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Identification of the satisfaction of university students through sentiment analysis: a systematic review

Omar Chamorro-Atalaya[1], Florcita Aldana-Trejo[2], Nestor Alvarado-Bravo[3], Constantino Nieves-Barreto[3], Santiago Aguilar-Loyaga[3], Carlos Gamarra-Bustillos[4], Almintor Torres-Quiroz[5], Alípio Riveros-Cuellar[6], Manuel Pérez-Samanamud[7], Luciano Pérez-Guevara[7]
[1]Faculty of Engineering and Management, Universidad Nacional Tecnologica de Lima Sur, Lima, Peru
[2]School of Economics, Universidad Nacional Federico Villarreal, Lima, Peru
[3]Faculty of Administrative Sciences, Universidad Nacional del Callao, Lima, Peru
[4]Faculty of Health Sciences, Universidad Autónoma de Ica, Ica, Peru
[5]School of Economics, Universidad Nacional del Callao, Lima, Peru
[6]Faculty of Administrative Sciences, Universidad Nacional Federico Villarreal, Lima, Peru
[7]Education Faculty, Universidad Nacional Federico Villarreal, Lima, Peru

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ABSTRACT

In these times it is necessary to use tools based on artificial intelligence (AI) that contribute to improving the quality of university education for the benefit of students. This article aims to define the state of the question on the application of sentiment analysis in the identification of student satisfaction, based on the systematic review of scientific publications. The research is of an exploratory level and of a mixed approach. The data collection method was based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) declaration, managing to focus the review based on 27 publications, downloaded from Scopus, ERIC, and Google Scholar. From the systematic review, the following conclusions were reached: the fields of application to a greater extent are found in the academic field and university well-being. Likewise, regarding the contributions achieved, these focused to a greater extent on aspects of the teaching activity, valuing their performance and contributing to their feedback for the redesign of didactic strategies. Finally, in terms of limitations, they focused mainly on the low student participation regarding the use of sentiment analysis to identify student satisfaction; this is due to the lack of regulations or regulations for it is application in the university environment.

Corresponding Author:

Omar Chamorro-Atalaya
Faculty of Engineering and Management, National Technological University of South Lima
Sector 3 Group 1A 03, Av. Central, Villa EL Salvador, Perú
Email: ochamorro@untels.edu.pe

1. INTRODUCTION

The rapid growth of content on social networks, forums, wikis or blogs has led to the possibility of massively analyzing texts using natural language processing (NLP), whose relevance is significant in the sense that these data contain highly useful subjective information for the public or private organizations [1], [2]. In some cases, different collections of lexicon are used for sentiment analysis, the most widely used being the valence aware dictionary and sentiment reasoner (VADER) lexicon or the national research council (NRC) lexicon, which allows us to distinguish eight different emotions: joy, sadness, trust, disgust, fear, anger, surprise, and anticipation [3], [4]. Sentiment analysis techniques correspond to an area of NLP, which

aims to identify and evaluate the emotional value of the text, through its structure, in such a way that it is quantified through polarities [5].

Focusing on the university educational field, sentiment analysis helps determine student satisfaction with the service provided by their institution, based on the analysis of the grammatical valence that exists in the comments or opinions about the service received [6]–[8]. An important aspect in the data extraction process is social networks, the same ones that have become universal, since students have fully incorporated them into the educational field, in which they exchange opinions or comments in a fluid and permanent way [9]. Sentiment analysis at the university level allows obtaining relevant information regarding the opinions or emotions expressed by students and teachers, and whose data extraction is possible from social networks [10]. It is important to keep in mind that the assessment of university educational quality is associated with the level at which the services provided meet the requirements and expectations of the students, and it is that the student satisfied with the services received confirms their quality [11], [12].

To determine the degree of satisfaction that students have with respect to educational quality, they are required to make a subjective assessment that involves expectations about their training needs and their motivation regarding the educational service received [13]–[15]. The quality of education is largely focused on student satisfaction, although it is recognized that the perception of satisfaction with educational quality is variable, since it can change suddenly, however the monitoring allows the application of various control methods that lead to a continuous improvement of the processes [16], [17]. It is necessary to evaluate the impact of student satisfaction in the university environment, which includes all the services that the student requires to have a quality comprehensive education [18], [19]. The analysis of student satisfaction with the education they receive is an imperative and relevant aspect to be carried out permanently, in order to have indicators of what is being offered as a quality teaching service [20], [21]. Likewise, university satisfaction with the quality of the educational service is usually a very subjective criterion and depends on emotional states [22], [23]. The role of the student is of vital importance for the evaluation and accreditation processes of the universities, since the diagnosis of the level of satisfaction of the institutional conditions and of the substantive functions allows the universities to improve the quality of the services [24]–[26].

Therefore, this article aims to generate knowledge from a systematic review on findings and results linked to practical cases in which sentiment analysis was applied, for the identification of student satisfaction, seeking the triangulation of aspects. significant as areas of application, contributions obtained and limitations presented. This research aims to benefit the construction of a state of the art on the use and application of sentiment analysis in higher education, identifying the knowledge gaps on which future studies should focus. Another benefit of this systematic review is to generate a reflection on the various solutions that artificial intelligence (AI) and data science bring to the different areas of higher education. Methodologically, the mixed, theoretical and exploratory level approach will be used. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) declaration was used in order to strictly and rigorously determine the scientific articles to be included in the systematic review, from bibliographic repositories, such as Scopus, ERIC, and Google Scholar, within the period 2015 to 2022.

