E-LEARNING UNIVERSITY EVALUATION THROUGH SENTIMENT ANALYSIS CENTERED ON USER EXPERIENCE DIMENSIONS

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ABSTRACT:

The COVID-19 crisis increased the number of users of university online teaching, enhancing the importance of this learning format. Additionally, ISO 9241-210:2019 standard sets the international standards for the design of products, services and interaction systems from usability, accessibility, and user experience (User eXperience - UX) perspective. Then, in order to design interfaces and learning experiences that include motivations, feelings and needs of end users, it is necessary to previously evaluate the UX of these environments, with less general and/or laborious methods than those that currently exist. Therefore, this work aims to establish the basis of a method that allows automatically to evaluate the UX of online teaching platforms by analyzing the users' sentiment about specific aspects of their virtual learning experience.

To do this, 2,035 users were surveyed about their online learning experience with a questionnaire and an open text field to give their opinion. The population surveyed were online postgraduate students of the Universitat de València and the Universidad Rey Juan Carlos, and university students of massive open online courses of the Universitat Politècnica de València. The opinions collected in Spanish from 476 students were processed with the commercial sentiment analysis and natural language processing tool MeaningCloud, to analyze the sentiment (positive, negative, or neutral) about aspects of their experience.

The results present a new model that, on the one hand, ontologically classifies categories and aspects of online education with sentiment analysis techniques, and on the other hand, the model groups these categories according to UX criteria, presenting its own classification to facilitate the evaluation of online learning experiences in a concrete and automatic way.

Keywords: user experience, UX, e-learning, virtual learning, sentiment analysis, data mining, MeaningCloud, natural language processing, university online learning, user centered design, UCD, NLP, VLE

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1.- INTRODUCTION

Online learning in higher education is a teaching model increasingly in demand due to the flexibility and personalization of the study system. Distance learning through virtual environments (e-learning) allows learning at the student´s pace, time and place, Berge. [1]. The COVID-19 world crisis triggered the number of new users in university institutions that began to use the online or hybrid teaching format (face-to-face and online simultaneously) with the consequent massive use of ICT tools (Information and Communication Technologies) applied to education, Ntshwarang. [2].

In recent years, human-computer interaction (-HCI-) in the field of higher education is a subject of research in order to ensure the success of the teaching process at the university and the quality of online learning for students. In this sense, some factors evaluated in the quality of interactive learning are the teachers, the e-learning system and the educational content according to Alebeisat [3]. The specifications for the quality of HCI systems are detailed in the ISO 9241-210:2019 standard. [4] with a framework on the interaction that considers usability, accessibility and user experience based on user-centered design. ISO describes user experience (UX) as all the emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and achievements that occur before, during and after the use of interactive systems. For Zaharias and Mehlenbacher [5] UX is a multidimensional concept focused on human needs and aspects of beauty, fun, pleasure, and personal growth that are experienced in human interaction with computers. Other authors, such as Rauschenberger et al. [6], define UX as a concept that encompasses both pragmatic (clarity, efficiency and dependence) and hedonic (stimulation and novelty) qualities. Along these lines, Hassenzahl [7] highlights the importance of the pragmatic aspect of interactive products and the hedonic aspect for the design of experiences, understanding the UX concept as a consequence of the user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (complexity, purpose, usability, functionality, etc.), and the context.

Moreover, in 2015, the UN adopted the 2030 Agenda with 17 Sustainable Development Goals (SDGs) to improve the lives of all. Goal 4 aims to ensure inclusive, equitable and quality education and promote lifelong and lifewide learning opportunities for all, including university education. UNESCO's regular report on SDG 4 [8] highlights the need for inclusive and quality ICT tools for learning.

Students access to the digital medium with different abilities, age, culture, location, context, browsing, study, socialization and interaction behavior within the same virtual learning environment, Sanchis-Font et al. et al [9]. Therefore, learning environments designed with interfaces that include the motivations, feelings and needs of all end users are required, with inclusive experiences that facilitate a successful learning process through university online learning platforms. A deep understanding of the UX of these platforms will enhance the design of environments that meet the functional, aesthetic and emotional characteristics and needs required by users. In order to understand the user's opinion from this perspective, Spallazo [10] brings together the 129 UX evaluation methods for interactive systems. The most prominent methods for evaluating UX by several authors, Diaz-Oreiro [11] are AtrakkDiff, UEQ, or meCUE. Despite these UX evaluation tools are very widespread, their application to the field of online education is very limited, as they are laborious to process and not very specific.

