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ABSTRACT

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I. INTRODUCTION

Sentiment analysis (SA) is the process of using natural language processing techniques, text analysis, and statistics to analyze subjective information such as opinions, attitudes, impressions, and feelings. It can be used to extract and classify students' opinions and feelings that are important in different aspects (1). This method is widely applied to reviews and social media on processing, searching, and extracting factual information from various platforms such as Blogs, Twitter, Facebook, Tumbler, Instagram, etc. (2). Students constitute a significant part of the universities; their perspectives and opinions are essential for improving teaching and institutional problems, matters, and issues. Therefore, it is important to know students' opinions in digital education resources or learning environments to evaluate the institution level, teacher, and teaching.

II. BACKGROUND

Previous research was applied SA in different platforms such as private systems or social media, especially Twitter, to make better decisions, recommendations and improve various services. Researchers addressed the publics' opinion in many fields, such as e-commerce, marketing, tourism, and politics (3-5). Additionally, the previous systematic reviews focused on techniques, methods, anddomains in various fields (6, 7) or specific areas such as Marketing (8), education (2), health (9), tourism (10).

Due to the increasing amount of online published data, Higher Education (HE) must use automatic techniques to acquire a deep understanding of this online data. For example, analyze the students' online opinions and behaviors to have a complete vision about the quality of the services and address some aspects that may affect their

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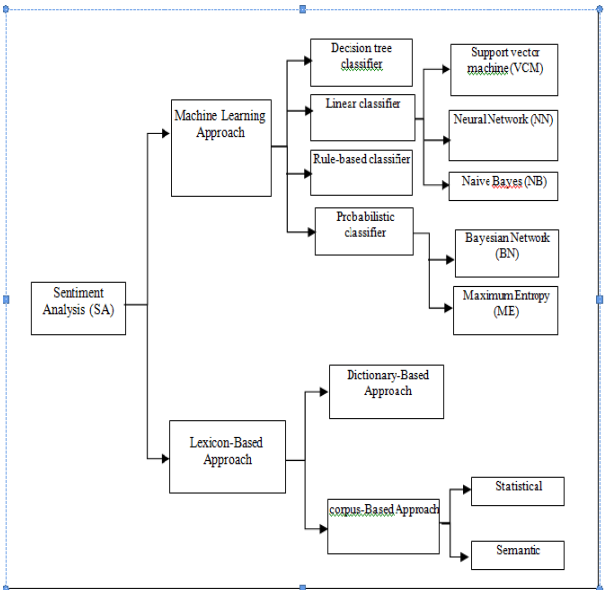
education (11). There is a lack of systematic reviews on studies applying SA in HE institutions. Thus, this systematic mapping provides in-depth information related to the SA application in HE. This information can be used to understand the benefits of SA in HE institutions and its potential to improve institutions' quality and evaluate the teaching process and teachers' performance.

Sentiment techniques

Sentiment techniques can be categorized into three main types: 1) Machine Learning (ML); 2) lexicon- based; 3) hybrid approaches (12). Machine Learning methods can be supervised learning or unsupervised learning, and it applies the common ML algorithms and uses linguistic features. The Lexicon-based approach refers to a list of words or phrases that convey positive or negative polarity information. It depends on the lexicon as a vital resource and is divided into the dictionary-based approach and the corpus-based approach, which use semantic methods or statistical to find sentiment polarity. While the hybrid approach combines both approaches, it plays a vital role with sentiment lexicons in sentiment classification (13). Figure 1 summarises the two main approaches and shows the most common algorithms of SA. From the literature, it should be noted that many other tools and techniques have been used based on these methods, as shown in Table 1.



III. RESEARCH METHODS

This study employed a systematic mapping study to identify, select, and synthesize production in a particular field or associated with a concept to determine what evidence is available on the topic (14). According to (15), a systematic mapping study focuses on subjective analysis, classification, and identification of publication without quality evaluation. This type of research differs from systematic reviews, which focus on quality, in order to identify the best practices based on empirical evidence (16).

3.1 Systematic mapping planning

This mapping study was conducted to investigate the current publications on the application of sentiment analysis in higher education and identify the most common and successful techniques and methods. The protocol's main steps that guided this study are as follows; (1 determine research questions; (2 select search strategy; (3 select studies and extract information; (4 how to report the study results.

3.2 Research question

According to this study's objectives, the main research question is:

RQ1) for what purpose was sentiment analysis applied in educational studies?
There are three subordinate questions generated from the main question to help guide the study's focus are listed below.