2. METHOD

2.1. Level, approach, and method

The research is exploratory level since it seeks to identify the state of the art or state of the question on sentiment analysis and its application to identify the student satisfaction of university students; and contribute to the generation of a framework state or reference state for future research. In this way, the review will also be addressed under a mixed approach, this because the systematic review will initially qualitatively address the analysis of the results published on the scope of application, contributions and limitations, seeking to categorize them according to binding aspects. To then quantify and determine in which category the findings published to date are concentrated to a greater or lesser extent. Likewise, the research is based on the method of systematic review of the literature, which seeks to identify, select, evaluate and qualitatively synthesize results related to the technique of sentiment analysis and natural language processing, to establish how they are applied in follow up satisfaction of students in the university educational field.

For which it has been established to formulate three research questions (RQ), in order to conduct and achieve the objectives of the systematic review. These questions are: i) in what areas of the educational system has sentiment analysis been used as a tool to identify student satisfaction? (RQ1); ii) what are the limitations that arise when using sentiment analysis to identify student satisfaction? (RQ2); and iii) what are the limitations that arise when using sentiment analysis to identify student satisfaction? (RQ3). These questions represent one of the fundamental aspects for carrying out a systematic review, since it allows defining the bases that will support the structured, transparent and efficient search of the existing literature [27], [28]. Thus, the PRISMA statement was also used, with the purpose of systematizing in an organized

manner the evidence found on the subject under study. In this regard, previous studies [29], [30] pointed out that this statement rigorously and transparently organizes the systematic review process.

2.2. Search strategy

As for the search strategy, descriptors related to the research questions were used, linking them with the keywords written in both Spanish and English, these being: "*analisis de sentimientos*", "sentiment analysis", "*satisfacción*", "satisfaction", "*percepción de la satisfacción*", "perception of satisfaction", "*Estudiantes*", "students", "*alumnos*", "*Universidad*", "University", "Educación superior" and "Higher education". Thus, a search protocol based on the association of keywords through Boolean integrations was also used, respecting the search forms of each database (Scopus, ERIC and Google Scholar), as shown in Table 1. In this regard, Ozdamli and Karagozlu [31] pointed out that through the Boolean integrators, the search strategies of the sources that will be part of the research articles to be considered in the systematic review of literature are established.

Table 1. Search equation through Boolean indicators

Database	Search equation
ERIC	(("Análisis de sentimientos" OR "sentiment analysis") AND (("satisfacción" OR "satisfaction" OR "percepción de la satisfacción" OR "perception of satisfaction") AND ("estudiantes" OR "students" OR "alumnos")) AND ("universidad" OR "university" OR "educación superior" OR "higher education")))
Scopus	((TITLE-ABS-KEY (análisis AND de AND sentimientos) OR TITLE-ABS-KEY (sentiment AND analysis))) AND ((((TITLE-ABS-KEY (satisfacción) OR TITLE-ABS-KEY (satisfaction) OR TITLE-ABS-KEY (percepción AND de AND la AND satisfacción) OR TITLE-ABS-KEY (perception AND of AND satisfaction))) AND ((TITLE-ABS-KEY (estudiantes) OR TITLE-ABS-KEY (students) OR TITLE-ABS-KEY (alumnos)))) AND ((TITLE-ABS-KEY (universidad) OR TITLE-ABS-KEY (university) OR TITLE-ABS-KEY (educación AND superior) OR TITLE-ABS-KEY (higher AND education))))
Google Scholar	(("Análisis de sentimientos" OR "sentiment analysis") AND (("satisfacción" OR "satisfaction" OR "percepción de la satisfacción" OR "perception of satisfaction") AND ("estudiantes" OR "students" OR "alumnos")) AND ("universidad" OR "university" OR "educación superior" OR "higher education")))

2.3. Inclusion and exclusion criteria

The inclusion and exclusion criteria defined to carry out the systematic review process were established and defined with the purpose of contributing to obtaining eligible articles that are significantly related to the research questions and that contribute to minimizing some type of bias in the information extractions to be obtained from the articles identified from the search strategy. In this regard, several researchers [32], [33] point out that after having identified scientific articles through search strategies, it is necessary to establish inclusion and exclusion criteria that define the search focused on what you really want to discuss in the systematic review. Table 2 specifies the inclusion and exclusion criteria used for the collection of scientific articles. The criteria focused on the rigor of the review of the scientific article, its availability or access, the period of publication and the language in which it was written.

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Bibliographic sources must be scientific articles submitted to peer review.	Conference proceedings, books or theses.
Articles available in full text or open access.	Articles in which you only have access to their abstract
Articles published during the years 2015 to 2022	Articles published in years prior to 2015
Articles written in Spanish and English	Articles written in languages other than English or Spanish
Bibliographic sources must be scientific articles submitted to peer review.	Conference proceedings, books or theses.

