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Visualization of indicators of teaching activity in online education as support for formative evaluation

Visualización de Indicadores de actividad docente en educación en línea como apoyo a la evaluación formativa

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Abstract

Online education has had a significant growth and evaluation of learning, the system and the teaching activity to assess its success is particularly relevant. The latter has been evaluated in the literature based on indicators of teaching activity that come from the face-to-face modality, which restricts its scope. Therefore, indicators of teaching activity that respond to the characteristics of the modality are required, indicators that consider the data stored in the databases of the used digital environments and, simultaneously that these are presented to the teachers in a comprehensive way to contribute to his training regarding his execution. Thus, the present work has the objective to determine the use of the visualization of formative indicators describing two indicators, the estimated working time in the platform and the dialogical teacher-student interaction in the platform. We analyzed data on the activity of 146 teachers and 3,556 students in a period of 18 weeks with 18,592,774 records on the platform. Heat map visualization techniques and network analysis were used. They allowed us to observe the time the teacher works in the platform with respect to their hired time, as well as their interaction in an understandable way regarding their position compared to others. Finally, it is considered pertinent to use visualizations of the indicators in the platform as formative feedback for teachers. It was found that teachers can have among one and nine subjects, with an average of 4.77; between four and fifty-six curricular hours. The percentage of the dedicated time during the semester was 38%. Also, the percentages of time in the virtual environment were classified into four ranges, "very low", "below expected", "good" and "very good". Four teachers stood out from these ranges, with 113%, 134%, 267% and 473%.

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When mapping the network in three degrees of separation we found 2,103 nodes (63% of the nodes) and 16,438 edges (80% of the relations); with four degrees of separation we found 2,863 nodes (85% of the nodes) and 20,297 edges (99% of the relations).

Keywords: Evaluation, online teaching, activity indicators, visualization indicators, visualization techniques

Resumen

La educación en línea ha tenido un auge significativo y cobra especial relevancia la evaluación de los aprendizajes, del sistema y de la actividad docente para valorar su éxito. Este último ha sido evaluado en la literatura a partir de indicadores de actividad docente que provienen de la modalidad presencial lo cual restringe su alcance. Por ello, se requiere de indicadores de actividad docente que respondan a las características de la modalidad, que aprovechen los datos almacenados en las bases de datos de los entornos digitales utilizados y, simultáneamente que estos puedan ser presentados a los docentes de forma comprensiva para contribuir a su formación respecto a su ejecución. Así, el presente trabajo tiene como objetivo determinar el uso de la visualización de indicadores formativos describiendo dos indicadores, tiempo estimado de trabajo plataforma e interacción dialógica en plataforma docente-alumno. Se analizaron los datos de la actividad de 146 docentes y 3,556 alumnos en un periodo de 18 semanas con 18,592,774 registros en plataforma. Para el análisis se utilizaron técnicas de visualización de mapa de calor y el análisis de redes que permitieron observar el tiempo que trabaja el docente en la plataforma respecto a su tiempo contratado, así como su interacción de manera comprensible respecto a su posición frente a los demás. Finalmente se considera pertinente el uso de visualizaciones de los indicadores en la plataforma como retroalimentación formativa para los docentes. Se encontró que los profesores pueden tener a su cargo entre uno a nueve asignaturas, con media 4.77; entre cuatro y cincuenta y seis horas curriculares. El porcentaje de tiempo a lo largo del semestre dedicado fue de 38%. Asimismo, los porcentajes de tiempo en el entorno virtual fueron clasificados en cuatro rangos, "muy bajo", "abajo de los esperado", "bueno" y "muy bueno". Cuatro docentes sobresalieron de estos rangos, con 113%, 134%, 267% y 473%. Al graficar la red en tres grados de separación encontramos 2,103 nodos (63% de los nodos) y 16,438 aristas (80 % de las relaciones), con cuatro grados de separación se encontraron 2,863 (85 % nodos) y 20,297 aristas (99 % de las relaciones).

Palabras Clave: Evaluación, docencia en línea, indicadores de actividad y visualización, técnicas de visualización

Introduction

In recent years, there has been a growing number of educational modalities mediated by technology, such as blended learning education, mobile education. This fact has not only transformed the way in which the teaching and learning processes occur, but also transforms the roles of the people involved and the ways in which both parties' performance can be tested. The teacher becomes especially relevant in online education, since many questions have been raised regarding the role of the teacher in the online classroom. Solutions

from other educational modes cannot compete with the possibilities provided by a digital classroom. In the opinion of Zapata-Ros (2013, 2014 and 2015), the problem with the teaching activities is that they are not visual elements. This is a main political concern, because it makes it difficult to set a standard.