RQ1.1) What SA or opinion mining application domains are used in a higher education context?
RQ1.2) What the most SA techniques and tools are frequently used in educational studies?

RQ1.3) What platforms are commonly used to collect data, social media platforms, or academics systems?

3.3 The search strategy

According to the systematic mapping process, conducting the search involves identifying the search string. Thus, in this review, these search strings were used to search for sentiment analysis

articles in different digital libraries; ("sentiment analysis" OR "opinion mining" OR "text mining") AND ("higher education" OR "educational domain") AND ("Twitter" OR "Facebook") AND ("Machine Learning" OR "soft computing"). The identification was made by searching for studies in seven electronic databases: Science Direct, Web of Science, IEEE Xplore, Wiley, Springer. ACM Digital Library, and Scopus. However, more articles were also identified by scanning the reference section of some of the researched articles.

3.4 Study selection

The studies were selected based on the title, abstract, and paper information, representing sentiment analysis specifically to Facebook and Twitter. Besides, to ensure that the search process would be focused and manageable, some inclusion and exclusion criteria were defined to select the articles for review as follows:

Inclusion and Exclusion Criteria. On the one hand, the inclusion criteria were used; (1) SA studies that investigated the SA tools and techniques in HE; (2) published between 2013–2020; (3) Written in English.

On the other hand, the exclusion criteria were: (1) Duplicate studies (published in more than one journal or conference proceeding); (2) Short Articles, posters, abstracts, and essays; (3) Inaccessible full text;

(4) Irrelevant to the research questions of the current review; (5) Published in unknown journals or conferences.

Data extraction. After applied the inclusion criteria, the primary data was extracted from the selected articles for mapping according to the study's research questions. For each article, specific data was extracted included authors' details, the study's purpose, platforms used, techniques/tools applied, number of comments, and summary of the evaluation process and outcomes.

3.5 Data synthesis

The data synthesis stage aims to collect and summarize and interpret the included studies' data to answer the research identified questions. The data was retrieved from 22 studies associated with SA and text mining. These mapping review results were finally summarised in tabular form, and the data was interpreted by various visualization tools such as graphs and charts, finding research gaps and future directions. Briefly, the research process in this review is shown in Figure 2.

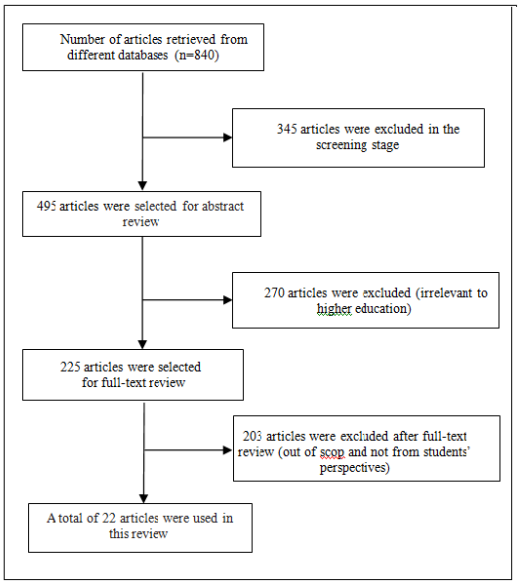


Figure 2: Systematic mapping process

IV. RESULTS AND DISCUSSIONS

This review's results yielded the selection of 22 articles that have met the criteria and the study's objective. The distribution of these articles by publication year is presented in Figure 3. It can be noted that the SA in HE was addressed more frequently in the last years when higher education institutions, mainly universities, showed some interest in opinion mining and SA area to evaluate the academic situation. These studies are summarized in Table 1. The information extracted from the selected papers is presented according to the year of publication, the study's purpose, SA technique, platforms, data, and outcomes.

