distances and the limited land access shapes a critical factor that can be important obstacles at the moment of making a red planning [3]. Therefore, in the first step of the project was made a studio of the zone to obtain information about the access and characteristics related to the infrastructure. The visited places were in the municipalities of Toribio, San Julián's hill, small Munchique's hill, and in Pýumat (Santander de Quilichao), where the dates are coined in the following Fig. 2 as follows:

Toribio Studies Infrastructure	
Access	Time from Santander de Quilichao to Toribio two hours, half of the route is paved road, the other half by dirt road in good condition.
Infrastructure Studies Area	Studies are available in Services of Water and Power (single phase). There are some studies which are located on the second floor of the Indigenous House, which feature ceiling Composite triplex and polystyrene. We recommend installing a voltage stabilizer and surge and ground system.
Infrastructure San Julian hill (Repeater System)	
Access	Access path from Toribio takes 90 minutes. Today is a guarded area by the army. You must request permission to access the site.
Infrastructure San Julian hill area	There is a TELECOM self-supporting tower 60 m and another 10m tower belonging to the indigenous community. There shed belonging to the indigenous community, you must provide a rack or holder for placing equipment there. Service is available Electric Power enough to feed the repeater system (single phase, 25 kW). You must install the system ground to the house of the indigenous community, voltage stabilizer and surge. To install the antennas can be used either towers are in place, but preferably to use the tower of 10 m, which would require repair you the reins and paint. To this point the line of sight to the Munchique hill verified through binoculars.
Infrastructure Munchique Pequeño hill (Repeater System)	
Access	Paved access road from Santander de Quilichao about 1 hour. Then you must walk 15 minutes up with strong inclination. In the place the transmitter station is installed P'yumat.
Infrastructure Munchique Pequeño hill area	There is a tower of 30 m in which the antenna system of the transmitter and stand Pyumat is installed. it is recommended installing , stabilizer and surge voltage to be used by the radio relay system , you must also install a rack or stand to place there the transmitting equipment and radio receiver To install the radio relay antennas can be used tower It exists at the place . To this point the line of sight with the studies was not verified and currently operates a radio link with P'yumat studies additionally the day of the site visit the sector remained cloudy
Infrastructure P'yumat Studies (Santander de Quilichao)(Receiving End)	
Access	Access by paved road from Cali to Santander Quilichao about 2 hours.
Infrastructure P'yumat radio studies area	There is a tower of 10 m in which the radio link system is installed at Cerro Munchique of P'yumat station. To this point the line of sight to the Cerro Munchique Small was not verified and currently operates a radio link with the aforementioned hill.

Fig. 2. Summary data survey in rural sites in Cauca.

1.2 Research Location Conditions Links

The location and determination of radio link point is between the site of the survey in Santander de Quilichao and Toribio zone; this condition is made by taking into account, among others established considerations and following the invitation to make the quote of the studio technique:

- Any individual who wants to visit or to work, he or she must take into account that has to know the steps in the indigenous communities where the station and the link system are developed and also he or she has to have a respectively consent of the representative of traditional authorities and it must be coordinated between the contractor and the respective indigenous community authority to carry out any kind of activities.
- With respect to the previous consideration, the same indigenous community represented by Mr. Leonardo Jurado who suggests the places, the location of the repeaters systems, even it was signed a record in which the community was compromised to ensure the availability, in the same way, the technical visit to the zone was made with the support and accompaniment of Mr. Jurado.
- The selected place for the establishing of the radio link constituent points must count with electrical energy provision.
- In all the radio link constituent points this condition is accomplished.

- It must exist an access facility in the selected place for the installation of the repeaters systems.
- The San Julian's hill is the unique place chosen for the radio link that doesn't have highway access. A person should walk around 90 min to get there, however taking into consideration that the reliability of the link system is high, this condition is not an impediment for installing there a repeater system.
- The selection of the landmarks for studies and transmission systems must seek zones with the best possible security conditions, in such a way that decreases the damage or robbery risk of the equipment that will be used.
- The place called Munchique's hill has already communications equipment installed for the community program and its construction in where they were installed is quite safe.
- Currently, the place San Julian's hill is guarded by the National Army. However, it is necessary to analyse if its presence will be permanent. Anyway, at present are installed communications systems of Telecom and safe booths.

