Application of a Learning Analytics tool to a Moodle virtual classroom

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Abstract

In the last decade Information and Communication Technologies (ICT) emerged and influenced almost all fields: education was not an exception. Their use and development brought with it changes in the learning and teaching processes, but they were oriented towards generation of contents and activities inside traditional or virtual classes. However, an important part was left behind, i.e., all the information that a student can generate. In taking this data, there would be so much information that it would not be possible to analyze it in a simple manner, without high advanced methods of data analysis Thus, the purpose of making a tool that applies Learning Analytics (LA) techniques, collects data, analyzes it and finds behavior patterns that can be used by the administrators and teachers was born. A platform was created then under the programming language PHP with the database sengine MySQL that allows to connect to a virtual classroom designed in Moodle and, based on this, generate statistic graphics about the student's interaction with activities and resources of the course. Graphics are generated for access and presence, use of resources, activities and participation, established communication, traceability in the platform and interaction among people. Each of these allows to make and individual or group analysis by comparing a student to the group progress. Using the LA tool developed, educational processes can be improved because it shows academic progress of students and enables teachers to characterize and monitor students and see in detail their behavior in the virtual classroom. Some aspects are still missing such as prediction and recommendations that the platform must provide to students and teachers.

Keywords: Learning Analytics, E-Learning, Moodle

1. Introduction

Massive collection of data identifies behavior patterns of users or a specific population for multiple purposes, such as carrying out advertising campaigns, identifying interests of people, etc. Yet, technology is in charge of performing this collection data and intends to facilitate it for, among others, categorization and labeling. Actions to which humans have always tended since the beginning of humanity because it provides access to knowledge of one's self and one's environment.

At this point is where the reason for using learning analytics is structured. This is an emerging science that allows to potentiate and customize educational processes of students and academic institutions based on the measurement, collection and analysis of data sources. These sources are widely contextualized, depending on particular interests, to propose, act and refine the same educational methods, following correlations among variables identified, and thus form more complex qualitative conceptions that frame causalities within learning and virtual pedagogical dynamics.

Then, it is a proactive view of the use of data where they are assigned more than a numerical value and the notion that the student has a passive participation in virtual classrooms is put aside. On the contrary, the student is made a constructive maker of their process based on adjustments made by the tutor, teacher or institution through learning analytics. The objective is then to increase and channel the most appropriate tools for the proposed methodologies or build pedagogies that optimally interrelate according to population, identifying a trajectory, as mentioned, a propensity that can be glimpsed in the data and can predict the success or failure of the suggested programs and the resources made available to the students.

Learning analytics is a multidimensional science that integrates educational reality with the exponential growth of data, producing comprehensive, complex environments for constructing knowledge. Additionally, in identifying patterns in students, teachers and aspects of the platform, teaching-learning processes may be customized, just adjusting the resources to deliver as many aids as necessary to promote the use of activities that increase active student participation and therefore maximize their educational process.

The current research has proposed the creation of a tool to measure and collect six factors that, after analysis and at our sole discretion, will allow to produce specific strategies for customizing students' educational processes, namely: (1) access / presence; (2) use of resources (how many times, what resources, how much time per resource); (3) activity and participation (what to do on the platform); (4) established communication (among students, student-teacher); (5) traceability in the platform (where students start, where they end, what they see) and (6) interaction among people.

Human beings, in their continuous and permanent construction process, are associated with the establishment of bilateral relations and socialization processes that put them in a framework of special features. This is related to what Suarez (2003) stated in correlation to education, which he defines as a social process by nature, as an event that, for being involved in a network of mutual influences, is undoubtedly the most human and humanizing event of all social purposes.

Social issues are indivisible from the notion of human and this from the conception of education. Man is a social being by nature as suggested by Aristotle and, therefore, when speaking of the educational process, it cannot occur in isolation. The educational process runs parallel to self-knowledge in its multiple biopsychosocial aspects (biological, psychological and social) and society, which invigorates and changes demand with specific aspects to be maintained operable and for the common good.

