

## Student satisfaction in the context of hybrid learning through sentiment analysis

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### ABSTRACT

With the incursion of data science into the academic field and the massification of social networks, it is possible to extract information on student satisfaction that contributes to feedback on teacher teaching strategies and methods. This article aims to determine student satisfaction with teaching performance, through sentiment analysis. Methodologically, the research is of a non-experimental longitudinal design, with a quantitative approach. Data collection was carried out through the social network Twitter, and data analysis was carried out through the sentiment analysis technique. As a result, it was identified that in the first week of class, the highest level of satisfaction was obtained, reaching 96.3% of the total number of students. Meanwhile, in the evaluation weeks, the highest level of dissatisfaction was reaching 29.17%. It is concluded that when going from totally virtual learning to hybrid learning, students express a certain level of dissatisfaction typical of a process of progressive adaptation. Therefore, teachers should take advantage of these findings to redesign assessment rubrics in the context of hybrid teaching. Aspects such as collecting opinions through social networks and extracting a degree of satisfaction through them apply in a crossed way to other professional fields.

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## 1. INTRODUCTION

In recent years, the rise of social networks has allowed users to use these resources to express their opinions on satisfaction assessments of the service or product received [1], [2], considering it is more authentic than what would result from applying a survey [3]. Messages published on social networks such as Twitter are material of great interest for detecting opinion trends among users [4]–[6]. In this regard, [7], [8] it is pointed out that Twitter is one of the largest real-time information services on the Internet and that it is fed by the opinions of millions of users worldwide. This preference for the massive use of social networks to issue opinions has made text a key component of communication in society [9]. However, it is important to take into account that the opinions or comments on Twitter are unstructured data, so tools such as natural language processing (NLP) contribute to their processing and subsequent analysis [10].

The detection of feelings and emotions in social networks is one of the newest uses of NLP [11]. The basic task in sentiment analysis, opinion mining, or emotional artificial intelligence is to classify the polarity of

the text present in documents, sentences, or opinions [12]–[15]. Sentiment analysis is a text classification task within the NLP area, its objective is to weigh the sentiment contained in opinions or comments through tones or polarities [16]–[19]. The task of identifying the predominant sentiment in a text is a complex task for the human being, however through NLP and text mining it is possible to extract relevant characteristics and qualities [20]–[22]. Currently, this methodology is applied mainly in the interpretation of texts disseminated on social media such as Twitter [23], [24]. In this regard, it is established that Twitter has become a trending social network that has transformed short texts into a key piece for expressing opinions [25], [26].

Focusing on the university environment, in any educational process reference is made to teaching performance, which is linked to the quality of the educational service [27], and since the teacher is one of the immersed actors, it is inferred that it is important to determine the aspects that are involved with student satisfaction [28]. The evaluation of teacher performance is an appreciation of its development that is valued through different perspectives, one of them being the most relevant from the student's perspective [29]. The importance of assessing teaching performance is linked to the purpose of identifying and diagnosing deficiencies in their performance in the classroom or other activities carried out in the university environment [30]. In the search to identify the assessment of university student satisfaction, using sentiment analysis is an interesting and quite useful tool [31]. The results obtained through the analysis of feelings linked to identifying student satisfaction with respect to teaching performance, allow us to identify significant aspects that serve as feedback in terms of pedagogical and methodological aspects developed by the teacher during the class session [32]. Thus, Puraivan *et al.* [33] also pointed out that the emotions or feelings generated during the class sessions help to identify linked and influential aspects with the improvement of the teaching and learning process.

Based on what has been indicated, this article focuses on the need to seek other strategies for the identification of university student satisfaction with teaching performance, since instruments such as questionnaires with answers whose nature are delimited by scales are generally used, such as the Likert scale, generating a certain degree of bias in the perception of student satisfaction. This strategy to be developed in this article is based on the collection of data through the social network Twitter to a group of mechanical and electrical engineering students, during fifteen weeks contained in an academic semester of hybrid class sessions. Thus, the sentiment analysis technique will also be used for data processing. Therefore, the objectives of the article are to determine the satisfaction of the students with the teaching performance through the analysis of feelings and identify relevant aspects of the teaching performance from the extraction of words through the technique Term frequency–Inverse document frequency (TF-IDF). For which a longitudinal non-experimental design was used, of an applied type and with a quantitative approach. This article is made up of a section on previous studies in which a brief review of the existing literature is carried out, regarding the topic under study; Thus, the methodological aspects used in the investigation are also described. In addition, the results found as part of the analysis and processing of the data are shown, to later carry out a discussion with respect to other studies seeking to identify differences or similarities. Finally, the conclusions section and limitations of the study are presented.