On the other hand, when trying to respond to these concerns about the online teaching activity, it becomes evident that the imported proposals of the teaching evaluation in the face-to-face mode are not enough to explain the activity of these actors. and therefore, make decisions regarding its execution.

Faculty of online education should respond to requests for changes so its functions and roles are transformed to fit the modality. It is very important to identify the online teacher's performance level, because they must have specific characteristics (Goodwin, 2010).

Because of the requests for change, alternative methods are presented to ensure the academic quality of online education. Elements questioned include student opinions, course instructional quality, or academic achievement tests (Rubio, 2003;) Belt, 2004; Abdous, 2009; Fields, 2009; Jung, 2011; De la Garza, Vinuesa & Zermeño, 2015; Martinez, Cegarra & Cepeda, 2015; Mengual, Roig & Català, 2015; Mejía & Lopez, 2016; Melendez, Roman, Pérez & Maldonado, 2017; Stracke, 2017). In this context, organizations responsible for rating higher-education institutions propose and offer models, criteria, indicators, and standards of quality for online education (Rice, Pace & Mellard, 2017).

This wide variety of proposals is, of course, aimed at improving evaluation, as it is a substantive element that optimizes the way online classes function, as well as the relationship between the students and teacher. As a result, the proposals become a source of information for decision making and intervention for the improvement.

Within the aspects of quality evaluation, teaching attributes and associated activities are considered fundamental (Van Duzer, 2002; Branch, 2007; Kebritchi, 2014; Guitert, Ornellas, Rodríguez, Pérez Romero & Romeu, 2015; Boettche & Conrad, 2016; Cabero, Llorente & Morales, 2018). The quality of the information and decision-making depends on the instrument and sources of information, the most common of which are teachers, students, institutional authorities, peers, and experts, although there has been discussion about what they measured and how the data was collected and interpreted (Fernandez & Coppola, 2010; Reyes & Rueda, 2016; Tejedor, 2016).

Due to the objectivity of these scenarios, it is crucial that the activity indicators utilize the masses of data generated, stored, and supported by Information and Communication Technology (ICT). These indicators also support the scale of growth of online systems' automatic processes.

It's deemed appropriate to make use of visual techniques that help users decode simple analyzed information. "Data visualization" is the area that lies between mathematics, computer science, and cognitive science and has a series of algorithms ranging from the simple to the complex (Telea, 2014) which seek to facilitate the representation of the analysis of one or more variables.

Roles of the teacher in online education

In online education, the role of the teacher has been redefined. The teacher is presented as a facilitator who acts as mediator between the students and their ability to achieve the proposed objectives. The teacher guides the usage of available resources and promotes the learning of module content to do well on evaluations. Thus, the role of academic staff is reconceptualized through alternative educational positions online.

Through feedback, mentoring, and advice, the teacher promotes and maintains the necessary processes to encourage the improvement of the educational system. The teacher is also in charge of designing highly interactive learning activities to increase the quality of their knowledge in their professional environment, as well as the personal development of pupils (Garrison, 2011).

Even though the teacher is very important, they do not play the main role in online education; they are in charge of facilitating the learning process.

Depending on the activities that the teacher creates for the class, they are able to identify a group of desirable attributes and different ways they can function for the class. In this regard, several authors who have made proposals regarding ways the online teacher should function. These functions are closely related to the characteristics of a scenario in which they promote collaboration; meaning that the scenario is interrelated with other scenarios and saturated with information (lawns, Brenes & Solano, 2010). Also, to be considered are the characteristics of the educational modality, which is directed toward the student population.

Therefore, teachers must possess clear and defined functions to carry out their activities considering pedagogical and technological aspects. In addition, the teacher must take into account that when the teaching/learning process is being developed, they must promote an environment in which to interact, communicate, share, and of course, build knowledge.

Shown in table 1 are the main functions carried out by teachers, recognized by various theorists.

Table 1.
Roles of the teacher in online education

	Author								
Function/ Role	Paulsen (1992)	Berge y Collins (1996)	Adell (1999)	Gisbert (2002)	Jonassen (2000)	Llorente (2006)	Urdaneta, Aguirre y Guanipa (2010)	Garrison (2011)	Quiroz (2011)
Social	X	X				X	X	X	X
Pedagogical		X	X	X	X	X	X	X	X
Organizational	X	X	X	X		X	X	X	
Technical		X	X			X	X		
Tutoring			X		X	X		X	X
Evaluation			X						X
Motivation	X				X				
Materials design			X	X					

As seen in table 1, there are coincidences within the proposals of authors who have tackled the subject of teaching in online education, which affects the educational and organizational functions, since both are essential to enable students to develop their activities. Other functions include tutoring, social and technical. Functions such as assessment and materials design appear less frequently, possibly because they are already included within the previously referred pedagogical and organizational functions, respectively. In addition, other theoretical proposals presented the role of moderator as a more specific function directly related to the teaching/learning process (see table 2).