New information technologies set a clear standard in the development of everyday activities within cities. There is an invisible consensus among citizen with respect to their constant and, many times, high use; classic notions of physical normality are modified and everything is virtualized. In educational processes, student participation and learning are sought to be optimized with the use of these technologies.

In Colombia, Law 1341 of July 30, 2009 defines Information and Communication Technology (ICT) as "the set of resources, tools, equipment, software, applications, networks and means for the collection, processing, storage and transfer of information, such as voice, data, text, video and images." The guiding principles of this law are as follows: 1) accessibility and use of ICT, 2) fair competition, 3) efficient use of infrastructure and scarce resources, 4) protection of user rights, 5) promotion of investment, 6) technology neutrality, 7) the right to communication, information, education and basic ICT services, and 8. massification of online Government.

Colombia has a Ministry that regulates all actions of educational plans with ICT, the Ministry of Information and Communication Technology (MINTIC by its Spanish acronym), which works in coordination with the Ministry of National Education (MEN by its Spanish acronym). The latter states that: "ICT not only make available to teachers and students large volumes of information, but also promote the development of abilities and essential skills, such as searching, sorting and processing information as well as autonomous learning. They also expand borders by making new resources available and the way of learning with others, including remote communities." (MEN 2009 p. 49).

Globalization as a worldwide phenomenon, technology growth and innovation, and the philosophy of knowledge societies have not only allowed to bridge the gap and bring educational training to places and people where it was unsustainable before, but increasingly include vulnerable populations. We continue thinking of a clear idea: Educating.

According to Márquez (2012), there are clear indexes for exploiting the methodological invention offered by ICTs, such as the high rate of school failure and the diversity and increase in the number of students per classroom, etc. For the author, ICTs and their proper use will allow for an effective, inclusive school.

For Sanchez et al (2009), the counselor or teacher is the one who mediates between students and their self-learning using ICT, enabling the student to assess information, form a critical personal opinion, and feel the maker of their learning.
Marin (2009) argues that "Training and ICT must be characterized by being personalized, flexible and interactive, enhancing thinking processes from a perspective that combines both the academic view of technology and practice" (p.100).

In that vein, new technologies facilitate learning and teaching, streamlining processes without diminishing education quality. The teacher continues to play a special and crucial role, which is to instruct, provide feedback, guide the student and, in this society of information massification, teach to filter information and form a critical view of their context.

Inclusion of ICT facilitates collaborative learning, but also proposes the creation of new information and digital competencies that teachers and students must have to optimize the process.
According to the Network of University Libraries (2014), there are five basic information competencies: 1) Searching information, which defines the need to know what are the resources where information is available to locate it effectively, 2) assessing information, which proposes to filter the selected information critically, 3) organizing and managing information effectively, 4) using, publishing and disseminating information, respecting ethical and legal standards, and 5) keeping up and sharing information in the network.

Information competencies should be part of frameworks governing educational processes in institutions in order to encourage proper and total use of new technologies and ensure a concrete, dynamic, collaborative interaction not only between teachers and students but among teachers and among students.
It is not uncommon to hear in the halls of universities, read in academic texts, or even attend trainings in business and organizational communities about "knowledge society".

This term is associated first with information and technology, where the entire industry is developed nowadays. But its scope extends beyond utilization of the technology gear.

Aristotle (undated) stated, referring to societies, that "all associations aim at some good and the most important of all goods must be the subject of the most important association." This suggests that current macrosociety should have as precept the common good that crosses distances and includes any and all its communities.

Knowledge as a particularity of human beings, is responsible for any and all advances in the history that marks society. Yet, at this specific time, it starts to play a leading role, the primary agent, in an elated and public manner. It is the main topic of world conventions and the ultimate goal, depending on the time.

Alavi and Leidner (2003, p.19 as cited by Flores 2005, p.22) define knowledge as the information the individual has in their mind, personalized and objective, in relation to facts, procedures, concepts, interpretations, ideas, observations, judgments and elements that may or may not be useful, accurate or structurable.