2 Scheme Radio Link Physical Configuration

The establishing of a certain number repeaters, it was used a free software tool in which starting of the studio location of both stations. Then, it was determined the visual coverage zones that were achieved since those points, as a first conclusion it was found that it did not exist a looking line between both points as the one shown in the Fig. 3a.

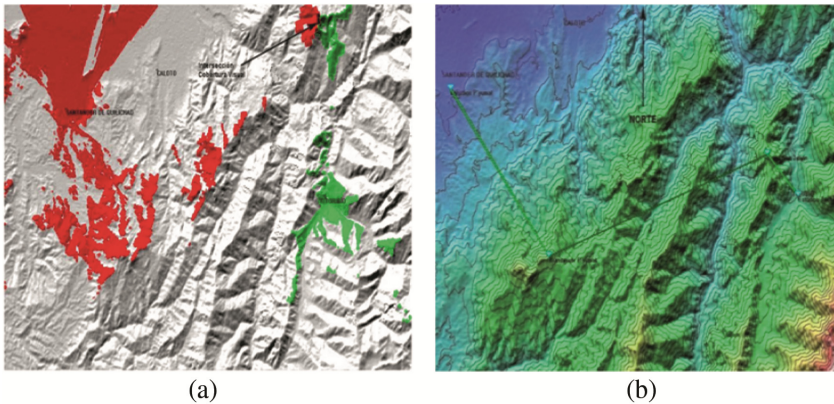


Fig. 3. Visual (a) and coverage area (b) between Santander of Quilichao and Toribio.

In Fig. 3, it is shown the visual coverage from the studio of the station of Santander de Quilichao (Radio Pýumat) this is shown in red and the Toribio's station. Additionally, there is a little area in that was transplanted into both visual coverage areas of each studio and therefore, it was used just one repeater, this area is located far from the wanted link points (23.8 km of the Radio Pýumat studio and 12.5 km from the Toribio studio). Besides, of having a very difficult access to the highway since the nearly road cross is

about 5 km far from the point and it does not exist energy supply because of this, it is not practical to install a repeater there. Taking into account this situation, there were installed 2 repeaters to achieve the link. Then, it is taken like installation place of a repeater the location in which is found the irradiant system of the station Radio Pýumat (Munchique Pequeño) place that counts with electrical energy, access facilities and it is safe.

To set up the second repeater, it was taken the place in that it was going to be located a microwaves system of TELECOM located at 2.7 km from the Toribio studios (San Julian's hill), to reach that place, it must be by walking or riding a horse, it takes around 1 h and 30 min time, the place also counts with electric energy and enough security because it is guarded by the National Army soldiers, so it is also necessary to ask for permission to that institution to reach that place. Both choices to locate the repeater systems has a visual line between itself and at the same time the San Julian hill has a visual line with the place where there will be located in Toribio, Small Munchique studio and the Radio Pýumat Station. The scheme is the radio link physical configuration as shown in Fig. 3

2.1 Establishing the Radio Link Location Sites

The location coordinates of the constituent radio link sites are determined by (Fig. 4):

Datum WGS84 Coordinates		
Geographical	Latitude N 2° 57' 20.64"	Longitude W 76° 16' 4.15"
West Origin Level	X= 818.315 meters	Y= 1' 090.401 meters

Datum Bogota Coordinates		
Geographical	Latitude N 2° 57' 30.9"	Longitude W 76° 16' 16.24"
West Origin Level	X= 818.630 meters	Y= 1' 090.030 meters

Height above sea level:	1697 m
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Datum WGS84 Coordinates		
Geographical	Latitude N 2° 58' 29.4"	Longitude W 76° 17' 11.7"
West Origin Level	X= 820.426 meters	Y= 1' 088.313. meters

Datum Bogota Coordinates		
Geographical	Latitude N 2° 58' 39.67"	Longitude W 76° 17' 23.69"
West Origin Level	X= 820.741 meters	Y= 1' 087.942 meters

Height above sea level:	2262 m
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Datum WGS84 Coordinates		
Geographical	Latitude N 2° 55' 40.3"	Longitude W 76° 25' 15.1"
West Origin Level	X= 815.221 meters	Y= 1' 073.386 meters

Datum Bogota Coordinates		
Geographical	Latitude N 2° 55' 50.57"	Longitude W 76° 25' 27.07"
West Origin Level	X= 815.541 meters	Y= 1' 073.016 meters

Height above sea level:	2462 m
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Datum WGS84 Coordinates		
Geographical	Latitude N 3° 00' 17.8"	Longitude W 76° 28' 52.8"
West Origin Level	X= 823.742 meters	Y= 1' 066.658 meters

Datum Bogota Coordinates		
Geographical	Latitude N 3° 00' 28.06"	Longitude W 76° 29' 4.76"
West Origin Level	X= 824.056 meters	Y= 1' 066.288 meters

Height above sea level:	1079 m
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Fig. 4. Coordinate Munchique Small hill area and transmitter Pýumat, Repeater System and final system.