## 2. SIMILAR STUDIES

University educational institutions generate large volumes of information in their day-to-day lives, and through the use of data science or the use of methods such as data mining, they can provide relevant information to improve decision-making that contributes to the increase of university educational quality. However, today it is also possible to generate large volumes of data through the use of social networks in the university environment. Although these data are considered unstructured, through techniques such as sentiment analysis and the extraction of relevant words such as the IF-IDF method, it is possible to extract significant qualitative and quantitative information on student satisfaction with respect to the different services offered in the field of teaching, research and social projection; represent a strategy to be used in parallel and crossed results contributing to its validation and suppressing possible biases. Analyzing the opinions generated through social networks allows the visualization of dominant comments avoiding falling into any type of bias, the analysis of sentiments guarantees the ability to extract subjective information on sensitive aspects [34]. The results of processing opinions collected from social networks form a component that contributes to success because it represents a competitive advantage for the institution that applies it as a knowledge-generating element [35].

Landínez and Rodríguez [31] applied sentiment analysis for the development of a tool that assesses the attitude of students towards a subject, using social networks, in which they concluded that sentiment analysis is a highly complex technique, due to the implications of data processing that it involves, such as cleaning and filtering and construction of classifiers, however, its contribution is relevant when generating knowledge that allows an efficient allocation of resources to programs or faculties within educational institutions. Likewise, Gil-Vera and Ramírez-Bermúdez [19], used sentiment analysis techniques through

Twitter to find out the perception of student satisfaction regarding virtual learning objects, in which they concluded that it was possible to identify that the majority of students feel positive emotions when expressing themselves about virtual learning objects, which allowed accepting the research hypothesis, while negative emotions arise mainly from ignorance about this type of tools. Furthermore, Chanchí *et al.* [32], used sentiment analysis to assess the perception of satisfaction of systems engineering students in the context of the development of virtual classes due to the declaration of the state of confinement by COVID-19, in which concludes that in general terms, systems engineering students, despite the adaptation process, have a positive perception of academic processes and look optimistically at the possibility of improving the practices developed in remote attendance.

In this same line of research, Mora and Varas [15] developed a study of the analysis of sentiments and their communication influence on students of the professional school of social communication, obtaining results that the surveys that are commonly used reveal that the students describe negative and irregular comments towards the faculty, so other strategies should be applied to identify the suggestions of the students to give them an immediate solution, in this way, it would be convenient to implement the sentiment analysis tool, in order to improve the status of the institution, its image, and acceptance by obtaining real data. So also Puraivan *et al.* [33], applied sentiment analysis on a population made up of first-cycle university students, in the context of a health emergency, through which they managed to characterize four groups, identified by hierarchical clusters, which are characterized by their perception of the COVID-19 context, belonging to said groups is validated through discriminant analysis, in which the first dimension obtained 59.90% of the variability, and the second, 24.80%. Empirical studies such as those carried out by several researchers [36], [37] showed the feasibility of identifying satisfaction in any field, including the university educational field, through comments or opinions extracted from social networks such as Twitter and integrated into sentiment analysis techniques, which show a strategy with application of form crossed in other organizational areas.

### **3. RESEARCH METHOD**

#### **3.1. Research design**

The research design used is non-experimental of a longitudinal type; it is non-experimental because student satisfaction is analyzed without applying any action that leads to altering the student's perception. It is also of a longitudinal type because the data was collected progressively, in each class session through a question formulated on the social network Twitter, in which the student was asked what opinion they have regarding the teaching performance. The period of time in which the data was collected corresponded to 15 weeks of class that is, in a period comprised during an academic semester. Therefore, based on the objectives established to be achieved in the research, the following research questions were established:

RQ1: What is the level of satisfaction identified in the opinions of the students from the social network Twitter, regarding the teacher's performance through the analysis of sentiments?