Knowledge is not on a full information plane. Ortega y Gasset (1940 as cited by Adriano 2015) identifies an evolution of knowledge from common sense or popular knowledge to that taught in school, which was of scientific nature. Knowledge, then, can be divided into two: Within a business environment that is often mistakenly transferred to the educational environment, there is tacit knowledge, which expresses what has been learned through personal experience and includes beliefs, own points of view and values; and explicit knowledge, which is expressed through formal language, including grammatical statements, mathematical expressions, specifications, manuals, etc. (Flores, 2005).

Coutin and Perez (2005) argue that information and knowledge are placed as principal elements for obtaining a real competitive advantage in a specific period of time. Materialization of knowledge as a commodity can lead to objectification of the person and it is precisely this vision what education avoids by promoting the opposite: personal identity.

Within the field of education, knowledge is closer to that expressed by Hernandez (2001, p.2) when identified as "the active and interactive apprehension of reality, an activity that is not devoid of an axiological characterization and has historical and social dimensions." Knowledge is constructed by the human being in society and for the benefit of society and here lies one of the main features of the so-called knowledge society, which will be elaborated on in the following paragraphs.

According to Piaget and Inhelder (1975), there are three types of knowledge: physical, logical-mathematic and social. Physical knowledge refers to empirical abstraction of objects in the natural world (taste, length, hardness, weight, etc.). This is acquired by manipulating objects around the individual's environment.
Logical-mathematical knowledge is part of a more complex reflective abstraction. It is knowledge resulting from prior coordination of actions taken by the individual upon objects. As an example, Piaget speaks of seeing three objects, but not seeing the number three anywhere.

Social knowledge, which is a consensus of the immediate context, friends, caregivers, parents and the non-immediate social context and its interpretation.
In addition to the above, not only the immersion of new information technologies, but the comparatively simple manageability they now have with regard to a couple of decades ago, allow to bring knowledge to communities, nations, places where considering the idea was once far-fetched not only in terms of distances, but also because of costs and human resources.

With this notion in sight, it is understandable what a knowledge society is according to Mateo (2006): A knowledge society highlights wisdom and knowledge as the parameters that govern and determine the structure and arrangement of modern society, while also being goods and determinants of welfare and progress of peoples.

Knowledge society is linked to all modifications for humanity, using as main vehicle new technologies that bring geographies together and reduce language gaps, among other particularities. But, prior to knowledge as complex construction of human beings, there is information as raw material. And in this journey of pedagogies and new technologies, there is the term Information Society, which has some key differences that will be briefly explained below.
Therefore, it should be noted that, when describing the age of information, production, reproduction and distribution of information are the founding principle of society (Krüger, 2006). Or as supported by Castell (1999 cited by Trejo 2001), it remarks the work content. It can be affirmed that information society directs its use to employment and production processes in business communities.
It is clear that we currently live in a knowledge society and, although there are shortcomings and weaknesses as seen in developing countries regarding education, optimization is continuously sought. But, when did this change of time and paradigm occur, what supports it and where are its horizons going?
Unesco (2005) describes certain features of the knowledge society. The following lines will briefly describe them.

A knowledge society is a society that thrives on its diversity and capabilities, which means that each society has its various forms of knowledge that should not be relegated but, on the contrary, efforts must be made to involve them in building society.

Knowledge society must ensure shared use of knowledge; this feature is related to the integration of each member, not only in the present but for generations to come. Everyone must have access to knowledge because this is how education is expanded and optimized.

Knowledge societies are not confined to information societies, which denotes that information itself does not form a knowledge society. There must be first equity in their people so that they can interpret this information critically and analytically.

In light of the above, and as a summary, knowledge societies seek comprehensive development, specifically the expansion and optimization of educational processes, and make use of new technologies to do this. It can be said that assertive use of ICTs for this purpose is a social constructivist pedagogical model that, using

concepts such as collaborative learning, can guarantee effective learning in virtual or classroom education means.