Table 2.
Main actions of teachers in its role as moderator

Author	Role of the moderator
Ryan & Hall (2001)	• Pedagogical • Technical
Barberá (2001)	• Preparing the discussion • Articulating the discussion, the transitions, and giving feedback • Closing the discussion
Salmon (2000)	• Access and motivation • Socialization • Sharing information • Knowledge building • Development

Table 2 specifically shows the role of the teacher as a moderator of the discussions on the themes of the course. Therefore, it highlights that constant interaction between the teacher and students is especially important, since that's what creates a sense of motivation. Feedback from the teacher

helps to improve aspects of students' learning, creating an atmosphere and language of friendly conversation that is closer to a personal relationship (covers, 2014).

According to Alvarado (2014), the constant presence of the teacher in the learning environment is essential because it allows interaction with students, as well as the feeling of not being abandoned. Such presence is not only beneficial for students, but also for the teacher, who can be made aware of questions that students pose, evaluate tasks, moderate conversations, and perform other functions.

This in turn creates the opportunity for teachers to reflect on their practice, allowing them to project into the future and thus anticipate situations that may occur.

Therefore, it is considered that, to make the process of teaching and learning from the technological mediation, it can be a new alternative of evaluation for the teacher, from the creation of tools and techniques that analyze large datasets of data that have registered. In this regard, it is pertinent to develop research on new forms of assessment deemed functions performed by teachers in this mode (Zapata, 2013). In addition, these techniques should systematize so that the analysis of data and information are carried out in an automated manner.

In this same line, Buckingham & Ferguson (2012) argue that assessment process must collect, measure, analyze and present data on teachers and its activity, with the purpose of, first understand and then try to optimize your practice.

Evaluation of the educational online activity

To redefine the role of the online teacher also transforms the way in which their activity and other functions are monitored. In this case, the evaluation should not be conceived as an institutional surveillance strategy to control the activity of the teachers; rather, it is intended as a way to promote and encourage their practice.

This way, we create the evaluation of online teacher's activities as a way to review and follow their functions with the purpose of improving their practice. It is necessary to bear in mind that, due to the characteristics of this educational modality, monitoring online teacher's functions is more complex than monitoring face-to-face teachers.

In the literature, we often see the use of evaluation indicators for traditional teaching, applied to online teaching. This does not favor the online teachers or allow for objective observation of productivity in online scenarios mediated by technology; for example, self-reports or the use of portfolio. Because of this, it's considered necessary to identify and create techniques and procedures based on the data generated at the teacher's workplace; i.e., in virtual environments to address the functions performed (Silva & Figueira, 2012; Alvarado, 2014).

Some analysis techniques commonly used to study the online teacher's functions emerged from analysis of face-to-face interactions, the availability of media and resources, and asynchronicity of the registration of non-verbal interactions and multiple temporary scales (Suthers, Vatrapu, Joseph & Dwyer, 2006). This makes evident the need for methodological techniques that take advantage of large amounts of information produced in the digital media within which the educational activity is carried out.

During learning processes mediated by technology, many actions associated with chosen activities are registered. Authority figures and teachers typically miss these data, which could be used to encourage a formative evaluation. The problem is that the volume of data accumulated on the platform is difficult to treat with standard techniques, so teachers and authority figures are limited due to the lack of experience for the treatment of the data and therefore cannot monitor or make decisions about the educational process with the wisdom of accumulated records (Ellis & Mansmann, 2010).

In this sense, they require techniques and procedures that allow the analysis of large amounts of data, as well as better and more effective ways to understand and analyze it. At the time, they are allowed to act on their findings immediately, in real time, with respect to the activity of the online

teacher. Gašević, Dawson, & Siemens (2015) report advances relevant to this topic, although they warn that there is a disconnect between research and educational applications in the classroom.

Display of training indicators of online educational activity

Databases are the record of teaching, but they are usually disregarded. At first glance, they do not offer information that can immediately be understood by all viewers. The 2013 Horizon report synthesizes interactive data sources (e.g. forums) data, navigation data, relational data (social network analysis techniques) and context data (Johnson et al., 2013), and in 2017 voiced the need for change in the teaching role (Becker, 2017).

In addition, authors such as Persian, Pozzi & Sartri (2009), Papamitsiou & Economides, (2014); Hernandez, Martinez, Pardo, Muñoz & Rodriguez, (2018) have reported research in technology-mediated learning environments and show that computer systems offer advantages for research and management of these environments and record the events and actions of people involved in order to monitor, evaluate and understand the processes of learning in online education.

However, this supports the thesis of Gašević, Dawson & Siemens (2015), regarding the relevance of the creation of analysis methods to identify patterns about the participants' activity, not only to help assess and understand the dynamics performance of proposals of education online (Hrastinski, 2008) but also to track and plan strategies for improvement.