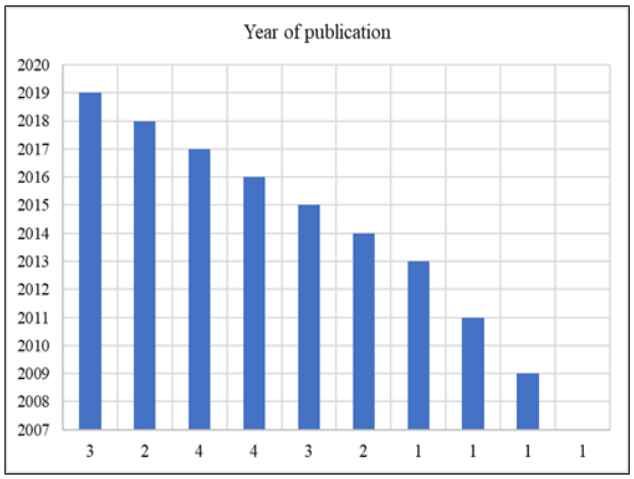


Figure 3: Distribution of the selected studies by the year of publication

To answer the first research sub-question based on studies reviewed shown in Table1, most of the studies in the HE context used SA methods in these domains; to evaluate universities' performance, courses, teacher performance, teaching quality, university rank, or to build models for improving the teaching quality of HE institutions. For example, Esparza et al. [1] applied SA to investigate students' reviews on teacher performance, and they found that social mining can be used to provide a possible solution to the problem of analysis of teacher evaluation feedback. Similarly, Balahadia et al. [2] applied SA and opinion mining to develop a teacher's performance evaluation tool, which might help identify the teachers' strengths and weaknesses based on students' positive and negative feedback. Rajput et al.[3] also applied SA to examine the textual teacher evaluation provided by students. The study's findings highlighted that the classification of students' feedback could enhance the teaching and annual evaluation process quality. Moreover, some of the previous studies used SA to evaluate HE institutions. For instance, İskender and Batı [4] applied SA to compare universities' rankings from the university and graduate students' social media posts and comments like Twitter. Besides, Abdelrazeq et al. [5] used SA to analyze Twitter data (16488 tweets) as a source of information for evaluating universities' performance using Natural Language Processing Techniques (NLP). This study recommended that the findings extracted from such analysis can support university rankings that experience criticism to measure key indicators. For this purpose, SVM and Naive Bayes (NB) Classifier algorithms were used to classify the data. Another study by Balachandran and Kirupananda [6] used SA techniques such as StanfordCoreNLP to help students find the right HE institution. This study's outcome was a system that retrieves review data from the social media data, such as Twitter and Facebook, to give a rating to an institution through analyzing the reviews' sentiment value. Also, Santos et al.[7] carried out a study to investigate international students' online reviews about their HE institutions based on the social platform using NLP. Furthermore, Rajput et al. [3], Aung and Myo [8], and Kaewyong et al. [9] used lexicon-based SA to identify students' positive and negative opinions for predicting teacher performance and evaluating the quality of the teaching process. In their approach, any teacher's opinion level score is automatically extracted and evaluated from students' feedback comments. The students' feedback opinions were automatically classified into a strongly positive, moderately positive, strongly negative, moderately negative, weakly negative, weakly positive, or neutral category based on two lexicons. Similarly, Altrabsheh et al. [10] used SA methods to analyze students' feedback to identify their positive or negative feelings towards the teaching process.