With respect to the unstoppable advance of process technologization and a society that reinvents itself day after day, it is necessary to delve into an issue that has gained particular interest in academia in the last decade because of its potential for continuously improving education, i.e. data analysis and learning analytics.

Relevant factors in the knowledge society and its difference with respect to information society have been previously identified. Information as a raw material of knowledge has in turn a source. Information lacks a sense of applicability if not analyzed within an environment or a context that gives it form and substance. The same happens with data if not contextualized, organized, structured and filtered. Their potential was discovered around the 1960s by large organizations that, due to constant monitoring of their customers, obtained in a short time enough data to redirect their marketing strategies and thus increase and position their brands.

According to Han et al (2012), databases and technology information has evolved from primitive system processing files to powerful databases at present.

During the 1990s, the World Wide Web (or WWW) and the technological development of hardware and applications at the virtual level ultimately led to create strategies to have a higher level of information security and repositories became the most protected objects in companies. Therefore, databases became more secure and reliable.

This situation soon became a technological field of information and communication where large amounts of data are handled, causing difficulties in information management, such as capture, storage, search and analysis. This gave rise to the integration of different components and projects that interact together to analyze large amounts of data.

Given the exponential growth of this new force and the urgent need for functional data (turning them into information and then into knowledge), Data Mining (DM) arises to make use of statistical methods in order to find correlations and/or patterns. According to Long & Siemens (2011), DM is the use of mathematical algorithms for the specific recognition of certain factors within large amounts of data, allowing to manage components such as connectivity management, high availability, security, performance optimization, filtering, monitoring, application management, SQL and customized scripts, etc.

Pérez (2008) holds that “data mining tools allow to extract patterns, trends and regularities for predicting standards and/or making strategic decisions” (p. 2). For Talegaon (2014), the analysis of large sets of data allows to discover patterns, unknown correlations and other information that may be useful to make the best decisions.

Then, there is a large amount of data that cannot be processed and/or analyzed by traditional means called big data. Therefore, it can be said that Big Data is the ability of society to level information by employing novel approaches in order to produce knowledge, goods and services of significant value depending on the context.

According to Gutierrez-Priego (2015), expansion of educational technology, implementation of virtual training and use of Internet as a learning tool have provided what is called fingerprints. These, like in the business context, provide data that are increasingly extensive in quantity. Big data in the educational environment are analyzed by educational data mining and/or learning analytics.

Bienkowski et al. (2012) identify a difference between educational data mining (EDM) and learning analytics. For the authors, these two lines complement each other, but their origins have different focuses. EDM develops methods and applies statistical and MD techniques to analyze collected data during teaching and learning.

Learning analytics applies techniques from information science, sociology, statistic psychology, and MD to analyze the data collected during the administration of education, teaching and learning. Learning analytics creates applications that directly influence educational practice.

De Laat & Prinsen (2014) state that SLA is necessary within the educational frameworks developed in social and interaction environments, because it is important to understand the learner's social mobility. If a good analysis of students' activity and connectivity is performed, better opportunities may be provided in learning networks of higher education by, for example, approaching the real needs of these institutions. Instead, LA uses information about learners and learning environments, evaluating, analyzing and proposing real time models for prediction and optimization of the processes of education and educational decision-making (Ifenthaler, 2015 cited by Ifenthaler & Schumacher, 2015).

Learning analytics has the potential to provide learners with substantial feedback to help and improve their understanding and skills. Analytics allows, when introduced deeply into the student learning process, to identify the impact of curriculum and learning strategy, while facilitating individual progress (Macfadyen et al, 2014).

Long and Siemens (2011) state that learning analytics is "the measurement, collection and analysis of information reported on learners and their contexts for the purpose of understanding and optimizing learning processes and environments." The authors hold that this line allows large quantities of information to make sense. Friesen (2013) highlights that the improvements that LA could make (in relation to the optimization of learning processes) relied on the definition of patterns, which in turn is based on the decisions of on-line platform users.