3 Propagation Budget

The propagation calculations are made based on the recommendations of the ITU-R PN: 525-2. Calculation of attenuation in free space and P.530-9 Propagation data and prediction methods required of a design of terrestrial sight systems [4]. The operating frequency band will be prepared by the Technologies of Information and

Communication Ministry, it is from point-to-point links with a channel width of 200 kHz, 390–400 MHz. It was also chosen a specific frequency of 395 MHz. and 390–400 MHz, as specific frequency of 395 MHz was chosen, however the calculation is performed in a band of 335.4–343 MHz, the frequency changing does not involve changes on the characteristics of the equipment.

The antenna heights were given to have an eye contact line in each link and it must have a clearing of the first Fresnel zone at least of 60% to be determined. (Rec. P.530-9). A software was used to determine the condition and it should take into account the field's profile and radius k factor of the Earth; where k in this case, is taken as $4/3$ and frequency [5]. The clearing condition was especially due to considering the link between studio of Toribio and San Julian Hill in both parts, thus, the condition of both is largely due to geographical conditions.

Once determined the antenna height and secured the line of sight condition, it can apply the equations for calculating a free space loss according to PN Rec. 525-2 and it is related to point-to-point:

$$Lbf = 32,4 - 20 \log f - 20 \log d(\text{dB}) \quad (1)$$

f = frequency (MHz)

d = distance (Km)

The FSPL expression (1) above often leads to the erroneous belief that free space attenuates an electromagnetic wave according to its frequency.

Based on the propagation in free space, we can use the following conversion equation [6]:

$$E = P_t - 20 \log d - 74,8 \quad (2)$$

The Isotropic received power for a given field strength; where:

P_t : Isotropically transmitted power (dB(w))

P_r : Isotropically received power (dB(w))

E : Electric field intensity (dB ($\mu\text{V/m}$))

f : Frequency (GHz)

d : Radio electric path length (km)

Lbf : Basic Transmission loss in free space (dB)

The Eq. (3) relating the field strength necessary to the sensitivity of the equipment is:

$$E = K + V_r \quad (3)$$

The sensitivity, is the minimum magnitude of input signal required to produce a specified output signal having a specified signal-to-noise ratio.

where:

V_r : Sensitivity (dB μV)

K : Antenna Factor (dB/m)

For an input of 50Ω receiver has a factor of antenna:

$$K = 20 \log f - G_{ant} - 29,78$$

where:

G_{ant} : Antenna gain (dBi)

K : Antenna Factor (dB/m)

The budget about radio link between Toribio and Cerro San Julian was determined by an antenna height of 5 m studies in the Cerro San Julian of 10 m and it has to be the clearing of the first zone Fresnel which is 150% so that, the condition for free space propagation is satisfied.

For values of 339 MHz and a distance of 3.03 km losses in free space are in:

$$L_{bf} = 96,63 \text{ dB}$$

The transmit power should consider the cable losses and antenna gain:

For the frequency of 339 MHz ½ inch cable LDF12-50 reference in the catalog presents an attenuation of:

$$A_{cablef} = 1.114 \text{ dB}$$

For a transmitter located in Toribio studios, one wire length of 12 m so, it has an estimated attenuation (4):

$$L_{cable} = \frac{L_{ongcable} * A_{cablef}}{100} = 0.134 \quad (4)$$

It should also be considered the loss connectors which are made of 0.2 dB. Then, the losses transmission line are:

$$L_{lineatx} = L_{cable} + L_{connectors} = 0.334$$

Thus, the power transmitted by taking into account the losses of the transmission line including an antenna gain of 6 dBi:

$$P_t = 10 * \log \left(\frac{10 \text{ watt}}{1 \text{ watt}} \right) - L_{lineatx} + G_{ant} = 15,666 \text{ dB} \quad (5)$$

The equivalent value in watts P_t is known as EIRP (Effective isotropically radiated power) and it is:

$$EIRP = 10^{\frac{P_t}{10}} \text{ watt} = 36,886 \text{ watt}$$

Then, the field strength obtained in the Cerro San Julian to an antenna gain of 6 dBi, a distance of 3.03 km and it is the power calculated above:

$$E = P_t - 20 \log(d) + 74,8 + G_{ant}$$

On the other hand, it must be determined that the field strength should be in the Cerro San Julian to the receiver operates in proper condition, according to catalogs link

receiving equipment have values between 50 μV up to 1000 μV . It works so that the worst case is that, of the highest signal that is required 1000 μV .