2.4. Data extraction and critical evaluation

In relation to data extraction, Figure 1 shows the flowchart that shows how the scientific articles have been rigorously selected to reduce any type of bias in the search for bibliographic sources. It should be noted that for the construction of the stages of the flow chart, the PRISMA statement was taken as a reference. In the initial identification stage, it was possible to select 10,320 scientific articles collected between November 25 and 27, 2022. Then, the articles whose title and abstract were not linked to the research study were discarded, obtaining in the projection stage a total of 1,120 articles. Then, the "inclusion and exclusion criteria" described in the previous section were applied, obtaining a total of 54 articles in the eligibility stage. Finally, in the last stage, those articles that strictly focus on the research questions were evaluated, obtaining 27 articles, to be included for the final review of findings and results in the subject or field of study.

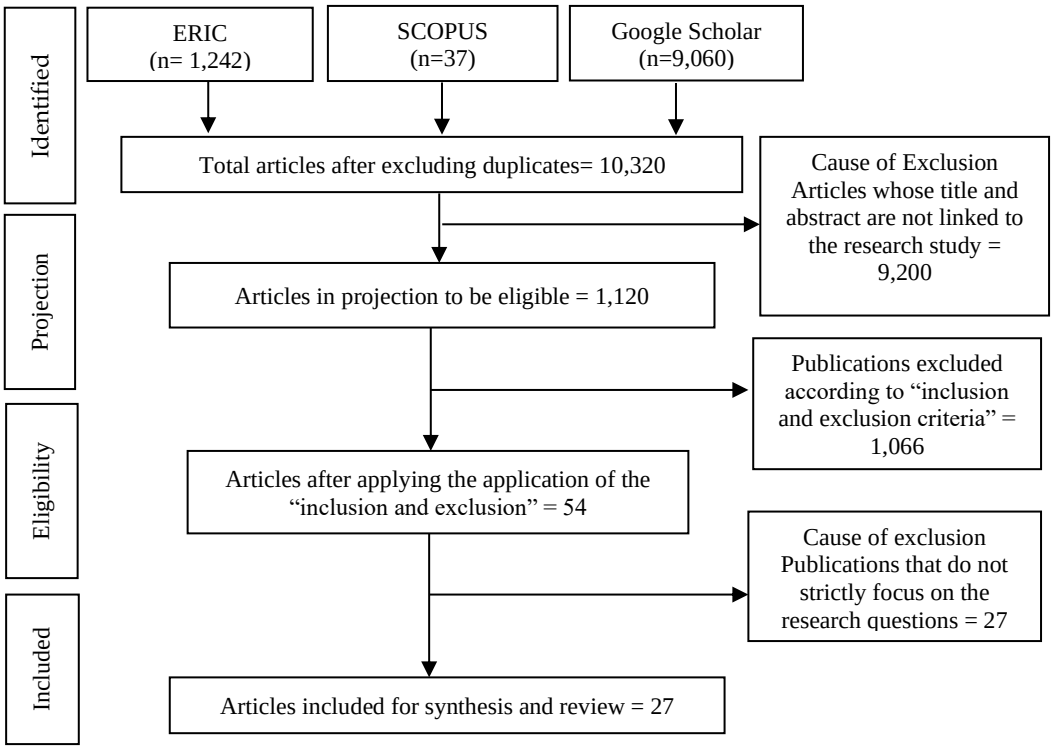

Figure 1. PRISMA flowchart used to extract scientific articles for systematic review

3. RESULTS

Of the articles finally chosen for the systematic review of the ERIC, Scopus and Google Scholar data sources, it was identified that in recent years there has been a significant increase in the production of scientific articles on sentiment analysis applied to the identification of student satisfaction university. That is, between the years 2019 and 2022, 88.89% of the articles eligible for this systematic review have been published. For greater detail, Figure 2 shows the grouping of scientific articles by year of publication.

Next, the findings of the systematic review will be shown. Each item seeks to answer the research questions formulated in the methodology section. It should be noted that the approach used is mixed, so tools such as Atlas Ti were used for content analysis and the statistical software SPSS for quantitative analysis.

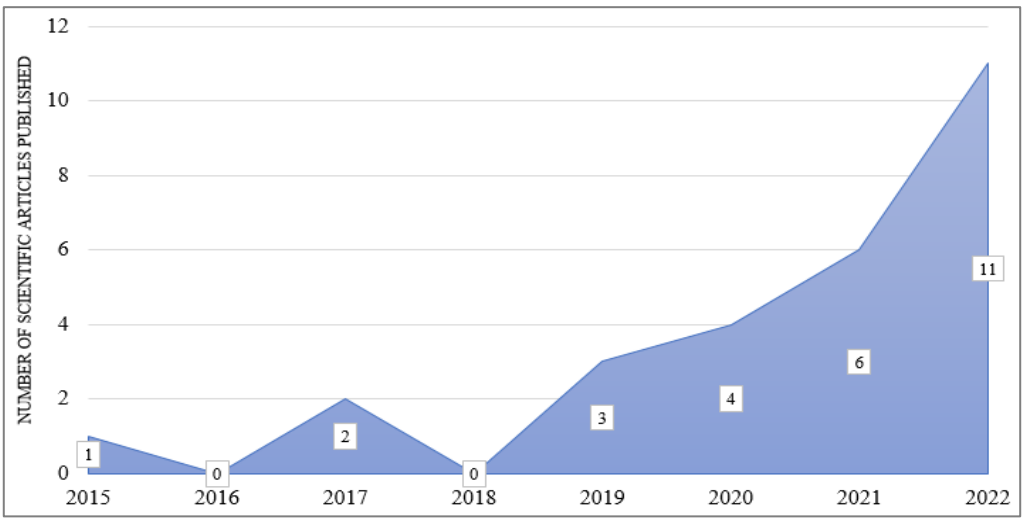

Figure 2. Number of scientific articles grouped by year of publication

3.1. In what areas of the educational system has sentiment analysis been used as a tool to identify student satisfaction?