Gewerec et al (2013) claim that through LA tools it is possible to find out what is happening in the "black box of the process conducted by students in the virtual environment of the social network, using friendships and content of the activity logs of students' blogs"(p. 58).

Lukarov et al (2014) refers to the importance of being clear about what is being looked for in the data; giving a sort of context becomes important when looking for correlations or patterns.

Then it is important to monitor and analyze the teaching process, not only because it is a mechanism to give academic, administrative and training guidelines, but also because their results contribute to decision making, using tools that help them adapt to training plans or resources. The tool built contributes to the collection and analysis of data generated in the virtual classroom, defining goals for both the student and the teacher. It also generates the Key Performance Indicator (KPI) to prepare final assessment reports. Based on this, the teacher can choose better the topics that will be covered in the classroom, guided by the learning styles of each student. The use of LA techniques allows to obtain information that facilitates the acquisition of deeper knowledge of students using on-line and/or mobile teaching systems, thus customizing learning and adapting it to the progress of each student (Martinez, 2013).

To improve the tools that measure the degree of knowledge of each student with mechanisms that provide teachers with information on levels of competencies in specific areas and the real situation of each student, a virtual classroom, where the strategy is qualitative assessment, is designed to measure login statistics, study preferences, and topics where greater risks are present.

2. Material and methods

The inclusion of agile methodologies in short projects has brought the benefit of including the user as a more active agent in the development of software, while traditional methodologies emphasized process control through a rigorous definition of roles, activities and artifacts, including modeling and detailed documentation, which is the reason why they are very effective in large projects. However, for changing environments such as those handled today, they are not very useful. Instead, agile methodologies provide a simplification of timelines but preserving practices of traditional methodologies, i.e. without losing quality. For this reason, this project was worked with an agile methodology.
Extreme programming. This practice arises from agile methodologies to develop customer-oriented systems. It is based on feedback for programmers, analysts, designers, users and computers; therefore, it is performed

cyclically, these cycles being more rapid and more intense and providing more and more information. The main objectives of this methodology are to create a global system plan, to develop and release the software rapidly, and then to revise it continually to incorporate additional features. Fig. 1 shows the interaction in the process of software development, using the XP methodology.

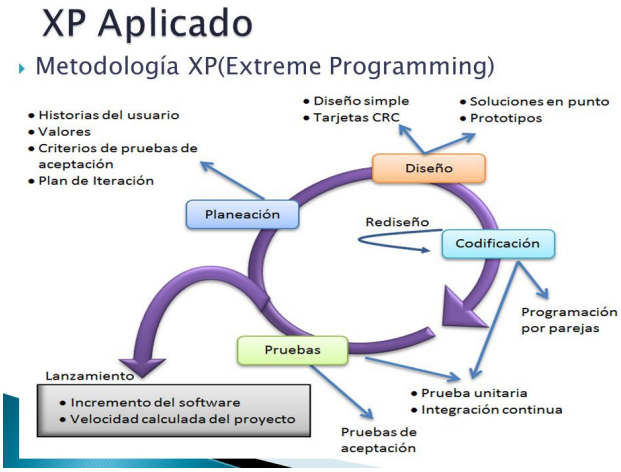

Fig. 1. XP methodology. Source: González C., 2012.