For example, the techniques and methods are used to analyze large datasets learning and academic analytics (Gomez, Garcia & Theron, 2014), with the goal of monitoring online teachers and students, which makes it possible for their lesson schemes to meet performance standards with respect to the analysis of the teaching/learning processes. Previously recorded data can be used to enable the identification of patterns, as well as the creation of predictive models.

From the analysis of data recorded from online academic scenarios, we can identify the type of interaction that occurs between the teacher and each student and the time taken to evaluate assignments, and the amount of time spent on the scenario, which together become fundamental indicators of other scenarios that can be carried out.

The adoption of these techniques allows educational institutions to develop the ability to act appropriately based on data and methodologies together as visual analytics. In this sense, the visualization of data and the corresponding analytics is an emerging field and its implementation makes use of visually appealing interactive interfaces, which stimulate the analytical approach (Thomas & Cook, 2006). Analytical data is combined with visual representations, interaction techniques, and content, allowing the user to access a resource that simplifies huge amounts of information (Gomez, Garcia & Theron, 2014).

Visual analytics integrates both the analytical capabilities of the computer and the capacities of the individual. This makes it possible to make novel discoveries and empowers people to take control of the analysis process. Thus, this technique sheds light on hidden and unexpected information, which can lead to a beneficial and profitable innovation (Ellis & Mansmann, 2010).

Visual analytics makes use specific techniques such as the spiral timeline, word clouds, heat maps, social network analysis, curriculum mapping and customization, adaptation, and prediction and adaptation of educational designs over short periods of time (Siemens, 2010; Gomez, Garcia & Theron, 2014). They offer clear and understandable information about the interactions between students and teachers, the use of tools arranged in the virtual learning environment, temporary presence, abandonment, and dropout, among many other elements (Johnson et al., 2013).

If the elements proposed by Johnson et al. hold true, they are attractive due to the wide range of data they generate in an online system. These procedures and calculations are of little use if they are not used as a form of feedback to the people immersed in the context analyzed. Although the institution develops assessment methodologies to calculate indicators of online teaching activities, the effectiveness of these begins with deci-

sion-making and direct institutional feedback to the teacher regarding their job performance. This is an invaluable formative training for teachers.

In this sense, Gomez, Garcia & Theron (2014) argue that advances in the creation of techniques and procedures for visual representation of data are closely related to the complexity of the data used. Visual representations are used to understand events that are not observable to the naked eye, in this case the records generated by the actions of users since its abstract form is transformed in such a way that the managers of the institutions, as well as students and teachers, can observe and understand the information represented.

Examples of this are the works of Heer & Agrawala (2008); Silva & Figueira (2012); Muñoz, Delgado, Rubio, Grilo & Basto (2017) and Liu et al., (2018) about the graphic representation of the interactions between teachers and students in virtual forums based on the analysis of social networks and established relationships.

In this sense, and for this work, use as technology-based visualization of networks for the tie-in Dialogic interaction indicator, from technique the sociometry and in particular the analysis of social networks; which focuses on the analysis of the structure of human groups, organizations and any other kind of system that can be represented as a cohesive grouping by connections of some kind (Han, 2015).

In this project, we used a technological base to visualize the network showing the indicators of dialogical teacher/student interaction.

Network analysis is considered a data visualization technique because it emphasizes structural pattern recognition and simplifies the understanding of the phenomena analyzed using a graph that functions as a condensed product topology set apart from any previously defined pattern

Considering these arguments, the objective of the present study is to describe indicators of educational online activity studied through visualization techniques. The goal of this is to contribute to a formative evaluation that meets the target described within two indicators of teaching activity: the estimated amount of time spent working on the platform and teacher-student dialogic interaction on the platform. The present study was conducted using records observed regarding a population of online Bachelor's degree teachers who carry out their activities on an institutional platform.

The indicators come from a proposal of formative assessment to for online teaching. They form part of a group of five indicators created ad hoc based on the selection of data such as time, identification of participants, groups to which they belong, who writes and receives messages, and types of activities done within the environment. These indicators can be calculated by selecting and combining variables.

These indicators are based on the data recorded in the online environment where teachers perform their main functions. Said data is analyzed using learning analysis. It is essential that the teacher can access the results, so viewing techniques allow easy-to-read representation. In this way, the teacher obtains a formative evaluation which does not seek to reward or punish, but provides elements that empower teachers to reflect upon and improve their activities.

Materials and Methods

Participants

Institutional authorization was given to access records regarding 18,592,774 instances of online activity of an online bachelor's degree program. These records are composed of the participation of 3,556 students and 159 teachers in 756 classrooms (distributed over nine semesters). 621 are regular classes and 135 apply specifically to the degree sought.