Again, taking into account losses transmission line on the receiving side, here the antenna has a height of 10 m, so that the transmission line is estimated at 13 m, then for cable LDF12-50 connector losses of 0.2 dB:

$$A_{cablef} = 1,114 \text{ dB}$$

$$L_{ongcable} = 13$$

$$L_{cable} = \frac{L_{ongcable} * A_{cablef}}{100} = 0,145$$

$$L_{connectors} = 0,2$$

$$L_{lineatx} = L_{cable} + L_{connectors} = 0,345$$

The sensitivity in dB μV from 1000 μV sensitivity value is:

$$Sensitivity \text{ dB}\mu\text{V} = 20\log\left(\frac{1000 * 10^{-6}}{10^{-6}}\right) = 60$$

The field strength required for the receiving equipment is working properly:

$$E_{requested} = (20\log f - G_{ant} - 29,78) + Sensitivity \text{ dB}\mu\text{V} + L_{lineatx} = 75,169 \frac{\text{dB}\mu\text{V}}{\text{m}}$$

Because of this, the field obtained at the point of reception is greater than required conditions, it shows that the radio link for operation are met.

4 Plot Links Result

Then profiles between different points system involving the link values with the calculations are shown below:

Figure 5 shows the result of the 3 km link, this radio link is adequate and allows you to see that it has no problems with the Fresnell zone.

Figure 6 below shows the link from the hill Pýumat to the city of Toribio, it is also observed that the conditions are adequate and therefore the link can work properly without problems.

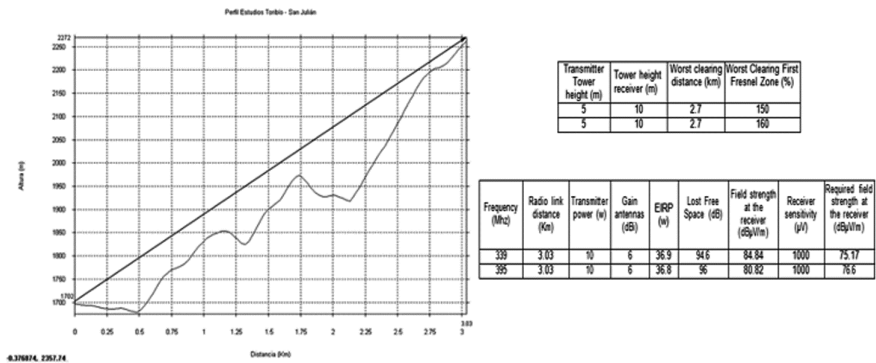


Fig. 5. Link profile and calculations Toribio Studies - Cerro San Julian

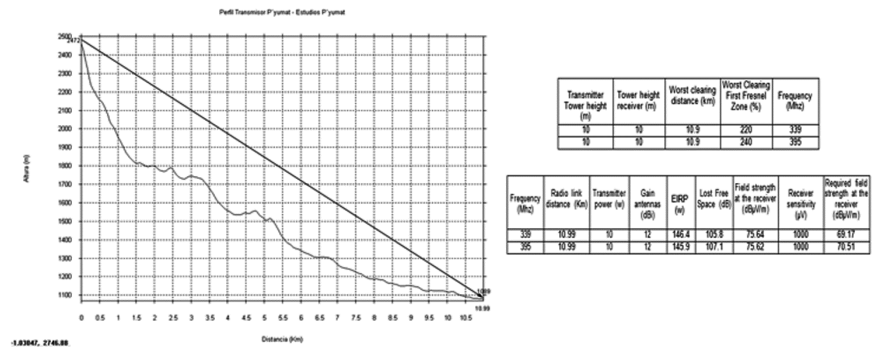


Fig. 6. Link profile and calculations Cerro San Julián – Transmisor Pýmat.