[Traducción de la imagen: XP aplicado = Applied XP / Metodología XP = XP methodology / Planeación = Planning / Historias del usuario = User stories / Valores = Values / Criterios de pruebas de aceptación = Acceptance test criteria / Plan de iteración = Iteration plan / Diseño = Design / Diseño simple = Simple design/ Tarjetas CRC = CRC cards / Soluciones en punto = Spike solutions / Prototipos = prototypes / Codificación = coding / Rediseño = refactoring / Programación por parejas = pair programming / prueba unitaria = unit test / integración continua = continuous integration / Pruebas = testing / pruebas de aceptación = acceptance testing / lanzamiento = reléase / incremento del software = software increment / velocidad calculada del proyecto = Project velocity computed]

Based on the XP methodology, the application was developed according to the following cyclic stages: Planning, Design, Encoding and Testing.
For the modeling of user requirements, a tool called Enterprise Architect was used, which has large high-end capacities to help manage information, rich on the whole and in features. This makes the tool very suitable for modeling any system and serves as specification, visualization and documentation language of the software.
The application was developed in the programming language PHP as it allows to create dynamic web pages, is easy to connect to the Moodle virtual classroom and was used as MySQL database engine. The interface, on its home page, shows interesting news for teachers and students as well as contact and registration links.

Application modules

Information. Information of application operation is shown here.

Fig. 2. Information module. Source: The authors.

Access/Presence. Individual statistical graph by group of time spent by students in the virtual classroom.

Fig. 3. Access/Presence. Source: The authors.

Use of resources. This option displays which resources are consulted by students, individually or by group.

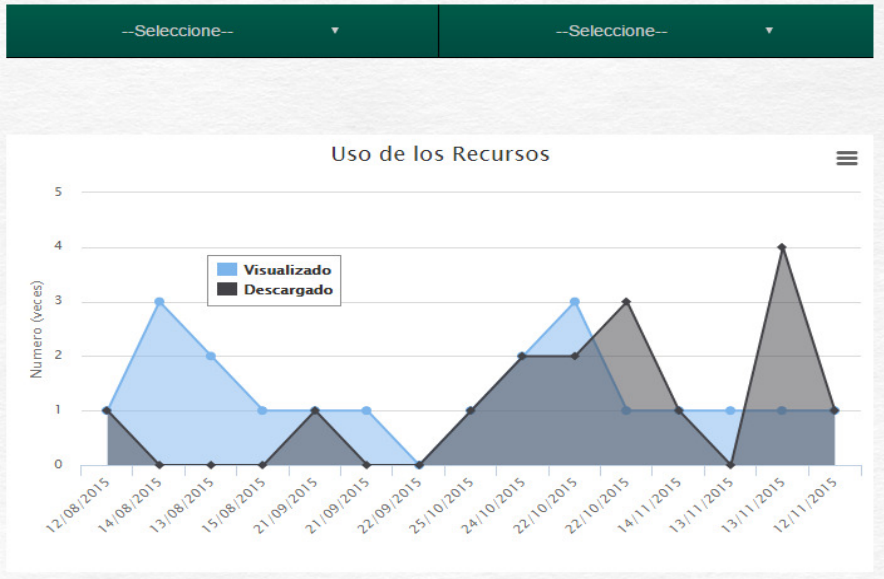

Fig. 4. Access/Presence. Source: The authors.

Activity and participation. This page shows activity, percentage completed by the student, date on which it was posted, date on which it was finished, and closing date of the activity.