Online degree enrolls in a school form online, i.e., their activities are mediated by an educational platform and this requires the student's rhythm and regular deliveries distributed throughout the school range.

Due to the nature of an online bachelor's degree,

all of the activities are mediated by an educational platform that requires the student to maintain a consistent rhythm.

This study uses a sample as used all records generated on the platform by the participant population, when of was calculate each indicator analysis variables were selected. That is, while they were used for the first indicator (time) times reported between one and the other activity; to the second indicator used records with respect to messages between students and teachers.

This study does not use a sample of a population; rather, it uses all records generated on the platform. Variables to analyze were selected for each indicator; time spent on the platform and teacher-student interaction. Results were then calculated.

Study design

The design is longitudinal and covers 18 weeks of work, corresponding to the duration of the school semester. The first week corresponds to academic planning, the following 16 are devoted to coursework, and the last week is used to conclude the course.
The study design has an exploratory scope, which presents displays from two indicators of educational activity. These indicators were developed from an extensive documentary research on the quality of online education.

Instruments

The two visualizations that are described here are based on the two indicators presented and are part of the instrument that forms the "List of indicators of teaching activity" deriving from the conceptual delimitation of 1188 documents on educational quality online from 2006 to 2016 in the Web of Science database, which validates the content and construct. Finally, indicators are manufactured from records automatically used by the servers of the analysis community, which has ecological validity.

Therefore, the following indicators were used:

1. The amount of time estimated working on platform (calculated using the teacher's actions, with a buffer time of 30 minutes between one action and the next).
2. The amount of teacher-student dialogical action, which refers to the percentage of received messages and the percentage of messages sent by the teacher in a dialogic scenario such as, but not limited to, platform forums.

For the calculations, the learning analysis technique was used, meaning that the measurement, collection, analysis and presentation of data about the participants, their environment, and interactions were generated on the platform.

Activity logs were automatically stored in MySQL, an open-source database management system. Every participant interaction that occurred in the learning environment (Moodle) was recorded there.

Activity logs were analyzed initially by SQL (Structured Query Language) and later put into a spreadsheet (OpenOffice Calc) and an open-source social network analysis program (Touchgraph).

Informed consent

Consent was obtained in two ways:

1. Accepting the conditions of use of the educational platform. Conditions of use included (among other things) acknowledging the unique software design and that all interaction in the program is recorded, and consenting that interactions are susceptible to analysis for educational research and improvement purposes.
2. The Bachelor Program academic administration authorization to use, analyze, and publicize results, provided any allusion to the participants' identity be omitted.

Procedure

Two visualization techniques were used to implement formative activity for the two indicators (estimated time spent on platform and teacher-student interaction records). These indicators are part of a four-indicator general proposal, in

which is given the time elapsed between activity completion and feedback. Results were obtained from arbitrary periods such as a week, month, or semester.

To make the visualization of the indicators, the analysis was divided into three steps:

Stage 1. Selection of records

The records were extracted with MySQL SQL spreadsheets, from which the records necessary to develop the two indicators (time spent on platform and teacher-student interaction) were selected.

For the first indicator we considered the teacher's identification records, the date, and the subject. The records corresponding to the teacher's identity, the module, the student's identity, and the date were considered for the second indicator.

Stage 2. Calculation of indicators

Visualization of the indicator for time spent on the platform

For the display of this indicator only data from 146/159 online teachers was considered, because the remaining 13 presented inconsistencies in the records of the platform. Additionally, the calculation took into account the number of contracted hours each teacher had. A buffer time of 30 minutes between action (between one click and the next) was given for each teacher. The hours the teacher spent in the classroom, not the number of subjects they taught, was considered.

Visualization of the indicator for teacher-student interaction

To create a topological representation of teacher-student interaction, the total number of registered users (teachers and students) on the platform (3734) and the number of logins into the platform were entered into a table.

Stage 3. Visualization of indicators

At this stage, we created the visualization of the indicators using the data obtained. A spreadsheet and the tool, which visualizes social networks, were used.

Results

Below are results and a visualization of the "estimated time spent on the platform" and "teacher-student communication rate" indicators, coordinating respectively to the visualization techniques of heat maps and social network representation.

Indicator visualization for "estimated time spend on platform"

We found that teachers may have a minimum of 1 class and a maximum of 9, with an average of 4.77; This means that the minimum time worked per week is 4 hours the maximum 56 hours.

The time each individual teacher spent in the virtual classroom during the week was compared to his or her contracted time. The average time worked each week for all teachers was also calculated, and finally the general average was calculated, with the result that only 38% of all contracted time was spent in the virtual classroom.

The visualization of these percentages based on data obtained is presented on a heat map (see Figure 1).