RQ2: What relevant aspects of teaching performance were identified from the use of the IF-IDF word extraction technique?

#### **3.2. Research type and focus**

The type of research is theoretical, since it is intended to contribute to the existing knowledge on the application of sentiment analysis on opinions generated from the social network Twitter, to identify satisfaction. This study will generate new knowledge about the application of the analysis of feelings to the university educational environment in a particular scenario such as the return of students to face-to-face after the COVID-19 pandemic, whose class sessions were developed under the modality hybrid. The approach established for the investigation that will allow answering the research questions is the quantitative approach, since what is sought is to identify the level of student satisfaction, from the application of the sentiment analysis. It should be noted that by applying the sentiment analysis technique, it will be possible to assign a quantitative value to the opinions of the students and depending on the assigned value, it will be possible to establish whether the sentiment contains a positive, negative, or neutral polarity.

#### **3.3. Analysis of data**

The data analysis was carried out through the sentiment analysis technique, which as indicated in the previous paragraph, is due to the fact that this technique allows analyzing the subjectivity contained in opinions or comments whose format is textual. In addition, by weighting or assigning a quantitative value to the feelings contained in the students' responses through Twitter, it will allow opinions with positive feelings to be categorized as satisfied and opinions with negative feelings as dissatisfied. It is specified that the numerical weighting that the sentiment analysis technique assigns to opinions is in the range of less than -1 to 1. That is, if the sentiment is assigned a numerical value of 0 to -1, it will be considered that it has positive polarity, while if it is assigned a numerical value -1 to 0 it will be considered that it has negative polarity, if it is assigned the value of 0 it will be considered that it has neutral polarity. Now, in order to carry out the text

extraction, the IF-IDF technique will be used, which allows extracting words that have a greater relevance from the universe of words contained among all the opinions generated by the students.

### 3.4. Analysis method

Regarding the method used for the collection, storage, and processing of data, it is shown in Figure 1, which was validated through what was developed by Chamorro-Atalaya *et al.* [38], in which he initially defines the way in which the data will be stored and collected through the social network Twitter, to then continue with the identification of feelings in which the levels of student satisfaction are described based on three categories, we define as “positive”, “negative”, and “neutral”, all supported by the “nltk” and “vader” libraries contained in the Python programming software. Then a data preprocessing is carried out, with which the opinions generated by the students from Twitter can be cleaned, converting all the texts to lowercase, eliminating repeated words, and eliminating excessive spaces between words. Finally, it is specified that the data will be processed using tokenization and vectorization techniques to weigh the relevance of the texts contained in the opinions of the students using the TF-IDF technique.

Based on what has been indicated, it is established that the result to be obtained after the application of the method is divided into 2 (output 1 and output 2). In the first place, the follow-up of output 1 will be sought, that is, monitoring the variation in the polarity of sentiments throughout the data collection period. Secondly, output 2 will be monitored, which means monitoring the variation of the most significant factors contained in the comments or opinions issued by the students when weighing the relevance of the texts, also throughout the data collection period.