On the other hand, Natural Language Processing (NLP) technologies allow to analyse user's opinion from text and sentiment analysis. Thus, Clarizia [12] proposes to use data mining to analyze the sentiment present through text comments among students in order to allow the teacher a better knowledge of the mood of online learners. The authors aim to outline a model that successfully responds to the analysis task, rather than the results of the experience, by obtaining an overall analysis of user sentiment. Depending on the level at which one wishes to treat the text, one can extract the polarity of the whole document, Moraes [13], the polarity of each sentence in Sanchis-Font et al. [14] or the polarity of each aspect appearing in the text. In other research Sanchis-Font et al.[15] apply PLN models with data mining to evaluate such systems automatically in order to know the polarity of each sentence expressed by users of university e-learning platforms, improving automation and efficiency in the UX evaluation process. The results of the research were very encouraging, but only allowed to know the assessment of the experience in a generic way as positive, negative or neutral and still did not show concrete aspects of a virtual learning experience such as the concepts "video", "slides", "teacher", etc.

Other preliminary studies on the application of sentiment analysis techniques to analyze the perceptions of distance learners have also been published, Magayon [16] and Mac Kim [17]. Both works focus on general aspects of the experience without addressing specific

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characteristics of the online learning process from a user experience (UX) perspective. So, the problem of detecting concrete areas for improving e-learning user experience in an automatic way remains unresolved.

Therefore, this research seeks more efficient and accurate automatic methods and tools related to certain aspects related to the student experience for UX evaluation in e-learning.

Currently, there are several commercial PLN tools on the market that analyse sentiment on texts automatically. Thus, MeaningCloud, Google Cloud Natural Language or Microsoft Azure Text Analytics stand out for their widespread use. In this area, we found studies of sentiment analysis of user comments on their experience with available techniques in the market, Zulkifli et al. [18]. These authors analyse the polarity of customer reviews in English from Amazon, Yelp and IMDb on social media using three tools: Python NLTK Text Classification, Miopia and MeaningCloud. The study showed that MeaningCloud is the technique with the highest accuracy at 82.1%. MeaningCloud is a commercial text analytics NLP API and tool, released in 2015 as an evolution of a former product called Textalytics. Both tools have been validated by several authors in the study of their performance, Joshi [19], Singh [20], or Zulkifli [18].

In order to evaluate the UX in e-learning, authors such as Zaharias [5], Ovesleová [21] or Mtebe [22] have established a series of UX categories or criteria applied to the field of online education that clarify the guidelines to ensure a user-centered design of interactive learning platforms and a positive and quality experience, but without developing automated methods. Therefore, taking as a reference the UX characteristics relevant to the e-learning domain defined by these authors, the present study aims to classify the opinions in favor, against or neutral in an automated way focusing on specific characteristics and dimensions of the user experience in e-learning university environments. For this purpose, this research presents the creation and application of an ontology model of UX in e-learning that allows using PLN tools to extract the themes of user comments in Spanish to detect the UX aspects of interactive learning systems associated with three dimensions and their aspects (VLE - Virtual Learning Environment-, Social Connections -Student, Communication and Teacher- and Learning Resources and Tools -Exercise, Assessment, Image, Material and Sound-) and analyses the polarity of user sentiment for these dimensions being positive, negative or neutral.

In short, the present work offers, for the first time, the basis of an automatic artificial intelligence model that allows the evaluation of user experience from sentiment analysis in university online learning environments and their related aspects, with the ultimate goal of improving the design of the online university student experience.