Figure 1 represents the calculated values of the indicator for time spent by teachers in the virtual environment. The periods of the semester are shown in the first row. These correspond to the weeks of: a) Inter-semester, which is made up of the first week of work and the last week of the semester; b) Active Semester, consisting of sixteen weeks; and c) test period, consisting of two weeks.

Below this row is the overall average percentage of time spent by all teachers on platform during the week. On the right side is the semester average per professor, calculated from the mean time per week.

The percentage of time spent in the virtual environment is measured on a scale from 0 to 100%, so this was divided into 4 ranges; "very low" ranging from 0 - 24%, "lower than expected" ranging from 25-49%, "meets expectations" ranging from 50-74%, and "exceeds expectations" ranging from 75-100%. In the same column, the semester average is displayed, allowing the user

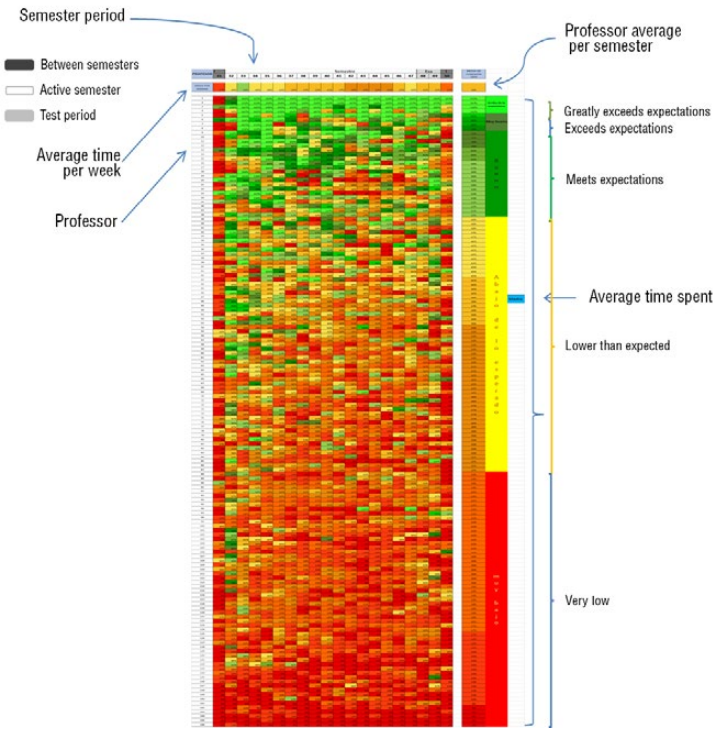

Figure 1. Visualization of time spent on platform (heat map); percentage of time calculated per week and the average of all teachers on the platform.

to identify their position in relation to other teachers. It should be noted that teachers know their position compared to the rest, but does not know to whom each of the other scores belong. This data allows the professor to take actions to improve their time indicator, since it is considered a fundamental element of the teacher's function.

The positioning of "meets expectations" at 50% is an arbitrary cut-off point. The principle of this thought is that not all online teaching activities are done directly on the platform, for example, reading and taking notes on the text. From this point of view, the administrative academic executives and researchers conclude that teachers spending half of the contracted time on the platform and the other half performing academic activities offline seems an acceptable use of time.

In the visual, different tones are intended to show the teacher which time percentage range they are in for both the short and long term; i.e., at the end of the week and the completion of the semester.

In this case, red implies "very low," yellow shows "lower than expected," green represents "meets expectations," and dark green signifies "exceeds expectations." This figure also shows cases of teachers who exceeded the 100% scale in a light green range called "greatly exceeds expectations." The different shades of each color imply its proximity to the next rank.

Also shown is that for the majority of the weeks, teachers spent a "very low" percentage of time in the virtual classroom performing activities. During the inter-semester period, some teachers fell within the "meets expectations" range, which would be a desirable range for time spent working with students during the rest of the semester as well. Within the second rank were 58 teachers of which only 17 (38%) were found to have exceeded the overall mean time, and only two teachers had exactly the average time.

The heat map shows that most often the percentage of time spent on the platform is low, but also shows a high number of cases in which teachers had greater than expected presence on the platform throughout the week, even during the semester.

19 teachers fall within the third range, "meets expectations," and only 4 teachers fall within the fourth rank. The green color, (exceeds expectations), has greater predominance during the weeks of the regular semester.4 teachers exceeded expectations so greatly that they did not fall on the scale, so a fifth range, "greatly exceeds expectations," was created for them. Their percentages were 113%, 134%, 267%, and 473%.

Within the results, you can see that the average total weekly percentage was low, with the exception of week 3, which presented a high percentage. From this data, the evaluations show that the total percentage of time spent in the online classroom by the teacher is low.

Visualization of the "teacher-student interaction" indicator

In a network analysis platform, the following records obtained from 567 class forums were combined: 63,876 messages, and 2,521 discussions,

with 113 messages on average.