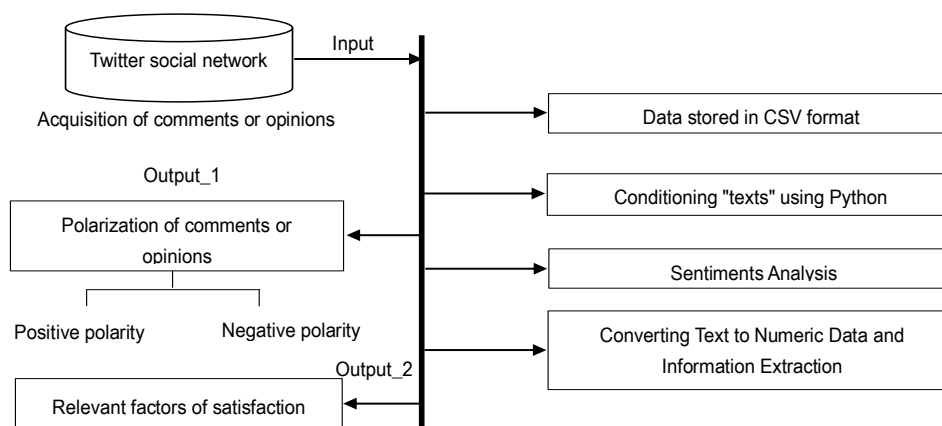


Figure 1. Method used for the application of sentiment analysis

## 4. RESULTS

### 4.1. Level of student satisfaction obtained from the application of the sentiment analysis technique

By carrying out the data collection process in text format in each class session through the social network Twitter, it was possible to generate 288 comments or tweets, the same ones that were linked to giving an opinion on the satisfaction of the teaching performance regarding the development of the class session. Figure 2 shows the evolution of the number of tweets collected, in which, on average, there was a total of 19 tweets for each class session. In the first week of class, the largest number of tweets (27) were collected, while in the ninth week of class the fewest number of tweets (13) were collected.

The result obtained regarding the sentiment contained in the tweets collected during the first class session is shown in Figure 3. As evidenced by the “Sentiment Intensity Analyzer” function, the sentiments have been quantified in the range of -1 to 1. It should be noted that Figure 3 only shows the first eleven tweets corresponding to the first week of classes, this is an example.

To identify the satisfaction and dissatisfaction of the students regarding the teaching performance, it proceeded to identify the number of tweets with feelings with positive, negative, or neutral polarity, through the distribution of tweets by value range of the feeling, as to demonstrate the results obtained, some of the distributions are shown. Figure 4(a) shows that of all the tweets collected, 96.3% contain positive polarity, while 3.7% contain neutral polarity. There are cases like the one from the fourth week, where it is shown in Figure 4(b) that of the total tweets collected, 88.89% contain positive polarity, while 5.55% contain negative polarity, and 5.55% contain neutral polarity. Then, in the case of the eighth week, Figure 4(c) shows the total tweets collected, 45.83% contain positive polarity, while 27.17% contain negative polarity

and 25.0% neutral polarity. Finally, in the case of the twelfth week, Figure 4(d) shows the total tweets collected, 88.24% contain positive polarity, while 5.88% contain negative polarity and 5.88% neutral polarity.

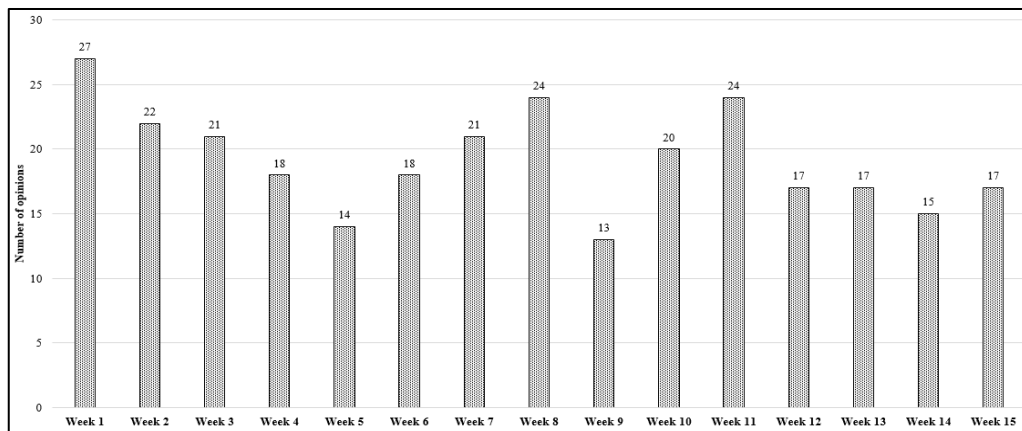


Figure 2. Number of tweets per class week

	Tweet	sentiment
0	Sorry teacher I couldn't get into the class bu...	0.5719
1	I was not able to attend the first class. but ...	0.5719
2	The session presented was interesting and moti...	0.7096
3	Interesting session. understandable to familia...	0.4019
4	The class session seemed very precise and I re...	0.7178
5	Very good. very clear and didactic with his ex...	0.7468
6	Interesting start. see you next week.	0.4019
7	interesting start of class.	0.4019
8	the class was very didactic and participatory....	0.7089
9	Excellent start to the course. resulting in th...	0.7506

Figure 3. Quantification of the sentiment contained in the opinions of the students