2.- MATERIALS AND METHODS

2.1.- CORPUS CREATION BASED ON E-LEARNING USER´S OPINIONS

For the creation of the corpus, we used the data previously obtained in the research by Sanchis-Font [15] on the experience of using university e-learning platforms for graduate and undergraduate courses. The data came from the validated UEQ and UEQ-S user experience questionnaires with an open field for student´s observations. The questionnaire was delivered to 2,035 users during 2016 and 2018, which were biomedical postgraduate students coming from the Universitat de València (UV) and the Universidad Rey Juan Carlos (URJC), and university students of massive open online courses (-MOOC-) of the Universitat Politècnica de València (UPV). The online learning was carried out on three different platforms depending on the university providing the course. Thus, the questionnaires were adapted and integrated into the ad-hoc system called "Conecto" for the UV master's degree courses (in Spanish and English), into the open-source Moodle platform for the URJC postgraduate courses and into the edX platform for the UPV MOOCs (in Spanish) [23].

Out of the 2,035 students surveyed, only 583 users made comments, of which 476 commented in Spanish and 107 in English. For this study it was used the data collected from the opinions of users who answered in Spanish with a free text field with their comments (476 users). Comments without information or sentences that were not meaningful (e.g., "nothing") were manually cleaned. Afterwards, we obtained 410 useful comments from different users. These opinions formed a corpus consisting of 599 statements (including phrases and sentences -with verb-).

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Then, machine learning models of sentiment analysis would allow us to classify the aspects found in these sentences based on their Positive (P), Neutral (NEU) or Negative (N) polarity. Three examples from the corpus and how they were supossed to be classified are shown in Table A of the appended supplementary material.

2.2.- CREATION OF AN ONTOLOGY OF E-LEARNING ASPECTS

The ontology was created with the corpus found in users´ comments (599 statements). The corpus consists of a closed set of texts or data intended for scientific research and the ontology catalogs the variables required for some set of computation and establishes the relationships between them. The authors created the ontology in order to be able to categorize the aspects present in the text and focused on nine categories or aspects related to the main peculiarities of a virtual learning system. Each sentence was classified into one aspect or category. For this purpose, entries or entities in the text were detected. An entry or entity is a word that can appear in the text denoting a category. For example, possible entries for the VLE aspect or category would be course, environment, experience, master, etc.

To select the different ontology entries, at the first stage, the inclusion or exclusion criteria was based on the expert knowledge of the task. This knowledge relates to the authors' knowledge of which concepts may be the most important for online learning. Then, several entities were selected by the authors based on their experience in the field, such as "tutor" or "student".

In this way, a proprietary ontology of e-learning aspects was created to evaluate the user experience based on the following categories or aspects: VLE, teacher, learner, sound, image, material, exercise, evaluation and communication. For each category, a list of entities or entries related to the e-learning aspect to be analysed was specified. The complete description of the ontology (in Spanish) is detailed in table B of the supplementary material.

Next, an analysis of word frequency and its importance in the text was performed using the default ontology of MeaningCloud and Google Cloud Natural Language. Then, in the first phase, the frequencies of appearance of the various words existing in the corpus were analyzed together with the metrics returned by the tools, which indicated how important the words are in the statements. The non-formal validation of the ontology was given by the high concordance between the a priori knowledge with the most repeated words that the tools considered most important. There were 248 appearances of aspects related to the categories of the e-learning ontology itself, as shown in Fig. 2.

2.3.- APPLICATION AND EVALUATION OF NLP TOOL FOR THE ANALYSIS OF SENTIMENT AT ASPECTUAL LEVEL IN E-LEARNING

To analyze the user experience aspects of online learning platforms in our data corpus, consisting of 599 statements, we applied the commercial NLP MeaningCloud tool, specifically its free text sentiment analysis application programming interface (API) [24]. This is one of the data mining tools on the market for text analysis that allows the own creation of ontologies through a web interface. With this API, the authors were able to select the key aspects associated with the UX evaluation and enter the ontologies used in the study. The software used for sentiment analysis at the aspectual level in e-learning was MeaningCloud (MC), Sentiment Analysis API version 2.1. [25]. The tool returns a file with the information that has to be processed, analysed and converted to graphs. This after data processing, analysis and creation of graphs was done with proprietary software that the authors programmed in Python.