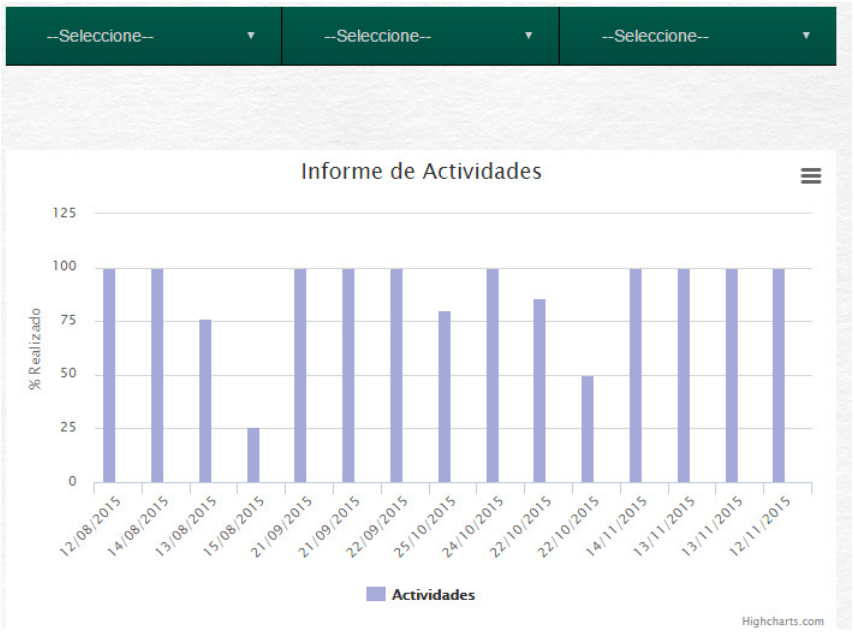

Fig. 5. Activity and participation. Source: The authors.

Communication established. This page shows the type of communication established, which can be a message, mail, forum or chat, and whether it was synchronous or asynchronous (one-to-one, one-to-all, all-to-all), date of communication, and number of messages.

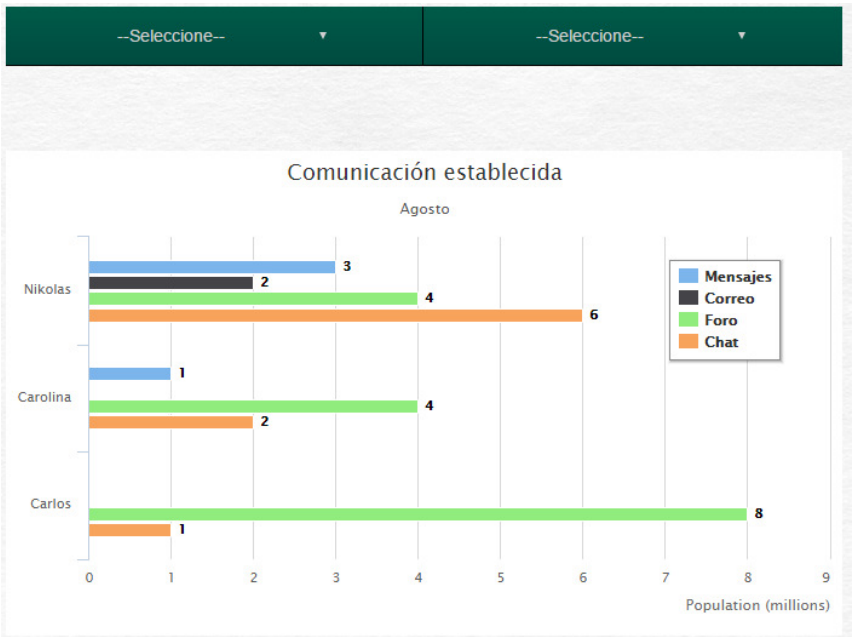

Fig. 6. Communication established. Source: The authors.

Traceability in the platform. This module shows traceability of the student in the platform, from login to interaction with resources, chats, etc.