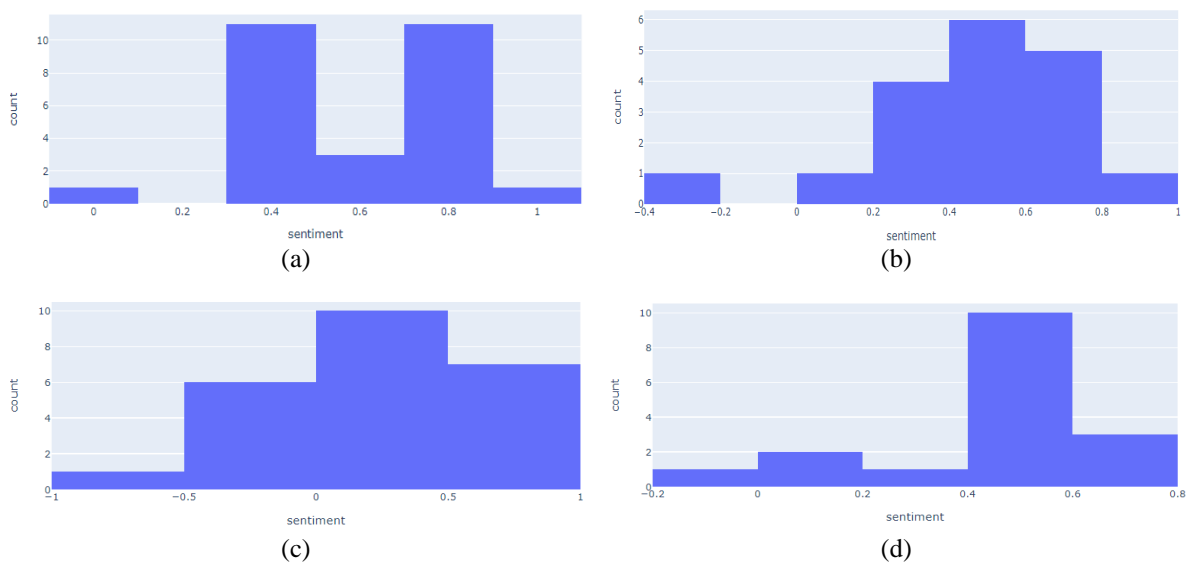


Figure 4. Distribution of tweets by sentiment value range corresponding to (a) the first week of class, (b) the fourth week of class, (c) the eighth week of class, (d) the twelfth week of class

Figure 5 shows the evolution of the polarities contained in the feelings of the opinions made by the students during the fifteen weeks of class. In general, it can be established that the opinions with a positive polarity that are linked to "student satisfaction" always remain above the opinions with a negative polarity that is linked to "student dissatisfaction". However, in the follow-up of the feelings with positive polarity, it is observed that after the eighth week, there is a quite significant decline, since less than 50% of the students' express opinions with a positive feeling, while if we add the opinions with negative and neutral polarity reach a value of 54.17%. Taking into account the context of the eighth week of class, this coincides with the week of evaluations, that is, the comments are focused on feelings possibly linked to the instrument that was used for the evaluation, the type of questions, or perhaps the level of difficulty of the evaluation the questions. It is here where the purpose of carrying out an analysis regarding the extraction of words that are contained in the opinions of the students is justified in order to have greater detail and a better understanding of the variations that occur in the levels of positive and negative polarity and associated to student satisfaction and dissatisfaction respectively.