The MC tool uses a polarity scale consisting of six elements, but we have compressed them into the three basic polarities, using proprietary tools developed for the task:

- Negative: it joins the negative polarity N and very negative N+.
- Positive: it joins the positive polarity P and very positive polarity P+.
- Neutral: it joins polarity NEU and no NONE.

2.4.- CLASSIFICATION OF CATEGORIES OF SENTIMENT ANALYSIS IN UX DIMENSIONS IN E-LEARNING

Subsequently, in order to evaluate e-learning systems automatically from the UX perspective, we propose the classification and relationship of the categories present in our ontology grouped into three UX dimensions related to the UX e-learning research of

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Zaharias [5] Ovesleová [21] and Mtebe [22]. This classification of categories is shown in Table I. The three authors largely agree on the importance of three areas for e-learning UX: the online teaching platform, social relations, and the availability of resources and instructional tools for the quality of online learning. For this reason, we propose a grouping of the categories of our ontology into three UX dimensions in e-learning, which we will call "**UXEL Dimensions**":

- **VLE (Virtual Learning Environment)** refers to the practical and functional properties of the virtual learning platform and includes only the VLE category**.**
- **Social Connections** groups together the whole set of tools that enable interpersonal communication and collaboration in e-learning systems. This dimension includes the categories: Student, Communication and Teacher.
- **Learning resources and tools** encompasses the whole set of materials and resources used in the learning process, from exams or exercises to videos and their graphic and sound quality. This dimension includes the categories: Exercise, Evaluation, Image, Material and Sound.

Own e-learning ontological categories	**Categories Zaharias-Pappas Model**	**Requirements Ovesleová**	**Mtebe Criteria**	**UXEL dimension**
VLE	Pragmatic Quality	Gaining attention	-	VLE
Teacher	Autonomy and relatedness	Providing learning guidence	Collaborative learning	Social connections
Student	Autonomy and relatedness	Providing learning guidence	Collaborative learning	Social connections
Sound	Authentic learning	Presenting the stimulus	Instructional Materials Accessibility	Learning resources and tools
Image	Authentic learning	Presenting the stimulus	Instructional Materials Accessibility	Learning resources and tools
Material	Authentic learning	Presenting the stimulus	Instructional Materials	Learning resources and tools
Exercise	Authentic learning	Eliciting performance Enhancing retention and transfer	Instructional Materials Feedback and assessment	Learning resources and tools
Evaluation	Pragmatic Quality	Assessing performance	Feedback and assessment	Learning resources and tools
Communication	Autonomy and relationships	Guided teaching	Collaborative learning	Social connections

Table I: Relationship between e-learning UX categories and ontological categories and dimensions in online learning platforms ("UXEL Dimensions").

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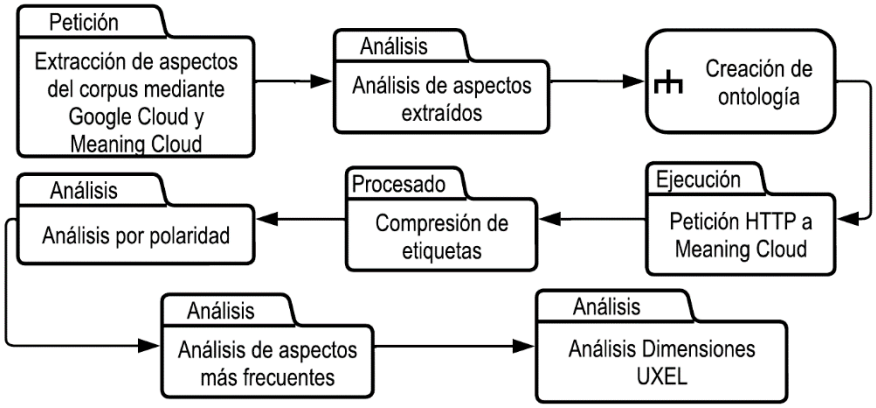

Diagram of the experimentation process at the programmatic level.