From the systematic review of the literature, it was possible to determine that the areas of the educational system in which sentiment analysis was used as a tool for the identification of university student satisfaction are to a greater extent in the "academic field", representing 77.8% of the total number of scientific articles reviewed, as well as being applied in the field of "university student well-being" representing 18.5%, while to a lesser extent it was possible to identify that it is applied in the field of "Image of the educational institution" representing 3.7% of the total articles reviewed. However, when carrying out a more in-depth review of the "analyzed dimensions" through sentiment analysis that were addressed in each of the areas of application identified in the systematic review, it is found that 77.78% of applications that focus on in the "academic" field, 70.4% are linked to the "student experience on the teaching-learning process" and 7.4% with the "Student experience on the learning environment". Likewise, with respect to the field of "university student wellbeing", 3.7% are linked to the "effects of confinement on students by COVID-19", 7.4% with the "emotional state of the student" and in the same percentage 7.4% with "library service". Figure 3 shows the percentage of reviewed scientific articles grouped by "field of application" and "analyzed dimension" through sentiment analysis.

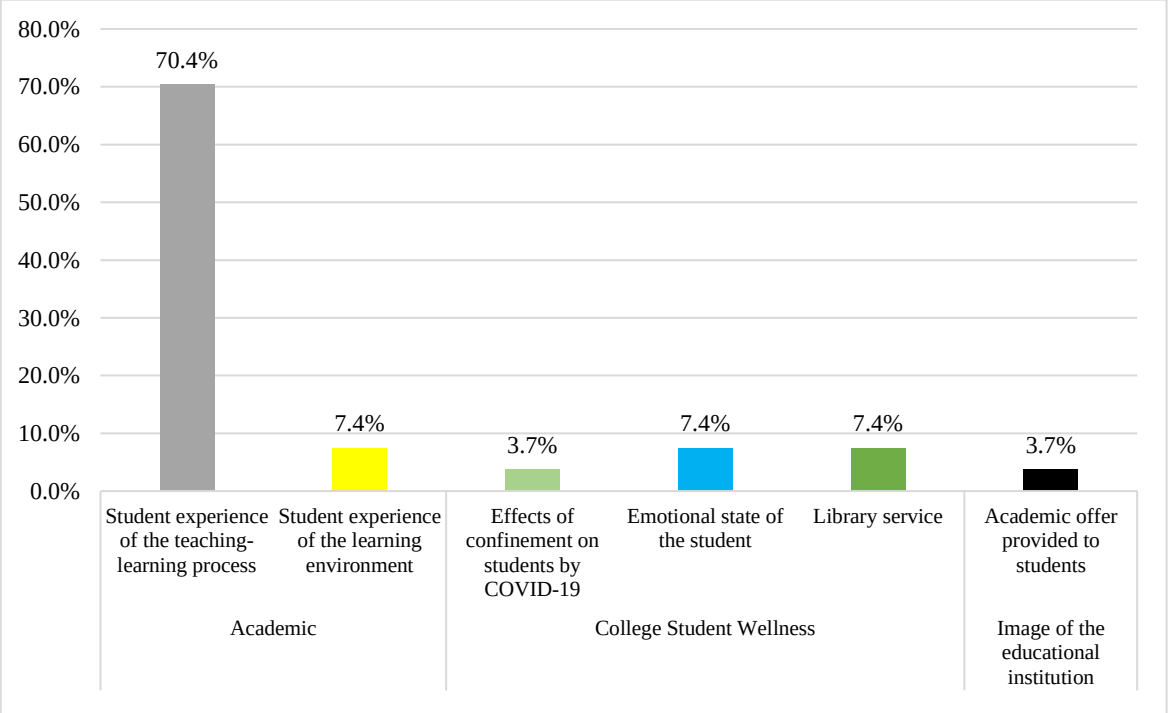

Figure 3. Percentage distribution of scientific articles by field of application and dimension analyzed

However, from the identification of the "analyzed dimensions", it was also possible to determine the "evaluated indicators" per dimension analyzed in each scientific article. It was identified that the dimension with the greatest number of indicators is the so-called "student experience on the teaching-learning process". Figure 4 shows the total number of articles that have focused on this dimension, 37% have evaluated the indicator "perception of online learning", 26% the indicator "perception of the learning experience of students in MOOC courses" and 16% the indicator "perception of teaching performance", among the most prominent.

Table 3 contains in detail the rest of the indicators evaluated in the different scientific articles analyzed in this systematic review. Taking the case of the dimension "student experience of the learning environment" as an example, its indicators are "perception of satisfaction with learning of the learning environments" and "Perception of the student's experience of the Google applications used in learning". On the other hand, it is also evident that the indicator evaluated to a lesser extent through sentiment analysis is the "Perception of the academic offer of universities".