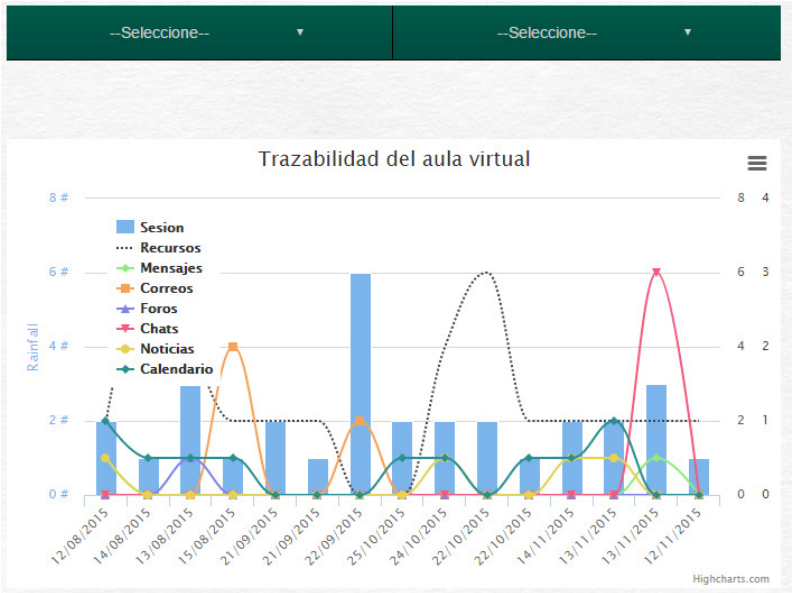

Fig. 7. Traceability in the platform. Source: The authors.

Interaction among people. This page shows the type of communication established, which can be a message, mail, forum or chat, and whether it was synchronous or asynchronous (one-to-one, one-to-all, all-to-all), date of communication, and number of messages. Unlike the communication page, this specifies the individuals who were involved in the communication.

Fig. 8. Interaction among people. Source: The authors.

3. Results

Having applied the tool developed on a virtual classroom, the finding were as follows:

- The tool fulfills the initial purpose of learning analytics, i.e. to display data. It presents six items graphically: Access/Presence, Use of Resources, Activity and Participation, Established Communication, Traceability in the Platform and, finally, Interaction among People.
    - Access and presence: This option allows to know what hours are most used by students to connect to the virtual classroom and how many minutes on average they stay connected. It initially shows the total by group, but allows to compare the student with the group and filter data by month.
    - Use of resources: This module allows to see graphically what resources are most consumed by students, which is useful for the teacher to characterize the group he/she has in the virtual classroom.
    - Activity and participation: This module shows in what kind of activities students involve: forums, chat, messages, wikis, glossaries, etc. The purpose of all this information is to help the teacher in charge of the course make decisions geared towards improvement.
    - Established communication: This option shows with whom and by what means the student communicated with his/her peers and whether the student prefers to communicate with their peers through messages, forum or chat.
    - Traceability in the platform: This module allows to see graphically what the student does and where the student goes after logging into the virtual classroom. This module helps identify which section the student visits after entering the virtual classroom: Resources, activities, news, notes, etc.
    - Interaction among people: This modules allow to identify with whom the student communicates more, the teacher or a specific classmate.

It should be noted that the tool was used only in one virtual classroom as a test to validate its operation. Therefore, it would be hasty to assert and show some results that maybe in another course will not be as obvious as in the one it was applied.

Clearly, as a resource in the teaching-learning process, the tool offers solutions because it enables teachers to carry out an initial characterization of their students. This information is not directly provided by virtual

classrooms within their report options. Thus, it is useful for teachers to have these graphs that allow them to know the habits of their students and, based on this, develop strategies to improve and strengthen the process.

The tool does not have a feedback process yet that enables communication between teacher and student. Teacher's feedback to students is vital because he/she is in charge of guiding them in their training process.

Discussion and conclusions

The tool is in the first phase or stage of Learning Analytics. For now that was the purpose, but the authors are clear, and so is stated in the objectives sought by LA, that data alone are not significant. The second stage is oriented towards diagnosis (analyzing the data collected) and prediction (not just limit ourselves to analyze the data but to predict what may happen with a particular student based on this analysis). Finally, the prescription stage (aiming at providing personalized guidance to each student, according to the individual analysis of their data in the virtual classroom).

The tool is useful for both teachers and students; for teachers, because it helps them characterize their students in the virtual classroom and, based on it, take some steps and make corrections to the teaching process; and for students, because it allows them to measure their performance graphically, compare themselves with their peers, assess themselves and use it as a challenge for improvement in the case of low achievers.

The authors are clear that, regarding LA, there are some items that are critical and controversial, such as the ethics of data collection and their analytics. It is understandable that these issues always give rise to discussions about how appropriate it is to collect and analyze data of students in virtual classrooms.

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