3.- RESULTS AND DISCUSSION

3.1.- OWN ONTOLOGY OF E-LEARNING CATEGORIES AND ASPECTS

The ontology defined in this work was based on nine categories that encompass the main peculiarities of an e-learning system. Part of the work has focused on reorganizing the aspects that make up our dataset of the three UX dimensions of online learning (VLE, Learning Resources and Tools, and Social Connections) in order to analyze their polarity using the MC tool and evaluate the UX of the analysed university courses.

As for the distribution by categories, Fig. 2 shows that the most frequent category is VLE, with 115 appearances. The second most commented category is "Image", which has appeared 47 times and the rest of the categories have 25 or less appearances.

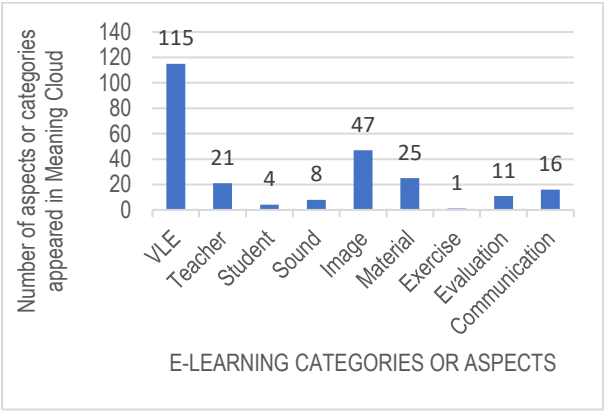

Figure 2. Histogram of frequency of appearance by category in MeaningCloud.

In Fig. 2 we observe how 248 aspects have been classified by MC, representing VLE 46.37%, image 18.96%, material 10.09%, teacher 8.47%, communication 6.45%, evaluation 4.43%, sound 3.22%, student 1.61% and exercise 0.40%.

This means that, among the 599 statements collected in this research belonging to a total number of 476 students, MeaningCloud detected 248 aspects or categories of the self-ontology associated with the UXEL dimensions. The most named category was the virtual learning platform (VLE) which appeared 115 times. The second most mentioned UXEL dimension was Learning Resources and

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Tools with 92 different entries (Exercise, Assessment, Image, Material and Sound). Aspects related to interpersonal communication and collaboration offered by the university learning experience, which were grouped in the Social Connections category (Teacher, Student, Communication), were mentioned 41 times. This data is shown in Fig. 4.

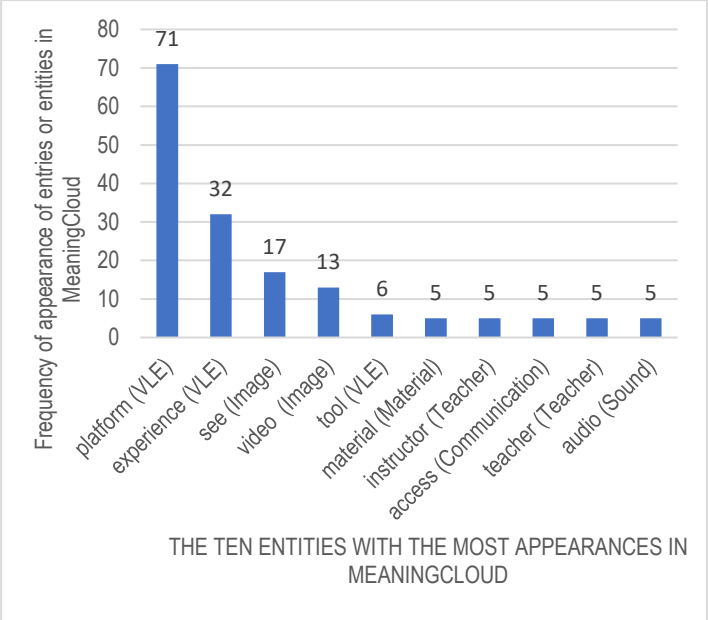

Figure 3. The ten entities or entries with the highest frequency of occurrence detected by MeaningCloud. The data show the number of times each entity has been detected by MeaningCloud, and the category to which they belong (in parentheses).