The result is a graph with 3,734 nodes (users), 3,332 of which are connected by 28054 edges (see Figure 2).

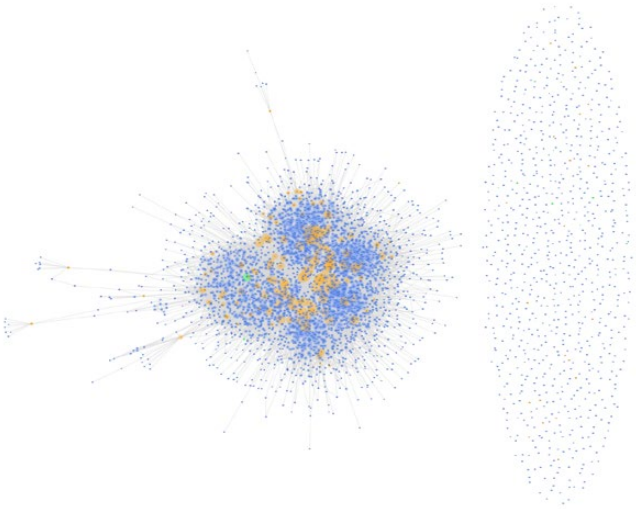

Figure 2. 63,876 messages, 2,521 discussions, 3,734 nodes (users)—concerning educational platform forums.

Figure 2 shows 159 teacher nodes (brown), 3,556 student nodes (blue), 19 administrative staff nodes (green). 402 nodes are disconnected, and the remaining 3,332 nodes are connected to more distant network nodes by 12 jumps; i.e., the most distant people in the online discussion platform network are 12 connections away. Finally, we observed an average of 19 outgoing messages per node and 17 incoming messages.

One element that stands out is that the network is densely populated in the central area. For example; to graph the network in three degrees of separation (from central persons and up to three dialogical connections), we found 2,103 (63% of total) nodes and 16,438 edges—80% of the relationships. At four degrees of separation, the figures were respectively 85% and 20,297 edges—99% of relationships. The remnants of the nodes and connections are distributed between 5 and 12 degrees of separation and 11% of nodes did not participate in discussions in the online forums.

In regard to the distribution of the discussions in online forums per professor, we found that out of 142 valid teacher profiles, there was an average of 71 outgoing messages, with a minimum of 1 message and a maximum of 415. The mode was 31 messages and the median 51, while the standard deviation was 71 messages. Professors received an average of 134 incoming messages, with 1 minimum, 1040 maximum, mode 28, median 91, with a standard deviation of 148.

In the context of the creation of indicators for online teaching, the visualization of the network serves as a comparative parameter of the contribution of the professor and his discussion group during the semester. The graph shows varying degrees of connectivity within this social network. For example, teacher number 100 displays an egocentric network analysis featuring 28 student connections. (see Figure 3).

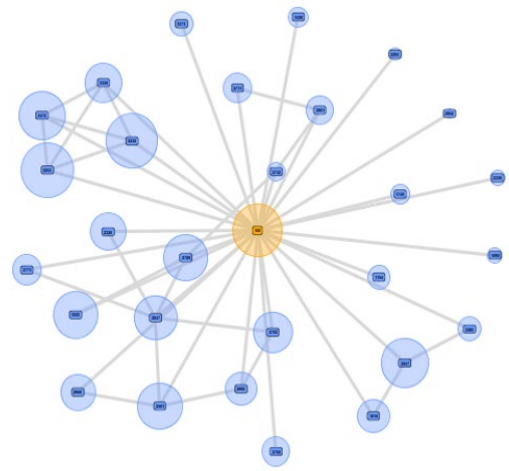

Figure 3. Egocentric network of first-grade of teacher number 100

The teacher who has an average dialogical connection is located in the central part of the network and if we visualize the egocentric network of the teacher in the second grade, we will see that they maintain a relationship with 28 teachers and 314 students, an average of 11 students per teacher (see Figure 4).

The proposed visualizations are designed to show the intensity of the discussion in the forums and have a parameter of comparison with the other classrooms. While it is true that the examples presented are restricted to a single variable, you can see other variables such as module type, cloister, modality, etc. Colors help contrast between

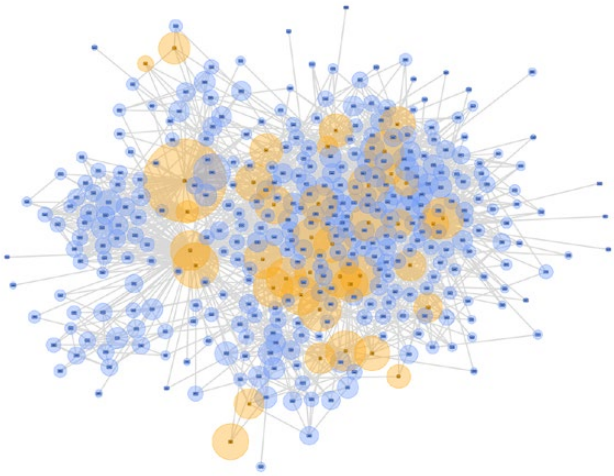

Figure 4. The egocentric network in the second grade of user number 100.

variables and facilitate the comparison between teachers.