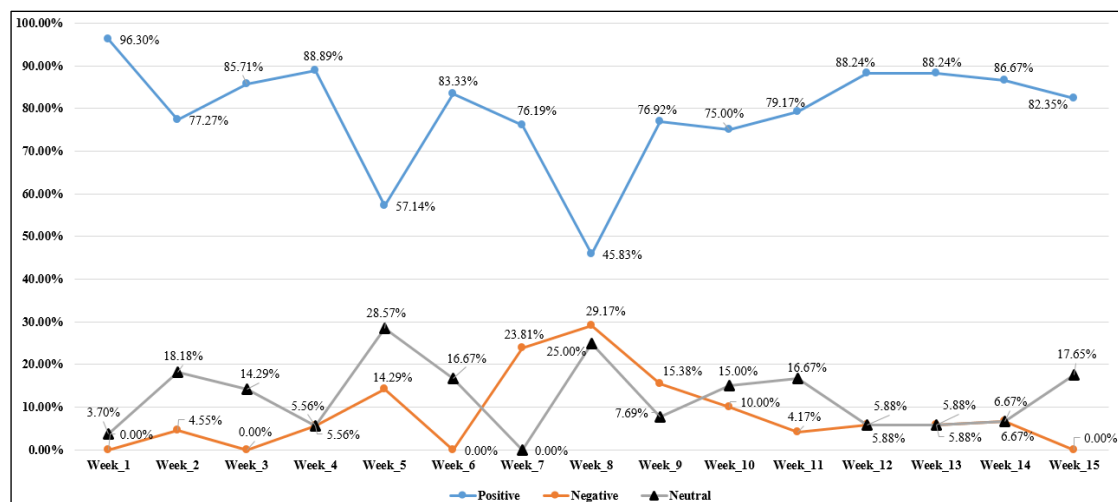


Figure 5. Student satisfaction with teacher performance by class week

#### 4.2. Relevant aspects of teaching performance from the extraction of words using the IF-IDF technique

Table 1 shows the extracted words according to their relevance weighting per class week. Based on the criteria established for the extraction of the relevant words, the opinions of the students are always oriented to give an appreciation regarding the teaching performance, since in a review of the words that are most repeated in the fifteen during the weeks of class, the ones with the highest weighting of "teaching" relevance are identified, followed by words very specific to the subject of automatic process control, such as: "MATLAB", "exercises", "simulation", and "Simulink". Another group of words linked to the assessments regarding the class session can also be classified as interesting, good, precise, doubtful, and difficult.

Table 1. Extraction of words according to their relevance weighting

Class weeks	Words with greater relevance, according to established criteria				
Week 1	Understand	Precise	Interesting	Teacher	Class
Week 2	Topics	Modeling	Interesting	Exercises	Class
Week 3	Exercises	Software	Simulation	Class	MATLAB
Week 4	Teacher	Session	MATLAB	Exhibition	Doubts
Week 5	MATLAB	Exercises	Software	Interesting	Teacher
Week 6	Exercises	Teacher	Simulink	MATLAB	Control
Week 7	Teacher	Exhibition	Simulation	Class	Exercises
Week 8	Topic	Difficulty	Questions	Accordance	Class
Week 9	Teacher	Simulation	Exercises	Simulation	Understand
Week 10	Teacher	Didactic	Simulink	MATLAB	Program
Week 11	MATLAB	Simulink	Teacher	Interesting	Learned
Week 12	Simulink	Teacher	Interesting	MATLAB	Session
Week 13	Exercises	Teacher	Project	Simulation	Exercises
Week 14	MATLAB	Simulation	Teacher	Recommendations	Session
Week 15	Teacher	Learning	Interesting	Simulation	Good



Figure 6 shows the word cloud or tag cloud of some weeks of class, in which the words with the highest frequency contained in the opinions of the students are evident. This result is somehow linked to what was obtained through the IF-IDF vectorization method. Figure 6(a) shows the word cloud corresponding to the opinions of the students on the social network Twitter written during the first class session. Thus, as seen in Figure 6(b), the word cloud corresponding to the fourth week. As shown in Figures 6(c) and 6(d), the word cloud corresponding to the eighth week and the word cloud corresponding of the twelfth week of class, respectively. It should be noted that some words that appear in the word cloud and do not appear in the group of relevant words, are because they only appeared in that week of class and not in the other weeks, for which reason it is considered not relevant.