Fig. 3 shows how "platform" is the most detected aspect followed by "experience". It is important to note that the data used come from various virtual learning platforms (Moodle, Ad-hoc –Conecto- and edX). However, the results of frequency of most detected entries show the object of greatest interest for students, with the entities "platform", "experience" and "see" and "video" being the most mentioned in the data set coming from the three university e-learning platforms.

3.2.- UXEL DIMENSIONS

The polarity for the 248 e-learning aspects rated by MeaningCloud was the following: 113 aspects rated as positive (45.56%), 99 neutral (39.91%) and 36 negative (14.5%). The figures highlight an overall positive e-learning experience for the surveyed students.

The results of sentiment analysis by UXEL categories and dimensions are shown in Fig. 4 to 7. Fig. 4 shows how MC distributes the number of aspects to rank them in the three dimensions. "Social connections" presents a lower number of aspects, while “VLE” is the most mentioned dimension.

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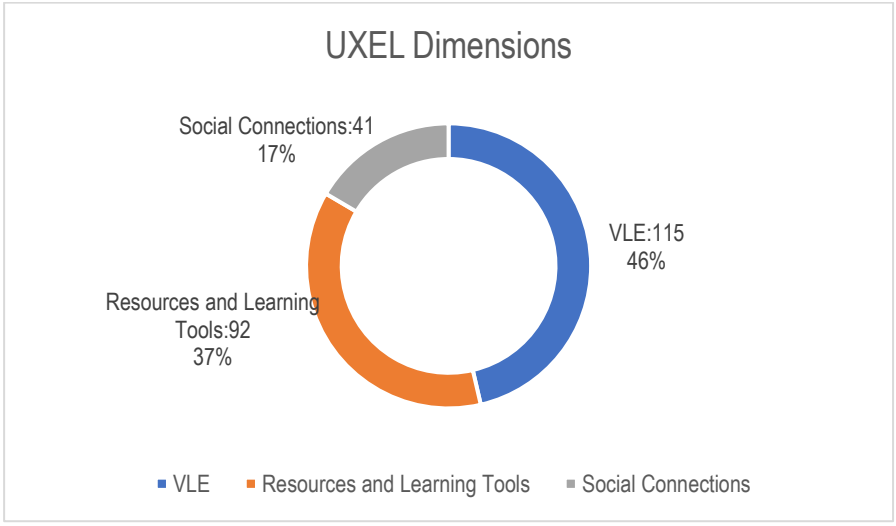

Figure 4: Relative distribution of UXEL dimensions, with the number of entries and their percentage of mention.

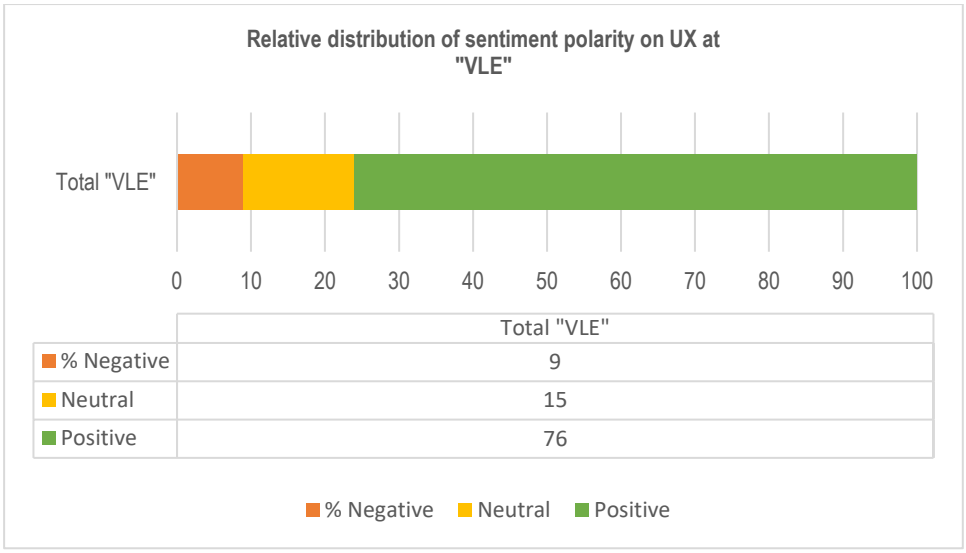

Figure 5: Relative distribution in percentage values of sentiment on "VLE" as a UX category and dimension.