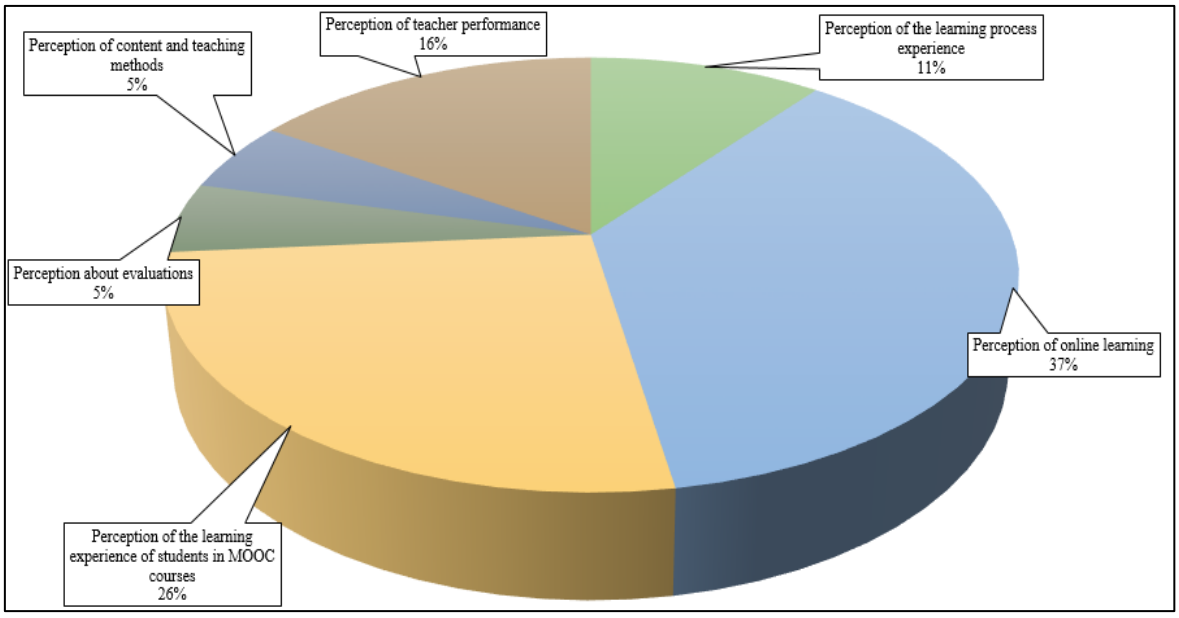

Figure 4. Percentage distribution of articles reviewed by evaluated indicator of the dimension student experience on the teaching-learning process

Table 3. Areas of application of sentiment analysis

Area of application	Analyzed dimension	Indicator evaluated	Bibliographic references
Academic	Student experience of the teaching-learning process	Perception of the learning process experience	[34], [35]
		Perception of online learning	[36]–[42]
		Perception of the learning experience of students in MOOC courses	[43]–[47]
		Perception about evaluations	[48]
		Perception of content and teaching methods	[49]
		Perception of teacher performance	[50]–[52]
	Student experience of the learning environment	Perception of the satisfaction of learning environments	[53]
		Student experience perception of Google apps used in learning	[54]
College student wellness	Efectos del confinamiento en los estudiantes por el COVID-19	Perception of the consequences of the pandemic on students	[55]
	Emotional state of the student	Perception of the student's state of mind and its relationship with academic performance	[56], [57]
	Library service	Perception of satisfaction with the library service	[58], [59]
Image of the educational institution	Academic offer provided to students	Perception of the academic offer of universities	[60]

3.2. What contributions have been achieved as a consequence of using sentiment analysis as a tool to identify student satisfaction?

Regarding the contributions obtained as a consequence of using sentiment analysis as a tool to identify student satisfaction, it was possible to determine three categories. These are “contribution focused on identifying aspects of the students”, “contribution focused on aspects of the teaching activity” and “contribution focused on aspects for decision-making by managers”. Figure 5 shows the percentage distribution of the scientific articles reviewed, according to the category identified.

Of the three categories identified, 48.15% is concentrated in the category “contribution focused on aspects of the teaching activity”, which is made up of three specific contributions. Table 4 shows the categorization of the contributions identified in the systematic review, as well as the specific contributions. In this it is distinguished that most of the scientific articles reviewed have as a specific contribution that “it allows the teacher to follow up on the student for the redesign of study plans, techniques, materials and didactic strategies”.