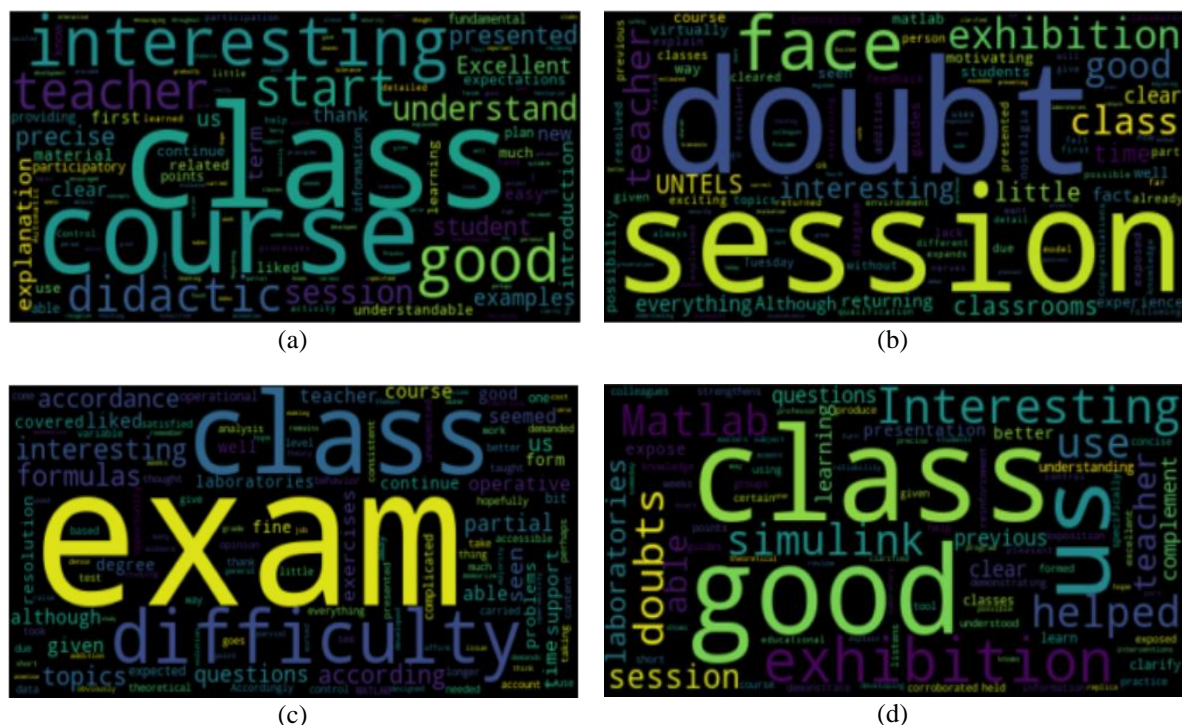


Figure 6. Cloud of words generated by the opinions of students in (a) the first week, (b) the fourth week, (c) the eighth week, (d) the twelfth week of class

## 5. DISCUSSION

In relation to the results obtained, it was evidenced that it is possible to identify the satisfaction of the students under a new approach based on the application of the sentiment analysis technique on opinions extracted from the social network Twitter. This approach is possible to generalize since it deals with the use of data science for the extraction of knowledge in educational environments. Therefore, as an alternative to assess student satisfaction in parallel to the methods traditionally used such as the questionnaire in which data collection instruments with questions categorized on a Likert-type scale are used, it is totally viable.

Reaffirming what was indicated by Landínez and Rodríguez [31], they point out that it is possible to carry out sentiment analysis with different instruments to assess student satisfaction, which will lead to the fact that, based on the information obtained, it is possible to make decisions that guarantee an efficient allocation of resources to programs or faculties within educational institutions. Likewise, according to Ppachristopoulos *et al.* [39], the development of applications of the sentiment analysis technique in the university environment will allow correcting the deficiency in the contextual understanding of student satisfaction; while Santiago *et al.* [40] pointed out that the application of the analysis of feelings in the identification of learning experiences allows to extract more information regarding the critical thinking of the students. In addition, Kastrati *et al.* [41] concluded that the analysis of feelings contributes to generating more effective feedback of the teaching process through the analysis of student opinions. In other words, as a new approach, it does not intend to displace traditional methods, however, it is appropriate to use alternative proposals such as the one proposed for, through an analysis of crossed results, possible risks generated by the subjectivity contained in the answers on the evaluation of the results of student satisfaction. In this regard,

Khairy *et al.* [42] point out that the extraction, analysis and classification of student opinions is relevant because traditional techniques focus on studying and analyzing aspects delimited by questionnaires.