Figure 7 below presents the profile of the terrain. It is possible to see the distance between the hills and the height at which the radio link is going to work. Here we show the utility of the computer tools that allow us to model the behavior of the links and how you can use the technical part with the distance teaching part.

The views of the radio links obtained are as follows land performance:

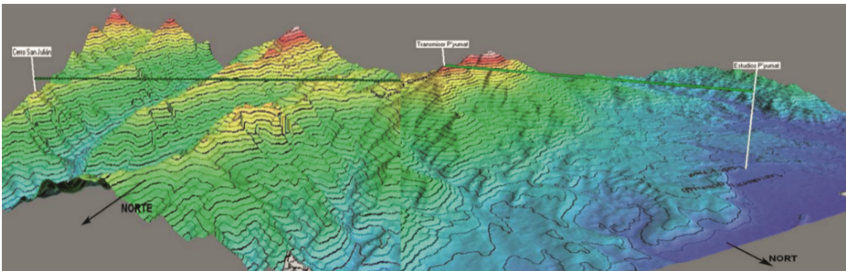


Fig. 7. View full Radio Link.

5 Web 2.0 LMS Tools Proposed to Cauca Indigenous Council

The inclusion and access to Web 2.0 platforms [8] is one of the key aspects in the information age and access to knowledge, the indigenous community of Toribio is located in a rural area of difficult access and does not have adequate access to the Internet connection. After performing the calculations presented above, teaching is done to use the Web 2.0 type tools. To achieve this, the research is performed on various platforms of web sites in the easy-to-use, cheap, widely supported, English and Spanish languages with multiple applications that can be installed quickly and intuitively [9].

The fundamental objective of the radio link is to have a communication with a network layer level since there is currently no connection of this type, once designed outdone by experts from the Universidad Distrital it is possible to teach the Web 2.0 tools, starting with courses of 120 h by using platforms such as: Moodle, Jommla, Jcow, and Commerce.

The best applied Cloud Computing solution for this, has about 14 websites were reviewed in English and Spanish, from which 2 of them were selected in Spanish and with applications in the cloud [10], Nixiweb and Hostinger, Nixiweb are adequate but it has some continuity faults of the site, for instance, Hostinger allows the installation in a few seconds of applications to create sites quickly and safely [11] (Fig. 8).



Fig. 8. View of Web 2.0 Hosting in the Cloud and free use tools. (Source: Hostinger (2016)).

The educational portal e-learning is made with Moodle with all its tool set, in the cloud hosting, it can be clicked and installed in less than a one minute, without using the classic structure with physical servers (Fig. 9).

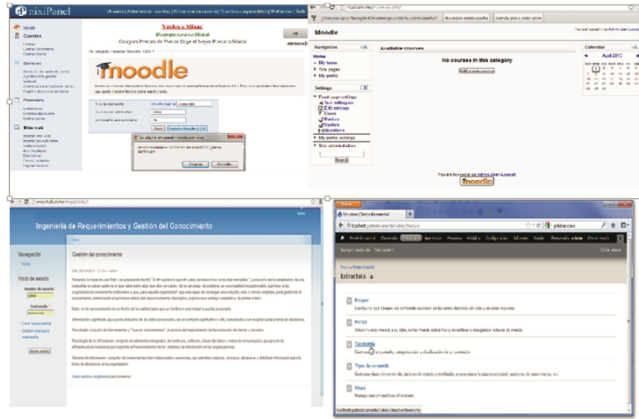


Fig. 9. Examples of learning applications of Web 2.0 Moodle and Drupal tools.

6 Conclusion

The developed radio link work was implemented and it is currently in operation benefit in 16 indigenous reserves, ensuring communication between their native languages and helping to preserve their culture, customs and relations as indigenous communities, a project like this materializes social inclusion of minorities and helps to reduce this digital gap in the nation. In the last two years, thanks to the progress of the peace agreements, there has been a significant advance in the incorporation of Web 2.0 and the use of ICT by the indigenous communities of Colombia and the case of the Region of Cauca. According to this, with the installation of a radio link that has allowed with the connectivity wirelessly and ubiquitously, it is possible to raise indicators related to the use and e-learning of ICT (computer use, Internet access, e-mail and learning Web 2.0 tools). It is also necessary to move towards a new holistic vision of the initiatives, where the policies of technological diffusion by the government of Colombia, all of this can become more relevant and can form part of a broader strategy in which they are linked with policies of innovation, industrial policies, human resource training, IT training and promoting business applications.

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