Fig. 5 shows how much users´ comments processed in MC about the VLE category and UXEL dimension are positive, neutral or negative. As this figure shows, the virtual learning platform (VLE) of these university courses is the highest rated dimension with 76% of positive opinions. This reinforces the positive polarity results of 45.56% obtained in the overall experience.

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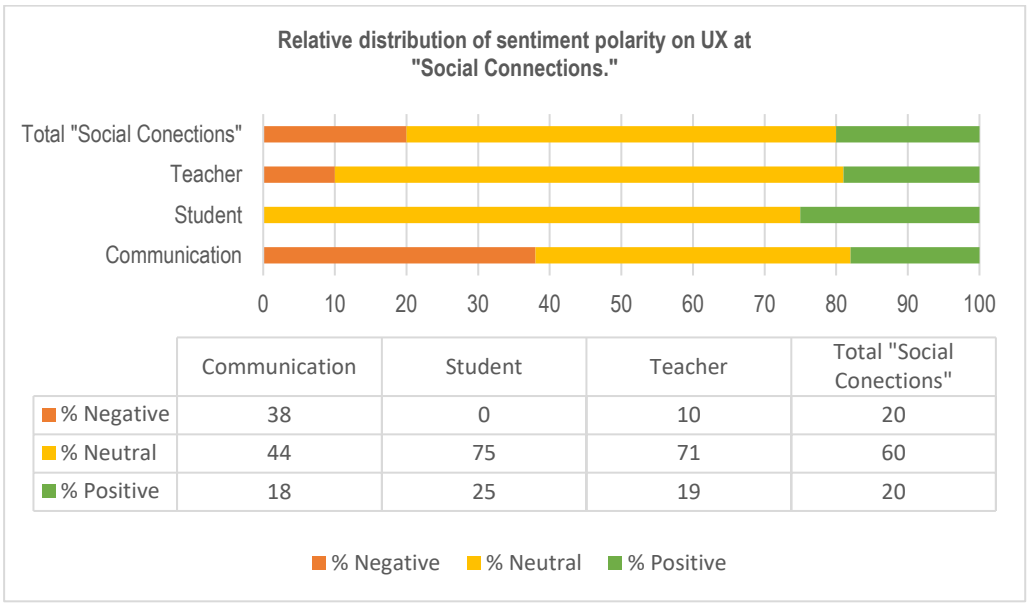
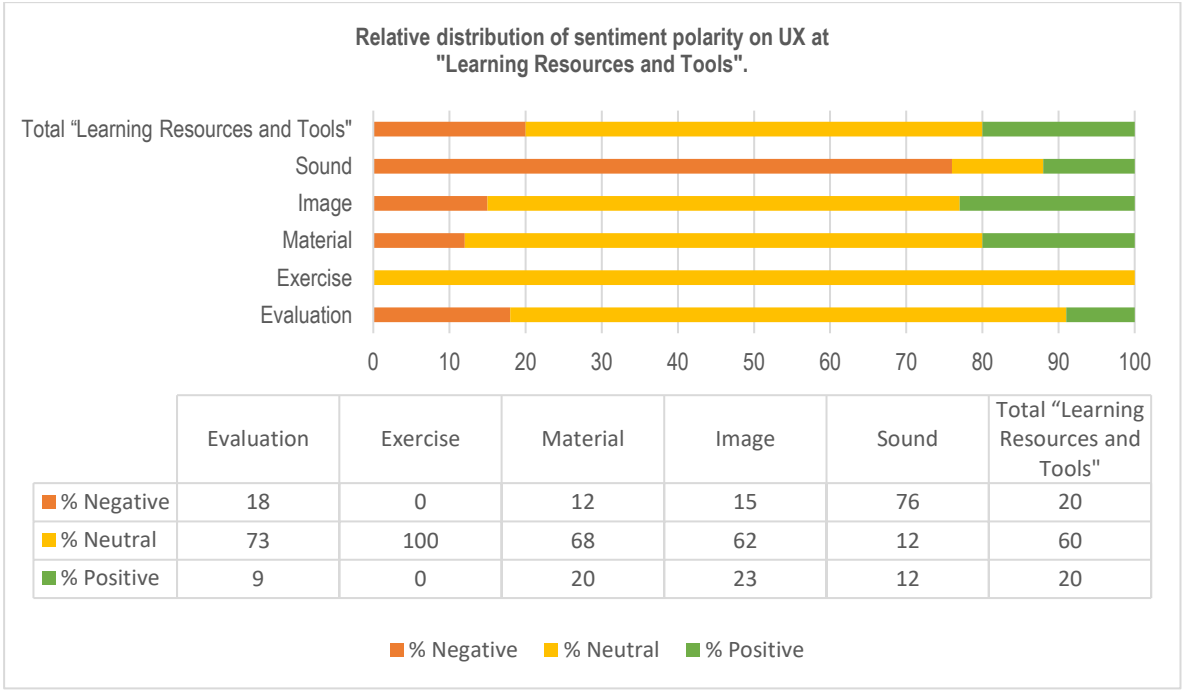