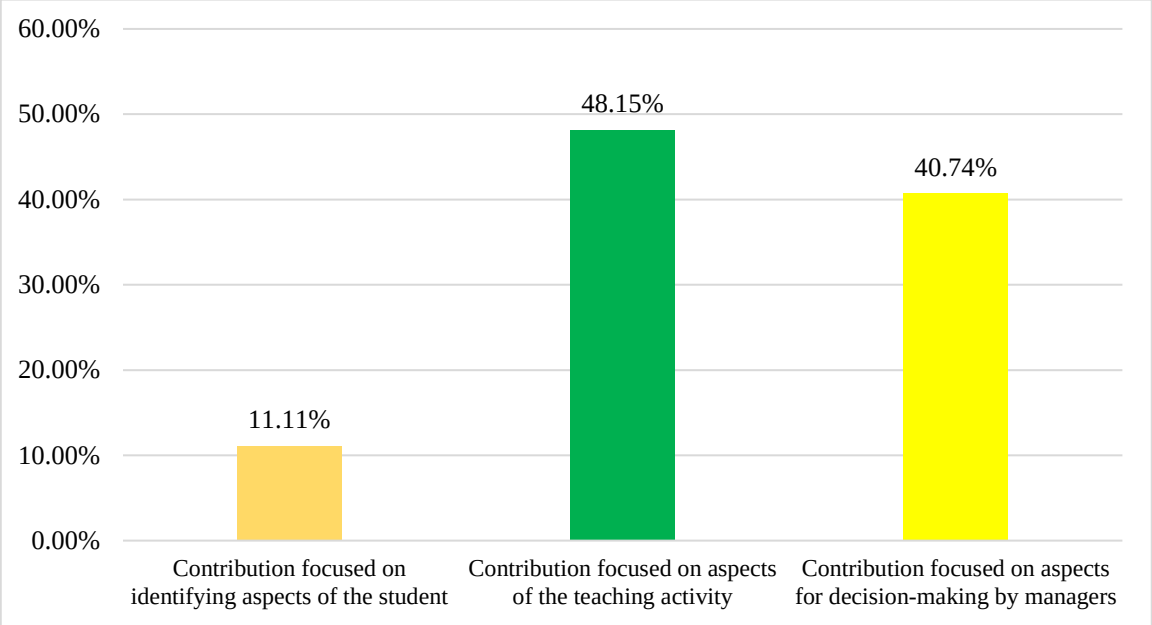

Figure 5. Percentage distribution of scientific articles, according to the categorization of contributions

Table 4. Categorization of contributions

Categories	Specific contributions	Bibliographic references
Contribution focused on identifying aspects of the student	Allows the identification of the student's emotions	[56]
	Allows the student to self-adjust according to the teaching process	[40]
	Allows the student to personalize their assessments	[48]
Contribution focused on aspects of the teaching activity	Allows the teacher to monitor the student for the redesign of study plans, techniques, materials and teaching strategies	[34], [37]–[39], [41]–[47], [49], [50], [57]
	Allows the teacher to develop formative assessments	[35]
	Allows the teacher to monitor the use of applications or technological learning tools	[54]
Contribution focused on aspects for decision-making by managers	Allows managers to design policies and strategies to optimize academic service	[36], [44], [45], [51], [60]
	Allows the manager to design strategies to improve teacher performance	[52]
	Allows the manager to design strategies to improve the library service	[58], [59]
	Allows the manager to design policies and strategies to optimize the emotional state of the student	[53], [55]
	Allows the manager to design policies and strategies to improve the image of the University	[46]

3.3. What are the limitations that arise when using sentiment analysis to identify student satisfaction?

Regarding the limitations that arise when using sentiment analysis to identify university student satisfaction, only 51.85% of the total scientific articles reviewed detail the limitations present in their research. However, in order to categorize the limitations found in the percentage of scientific articles that do detail it, it was possible to determine four categories: “low student participation rate and class imbalance”, “data collection based on a single population of study”, “lack of a lexicon and grammatical rules that allow to improve the precision of the students’ feelings” and “lack of analysis on the possible bias in the collected data”. Figure 6 shows the percentage distribution of scientific articles, according to the categorization of limitations.

Of the four categories identified, it is observed that the greatest concentration of limitations in the systematic review is concentrated in the “low rate of student participation and class imbalance” present in the collected data set. The number of scientific articles with these limitations represent 22.22% of the total scientific articles analyzed. Likewise, to be more precise in terms of the limitations found in the systematic review, Table 5 shows the “specific limitations” by bibliographic reference grouped by category.

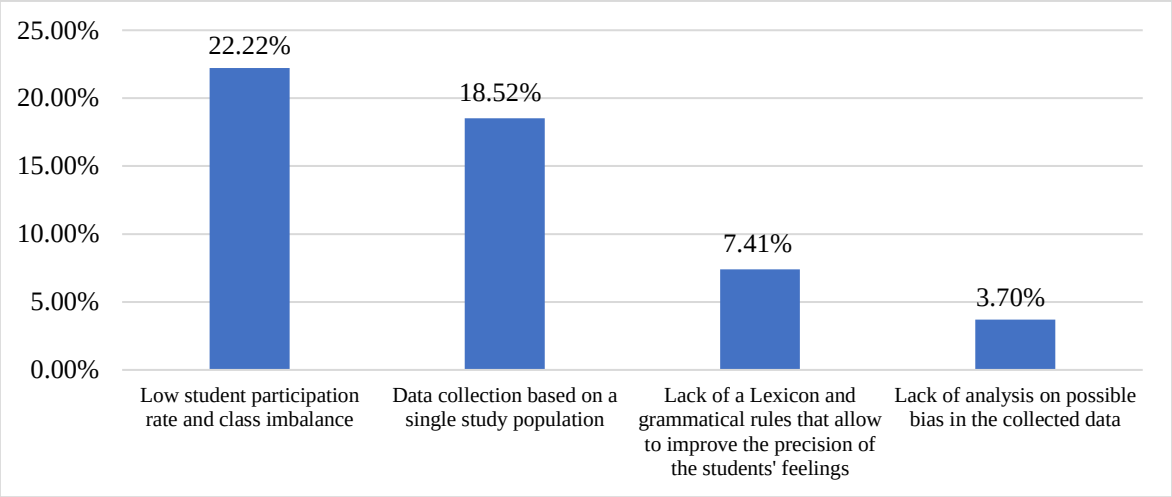

Figure 6. Percentage distribution of scientific articles, according to the categorization of limitations.