This study also closes a gap in relation to the aspects that are relevant for students in a hybrid learning environment, after more than two years they have developed a totally virtual modality. Thus, it is necessary to identify feelings and extract aspects that provide more information about the adaptation process since, as the survey techniques through a questionnaire with pre-established dimensions insist, it is not possible to express opinions that can be openly perceived by the participants. students. In this regard, Herrera-Flores and Benavides-Morales [43] pointed out that among the main aspects that were found as part of the application of opinion mining in the university educational field are linked to connectivity, problems with the platform, use of laboratories, tutorials, and teacher-student interaction. Hew *et al.* [44] in their research work on student satisfaction in which they apply the sentiment analysis technique, obtained results that the teacher's performance in the class session, the content, and the evaluation represent relevant aspects in the assessment of satisfaction. In addition, Liu *et al.* [45] applied text mining to identify relevant aspects of student satisfaction, finding that students place greater emphasis on case-based learning than on simulation-based learning with lecture-type class sessions. This shows that it is relevant to use word extraction techniques to identify aspects related to teacher performance.

Quantitatively comparing the results obtained with what was reported by Chanchí *et al.* [32] in their research work on the perception of student satisfaction with respect to the academic activities carried out by the teacher, a 27.47% contribution of the negative polarity was obtained over the total opinions, while the contribution of the positive polarity was 25.47%. In the same way, regarding the advantages evidenced, it was possible to observe that the positive polarity had a percentage of participation within the total opinions of 33.24% and a percentage of contribution of the negative polarity of 17.73%. Regarding the levels of positive and negative polarity, the results differ since they refer to studies in different contexts, one before the pandemic and the other post-pandemic, so the result obtained contributes to the generation of knowledge in a particular context. as it is the return to class sessions under the hybrid teaching modality. In this regard, Baeza [46] pointed out that hybrid education has several benefits, however, various aspects must be taken into account to ensure that its implementation is effective in student learning, since it is not only about implementing it but also about the appropriate and ideal conditions are available to satisfy the student.

The limitation of the study was the continued non-participation towards the final stage of data collection. Although a socialization process was carried out on the research to be carried out and knowledge was made about the contribution that their permanent participation would entail for the continuous improvement of the teaching and learning process; it was evidenced that during the first class sessions participation was massive, however upon reaching the final weeks of class participation decreased significantly. This reflects that it is necessary to regulate the use of social networks as a source of opinion gathering in order to treat opinions through sentiment analysis techniques that contribute to the decision-making of the authorities for the benefit of the educational process. This is an important aspect to consider in future studies, since it is not mentioned in the literature review that studies of sentiment analysis through social networks correspond to educational policies defined by the university.

## 6. CONCLUSION

In relation to the research questions and proposed objectives, it is concluded that it was possible to determine student satisfaction with respect to teaching performance, through the analysis of the polarity of feelings contained in the students' comments. It was identified that in the first week of class, it was possible to obtain the highest level of feelings with positive polarity, reaching a percentage of 96.3% with respect to the number of opinions generated by the students. Likewise, in the fifth, eighth, and fourteenth week of classes, the highest levels of dissatisfaction were evident, reaching the maximum level of negative polarity of 29.17%, so it can be inferred that it is due to the return to face-to-face modality, since that the students of the study population, since their entry in the year 2019, only two semesters carry out academic activities in person and then from their third cycle to the seventh cycle they are carried out virtually, so in this context of transmission to care show some feeling, as part of a process of progressive adaptation.

In relation to the extraction of words through the IF-IDF technique, it was possible to identify that these focus on two aspects related to teaching performance: the use of tools and simulation software specifically linked to the class session (MATLAB, Simulink, Simulation) and appreciations about the class session carried out by the teacher (interesting, good, precise, doubts, difficulty). With which the use of this technique in the processes of evaluation of student satisfaction becomes relevant and significant, since the application of techniques such as the survey through the questionnaire, will always focus on aspects or factors of performance. Defined, concrete teacher, limiting the expression of students beyond these factors, however, through sentiment analysis or data mining, aspects of teacher performance can be extracted that



contribute to enriching the results obtained through the technique of the poll. Aspects such as the collection of opinions through social networks and the extraction of the degree of satisfaction from the use of sentiment analysis techniques or opinion mining are cross-applicable to other professional fields. Although the study covered the academic field, the approach proposed for the identification of satisfaction and extraction of relevant aspects of the comments generated by social networks is applicable to any organization which would give it a competitive advantage.




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