	Communication	Student	Teacher	Total "Social Conections"
% Negative	38	0	10	20
% Neutral	44	75	71	60
% Positive	18	25	19	20

Figure 6: Relative distribution of the categories of the "Social connections" dimension in percentage values.

Fig. 6 shows how the most abundant rating of both the complete dimension and its different categories is neutral. Furthermore, it can be seen that the "Student" category does not have any negative rating and the "Communication" category receives the highest percentage of criticisms, despite this there is a balance between the proportion of positive and negative aspects of the dimension as a whole.



	Evaluation	Exercise	Material	Image	Sound	Total "Learning Resources and Tools"
% Negative	18	0	12	15	76	20
% Neutral	73	100	68	62	12	60
% Positive	9	0	20	23	12	20

Figure 7: Relative distribution in percentage values of the categories of the "Learning Resources and Tools" UXEL dimension.

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Analyzing the "Learning resources and tools" dimension, we obtain a similar percentage of aspects with positive and negative evaluations. The "Exercise" category stands out by receiving only neutral opinions, and "Sound", which receives 76% of negative reviews, being the category with the worst rating of the three dimensions analyzed.

In summary, the main novelty of this approach consists in the UX evaluation through a proprietary ontology that allows to know the e-learning user experience dimensions automatically with NLP. The model reveals the aspects of improvement or success that directly impact the online experience of university students through three specific dimensions (VLE, Social Connections, and Learning Resources and Tools). In the case of these 476 university students, the results show that they perceived a positive experience when using the virtual environment, but on the other hand they expressed a neutral opinion about the rest of the UXEL dimensions concerning communication tools and interpersonal collaboration or the set of materials and resources used.

4.- CONCLUSIONS

This research has made possible to evaluate automatically the user experience in university online teaching using a proprietary e-learning ontology and the use of free-to-use commercial tools for sentiment analysis. For the first time, the polarity of student opinions (positive, neutral, negative) has been classified by key categories of digital learning (VLE, Teacher, Student, Sound, Image, Material, Exercise, Assessment, and Communication) and grouped the comments into three UX e-learning or UXEL dimensions (VLE, Social Connections, and Learning Resources and Tools).

This new model provides specific information about the characteristics of the virtual learning experience that can be improved for this type of university users and which dimensions are most or least valued, as is the case of the dimension "virtual learning environment" which was rated positively by the majority of university students.

The application of sentiment analysis tools focused on aspects of online student opinions from the UX perspective will provide accurate and automatic information allowing to focus on the needs of human-computer interaction to design university e-learning experiences that meet ISO quality standards and ensure UNESCO's SDG 4 with inclusive, equitable and quality education for all.

In future works we intend to improve the model and compare the results between different artificial intelligence tools, include more samples. This will allow us to extend the ontology with new aspects of UX e-learning and develop a more accurate, robust and efficient automatic system that investigates user sentiment in order to obtain information that facilitates the design of inclusive and user-centered virtual e-learning environments.

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