It is thus that this indicator makes it possible to visualize the dialogic interaction established between teachers and their students, which is only one of the functions that online teachers perform.

Discussion and Conclusions

The transformation of the role of teachers in an online environment has raised several questions regarding their functions, constraints, and how alternatives for improvement can be evaluated. Thus, it is not enough to provide a series of values or data that are difficult to understand. Visualizations should be developed to represent the large amounts of complex data in these kinds of analytics complex data (Vieira, Parsons and Byrd (2018).

The heat map and network maps presented allow people to objectively observe, which is a key factor for the development of the online teacher's functions, like how much time is spent in the virtual environment that is their work area. Thus, this technique helps the visual representation of the information sourced from the records of the platform, which could be considered abstract and worthless. In this case, the potentialities of academic analytics allow the information to be analyzed and used in the development of systemic improvements, the monitoring and evaluation of teachers, and decisions regarding the regulation of educational systems.

In addition, the use of this information requires that it be presented in a way that is understandable for users (in this case the teachers), so that, with this type of visualization (which can be calculated in real time) it is possible to give the teacher a reference element about their execution. This could be considered a way to help the self-regulation teaching execution and, in the future, could improve the entire education system.

As found in the literature, visualization techniques allow the representation of principal data about the aspect of interest. In the case of online education, diverse works, such as those developed by Heer & Agrawala (2008) argue that visual analytics support the social interaction that occurs in virtual forums. In this way, the teacher-student relationships become visible, which subsequently allows teachers to make decisions regarding the design of the interactions that are part of their educational and social role, which ultimately contributes to the learning of their students.

In the same sense Duval Verbert, Klerkx, Wolpers, Pardo, Govaerts & Parra (2015) indicate the use of visualization techniques to provide relevant information relevant to teachers and students in order for them to understand their progress in online environments. El-Assady, Sevastjanova, Sperrle, Keim, & Collins (2018) take it one step further, indicating that it is possible to use automatic visualization modeling to further facilitate decision-making by the people involved.

This indicates that visualizing data in a pleasant way makes it easier for people on the platform to understand, enables the teacher to carry out the processes of meta-reflection, and provides the institution a panorama of the online system.

In addition, a correlational analysis could be done for the other indicators mentioned in this work in order to identify the closeness of the relationship between their presence in the online classroom, the degree of communication they establish with students, how much time it takes them to give students feedback, and the time it takes them to

respond to messages, among other factors.

In this work, although it is true that percentages of time spent on the platform were low, it is important to note that not all the teacher's work is done online, since they also make use of other tools. Although, as mentioned in the introduction, the teacher's presence triggers aspects such as interaction, motivation and student communication.

On the other hand, it is important to consider that when searching the literature, it is difficult to find information regarding measurement of a teacher's time spent in the online classroom, and in some cases, the indicators are provided by the face-to-face classroom, the questions of which do not fit the characteristics of online education. Thus, we consider that it is a fundamental aspect to identify this indicator, as it provides clarity regarding the time the teacher spends in the online classroom, and therefore can relate to other functions performed, like dialogic interaction and the amount of time it takes the teacher to provide feedback on student work, among other functions.

It is important to keep in mind that the teacher's presence on the platform, makes it likely that they will complete tasks, which is an element that impact the performance of students and success.

In this way, we should remember that the techniques are an auxiliary in the visual representation of the indicators that should be delimited according to the functions of online teaching and resources available in the platform database.

The use of visualization techniques to represent indicators is a way of giving users feedback, specifically to teachers about their activity. This allows the teacher to determine the compliance level of their main functions, to identify strengths and areas of opportunity, and plan improvement strategies according to their needs.

The indicator for the time it takes teachers to provide feedback on activities and the amount of feedback given at the end of a period are not included in this project. However, the techniques used for their presentation are illustrated heat maps with the indicator for time spent working on the platform.

Finally, we consider that the performance of the online teacher's activity has a fundamental role in promoting the learning of students, therefore, it can be said that the teacher's presence in both individual and group activities is essential. Teaching activity is summarized in commitment and discipline, since their presence in the course must be constant, and feedback must be delivered to students according to the institution's policies regarding response times. For this reason, we consider that these last indicators are worth studying more deeply in a future work that surpasses the objective of this paper.

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