Table 5. Categorization of limitations

Category	Specific limitation	Bibliographic reference
Low student participation rate and class imbalance	It was not possible to identify with great precision the feelings of the students in the neutral class, possibly due to the low rate of collection in that class.	[34]
	Reduced student participation during the tests of the sentiment analysis system to identify satisfaction.	[41]
	Low student participation rate, which could generate some bias in the results.	[43]
	Information was collected from students who fully completed the MOOC courses, while those who did not complete did not make opinions, so there was no information on that student's condition.	[44]
	There was no participation of the total number of students enrolled in the subject.	[50]
	The data was collected from the reviews of the students who presented restrictions. In addition, the research focused on a university and it was not possible to survey 100% of the students	[54]
Data collection based on a single study population	Data was collected in a student context, so you should work with other data sets that contain images or emojis.	[56]
	The source used to collect opinions on comments on the services and educational offers of the universities, may contain information from educational institutions but of another type, which are not universities.	[60]
	For the choice of the predictive algorithm, performance comparisons were made between fourteen classification algorithms, so it is recommended to make a greater number of comparisons with other algorithms.	[53]
	Information was collected only from the Coursera.com page and strictly about business courses; therefore, the results are limited to those contexts.	[46]
	Opinions were only collected for students of one subject, so the study should be extended to students of other subjects.	[52]
Lack of a Lexicon and grammatical rules that allow to improve the precision of the students' feelings	The most critical limitation was the lack of a lexicon that allows the precise identification of the polarities in the Turkish language.	[36]
	The limitation in the research centered on the non-observance of grammatical rules.	[37]
Lack of analysis on possible bias in the collected data	The student population, being classmates from the same university institution, can generate biased responses.	[49]

4. DISCUSSION

In relation to the results obtained from the systematic review regarding the first research question, in which it was identified that 77.8% of the reviewed manuscripts focus their studies on the academic field, 18.5% on the well-being of the students and the 3.7% in the image of the educational institution. Research by Puraivan *et al.* [61] stated that it is relevant to apply sentiment analysis to the academic field since this tool allows the identification of phenomena that impact the learning process. In addition, Chanchí *et al.* [5] in their research work in which they applied sentiment analysis to identify the satisfaction of university students, they obtain as results various reflections on the student's needs in the online learning process and aspects to be improved by the teacher in this same field. These two investigations agree with what was found in this systematic review, since the applications of sentiment analysis to a greater extent are closely linked to

its application or action on indicators in the academic field, that is, on the teaching-learning process. However, there are studies that contextualize the application of sentiment analysis in university education to the pandemic period. Thus, Jiménez *et al.* [62] through their research on sentiment analysis in higher education, were able to identify student satisfaction regarding teacher performance in different periods of time, managing to determine that teachers showed a good predisposition for the development of their academic activities during the pandemic period. In this regard, Pérez-Suasnavas *et al.* [63] in their study on data mining in higher education conclude that the main uses of data mining in education are framed in the identification of problems, categorization of opinions, as well as evaluating student complaints and preferences related to the COVID-19. These two investigations contribute to establishing that data mining and sentiment analysis are more focused on the search for university well-being, identifying the possible effects of confinement by COVID-19.

Likewise, in relation to the results obtained from the systematic review regarding the second research question, in which it was identified that of the scientific articles reviewed, 11.11% focused on identifying aspects of the student, 40.74% focused on identifying aspects for the improvement of decision-making by managers, and 48.15% focused on identifying aspects of the teaching activity. In this regard, Monje *et al.* [6] concluded that sentiment analysis helps to identify aspects related to teaching performance and activity, since sentiment analysis represents an evaluation tool that helps to identify the degree of progress of educational strategies and the relationship between teachers and students, evaluating the development and fulfillment of the objectives set by the teacher. Likewise, sentiment analysis allows extracting information from students to generate feedback on the teacher's work or activity [64], [65].

Based on the aforementioned statements, it can be established that what was determined in this systematic review study is coherent and consistent with what the authors indicated. However, the analysis of feelings also allows extracting information on aspects related to the emotional state of the student in certain particular contexts. In this regard, Zeng *et al.* [66] identified through the sentiment analysis that students, when attending a conference, at some point express their discomfort or disagreement with the teaching materials or resources, and express it through the constant sending of danmakus, thus concluding that the teachers must pay special attention to provide the necessary feedback in the teaching process. Likewise, within the categories identified in this systematic review on the aspects in which sentiment analysis is applied in university education is with respect to identifying the feelings of students for the improvement of decision-making by managers. In this regard, Lasri *et al.* [67] developed an application that provided real-time ranking of student opinion sentiments through a social network. It concludes that through this predictive system of classification of sentiment, the institutions that run the universities, such as the Ministry of Education, may have information to improve decision-making.

Finally, in relation to the results obtained from the systematic review regarding the third research question, Panico [68] in his research paper stated that since sentiment analysis is a relatively recent field of study, it still presents several problems and limitations that do not allow the accuracy of the results to reach 100%. Being aware of the complex process that involves applying sentiment analysis for the classification of university student satisfaction, it is important to discuss that for the application of this tool to be viable, it is important that students, teachers, managers and the academic community in generally get fully involved with these types of applications. This means that there must be regulations that support these applications and that they are not simply works or studies of specific cases without normative support or without regulations established by the university.

5. CONCLUSION

The research concluded that the areas in which sentiment analysis is applied as a tool to identify university student satisfaction are academic, university student well-being, and image of the educational institution, being in the academic field, in which the studies have mostly focused, representing a total of 77.8% of the total scientific articles reviewed. With respect to which are the contributions achieved through the analysis of feelings, it is concluded that three categories could be identified in which the contributions are grouped, these being: contribution focused on identifying aspects of the students, contribution focused on aspects of the teaching activity and contribution focused on aspects for decision-making by managers, finding that the contribution focused on aspects of teaching activity is the one that the studies have focused on the most, representing 48.15% of the total scientific articles reviewed. Likewise, with respect to what limitations have arisen in the application of sentiment analysis, it is concluded that four categories could be identified, these being: low student participation rate and class imbalance, data collection based on a single study population, lack of a lexicon and grammatical rules that allow to improve the precision of the students' feelings and lack of analysis on the possible bias in the data collected, being the low rate of student participation and class imbalance, the limitation that is mostly have presented in the studies, representing 22.22% of the total scientific articles reviewed.

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BIOGRAPHIES OF AUTHORS

Omar Chamorro-Atalaya is an electronic engineer, graduated from the National University of Callao (UNAC), with a Master's degree in Systems Engineering and a doctoral student at the Faculty of Administrative Sciences at UNAC. Researcher recognized by CONCYTEC (National Council of Science, Technology and Technological Innovation-Peru). Research professor at the National Technological University of South Lima (UNTELS), he teaches courses on automatic process control and industrial automation, and design of control panels and electrical control. He can be contacted at email: ochamorro@untels.edu.pe.

Florcita Aldana-Trejo is a research professor at the Federico Villarreal National University in Peru. She has a degree in economics. She taught at the Faculty of Economic Sciences from 1995 to the present. She has a Master's in Research and University Teaching and a Ph.D. in Administration. At the university level, she carries out research on topics of Economics, university education and management, she a thesis advisor, she carries out consulting and external training for small and micro companies. She can be contacted at email: faldana@unfv.edu.pe.

Nestor Alvarado-Bravo is a research professor at the National University of Callao in Peru. He has a degree in Psychology. He taught at the university from 1998 to the present, in the Faculty of Chemical Engineering. He is a Magister in Clinical Psychology and Doctor in Psychology. At the university level, he conducted research on topics of psychology, university education and management. He is a thesis advisor. He did consult and external training for small and micro businesses. He can be contacted at email: nmalvaradob@unac.edu.pe.

Constantino Nieves-Barreto has studied Administration at the National University of Callao, in Peru. He is a Doctor of Administration from the National University of Callao. Currently, he is in charge of the subjects of the curricular plan of the Faculty of Administrative Sciences of the National University of Callao. He can be contacted at email: cnievesb@unac.edu.pe.

Santiago Aguilar-Loyaga is an undergraduate and graduate professor at the National University of Callao, in the Faculty of Administrative Sciences and the Faculty of Industrial and Systems Engineering. He is also a professor at the National University of Engineering, in the Faculty of Chemical and Textile Engineering. He is a specialist in private finance. He has a Ph.D. in Administration from the Alas Peruanas University. He has a master's degree in Government and Business Auditing from the Nobert Wiener University. He is an Economist, graduated from the National University of Callao. He can be contacted at email: sraguilarl@unac.edu.pe.

Carlos Gamarra-Bustillos has a master's degree in education and a doctorate in public health from the Federico Villarreal University. He is a specialist in pediatric nursing. He completed the diploma in health quality management, as well as the specialization in the preparation of the study plan from the competency-based approach at the Cayetano Heredia University. He is also a specialist in quality management of the curriculum in higher education institutions based on quality standards by the Pontifical Catholic University of Peru. He currently works as a postgraduate professor at the Autonomous University of Ica in Peru. He can be contacted at email: carlos.gamarra@autonomadeica.edu.pe.

Almintor Torres-Quiroz is a professor at the National University of Callao in the Faculty of Economic Sciences. He is an ordinary main teacher and a research teacher. He is an anthropologist by profession from the National University of Trujillo. He has a master's degree in research and university teaching from the National University of Callao. He is a doctor in education from the Federico Villarreal National University. He developed a Post-Doctorate in Science with a major in Bioanthropology at the Atlantic International University in the USA. He can be contacted at email: agtorresq@unac.edu.pe.

Alípio Riveros-Cuéllar has a degree in Cooperatives from the Federico Villarreal National University. He has a Master's in Tourism and Hotel Marketing from the San Martin de Porres University. He has a Ph.D. in Administration from the Federico Villarreal National University. He is a professor at the Federico Villarreal National University. He can be contacted at email: ariveros@unfv.edu.pe.

Manuel Pérez-Samanamud has a degree in Mathematics and Physics from the Federico National University. He has a Master's in educational management from the Enrique Guzmán y Valle National University of Education. He is a doctor in Educational Sciences from the Enrique Guzmán y Valle University of Education. He has professional experience in university teaching at the Federico Villarreal National University. He can be contacted at email: mperez@unfv.edu.pe.

Luciano Pérez-Guevara has a degree in Biology and Chemistry from the Federico Villarreal National University. He has a Master's in Educational Management from the Enrique Guzmán y Valle National University of Education. He has doctoral studies in Education at the Federico Villarreal National University. He has professional experience in university teaching at the Federico Villarreal National University. He can be contacted at email: lperezg@unfv.edu.pe.