Table 1: Approach, algorithm, outcomes of SA, platforms, and number of posts

Authors	Purpose	Type of sentiment analysis tools	Platform	tweets/ comment	Outcomes
Cobos, Jurado [11]	To extract and analyze user opinion about the learning material of online courses and MOOCs, instructors, and services	NLP	edX platform/ Forum Data	-	The polarity is mostly positive along the length of all the courses. However, in the first part ot some courses, their learning materials have a negative polarity.
Kanchiro, Chiaro [12]	To build the sentiment analysis model for improving the teaching quality in HE institutions.	Multinomial Naive Bayes (MNB), Stochastic Gradient Decent, SVM, Random Forest and Multilayer Perceptron (MLP).	Dataset	950 posts	MNB and MLP were more effective to be used in the educational research context for the classification of the text.
Jena [13]	To examine the sentiment polarity from students' data and to model students' emotions	NB and SVM	Moodle, Twitter, and Facebook	12,300 tweets, 10,500 Facebook comments, and 8450 Moodle feedback messages	SM approaches can be used to understand student's sentiment in a collaborative learning environment
Esparza, de-Luna [1]	To analyze students reviews of teacher performance using a sentiment analysis	SVM	systems engineering students at Polytechnic University	1040 comments	Social Mining can provide a feasible solution to the problem of analysis of teacher evaluation comments
Balachandran and Kirupanandna [6]	To help students find the right HE institutes	Stanford-CoreNLP	Facebook &Twitter.	-	Build a system that gives a rating to an institution by analyzing the sentiment value of the reviews.
Cirqueira, Pinheiro [15]	To apply sentiment analysis techniques and topic modeling for a university Facebook fan page to find topics students compliment or complain about in their comments.	Latent Dirichlet Allocation technique (LDA)	Facebook	46271 comments	SA could help decision-makers in identifying periods of crisis or a high level of enjoyment.
Aung and Myo [8]	to measure the quality of teaching and predict the level of teaching performance.	Lexicon Based sentiment analysis	WordNet.	745 words	They proposed an automatic method to measure and evaluate the level of teaching performance.
Abdelrazeq, Janßen [5]	To analyze the social media sentiment as a complementary source for evaluating universities.	NLP	Twitter	16488 tweets	SA can support university rankings that experience criticism in terms of measuring vital indicators.
Balahadia, Fernando [2]	to develop a teacher's performance evaluation tool using opinion mining with sentiment analysis.	NB	Module Evaluation tools	-	SA can help to identify the strengths and weaknesses of the faculty members based on the positive and negative feedback of the students
Dhanalakshmi, Bino [16]	To explore opinion mining to find the student feedback's polarity generated through surveys and compare the performance of different algorithms.	NB, SVM, and KNN	Module Evaluation Survey	12866 responses	SA models can predict the polarity of the student comments based on features such as examination and teaching. The findings also showed that the NB algorithm outperformed others in terms of accuracy and recall, and the KNN algorithm achieved the best result in terms of precision
Rajput, Haider [3]	To analyze the textual faculty evaluation provided by students	A Knime workflow	Tag clouds, sentiment score, and other frequency-based filters	1748 comments	SA can be used to improve the quality of the teaching and the annual appraisal process.
Iskender and Batı [4]	To compare the rankings of universities from the university's students and graduate student's social media messages	SVM and NB	Twitter	1.353.803 Tweets	The importance of social media SA as a new mainstream and working with big data is required.
Shen and Kuo [17]	To investigate Twitter messages related to MOOC learning.	Opinion Finder tool and social media mining approaches	Twitter	402,812 tweets	Social media SA provide a comprehensive understanding of MOOC learning trends
Kaewyong, Sukprasert [9]	To investigate the possibility of the qualitative analysis of students' freestyle text comments to predict teacher performance.	Lexicon based sentiment classification	RateMyProfessors.com	1,148 comments	The qualitative results using SA are relative to enhance teacher performance evaluation using quantitative.
Altrabsheh, Cocea [10]	To analyze students' feedback automatically using sentiment analysis.	SVM, NB, and Maximum Entropy	Dataset	1036 comments	SVM and CNB are both could be used for feedback analysis. However, CNB can be the right solution for irregular training classes, and that this can be beneficial when there is not enough data in the neutral class.
Wen, Yang [18]	To examine the sentiment from MOOC forum posts to understand students' opinions towards the course and course tools	Lexicon -based sentiment analysis and clustering	Discussion forum	24963 posts	The findings revealed a significant correlation between sentiment expressed in the forum posts and the number of students who drop the course. The findings also asserted how sentiment analysis could be useful in a MOOC context.
Altrabsheh, Gaber [19]	To analyze students' feedback to identify their positive or negative feelings towards the teaching process.	NB and VSM	Twitter and Facebook	-	The adoption of SA in educational systems has great potential, and Naive Bayes and SVM techniques were superior for education data.
El-Halees [20]	To evaluate course quality	NB, KNN, and SVM	Discussion forum	4,957 Discussion posts	The findings showed that SA provides a promising way of improving course quality and extracting knowledge from students' opinions to improve academic institutions' teaching effectiveness.
Shen, Wang [21]	To investigate the evolution of emotion to predict emotions in e-learning and how emotional feedback can be used to improve learning experiences	SVM and KNN	E-learning system and sensors	43200 samples	The study suggested that using emotional data could significantly improve the e-learning system's performance and open the possibilities for instructors to understand distant learners' emotional states.
Song, Lin [22]	To identify the sentiment of opinions from the social media pages that users are discussing their personal opinions and their evaluation of the services.	SVM	E-learning Websites and social media pages	7,324 posts	The study showed that SA could provide accurate analysis with high performance on extracting opinions that can benefit e-learning developers.

Other studies used SA to propose new approaches and models to model students' comments according to a specific issue or problem or improve teaching quality in HE context. For instance, Jena [13] conducted a study for examining the sentiment polarity from students' views and for modeling students' emotions (Anxiety, Amused, Confused, Enthused, Excited, Bored, Frustrated, etc.) using machine learning techniques such as a sentiment classifier, NB, and SVM based on the big data frameworks. Likewise, Kandhro et al.[12] applied different ML methods such as SVM, Multinomial Naive Bayes, Random Forest, and Multilayer Perceptron Classifier, and Stochastic Gradient Decent to propose SA model for improving the quality of teaching in HE institutions. The study effectively examined different SA models to find the appropriate model for analyzing students' classroom feedback. The study stressed that social media websites such as Twitter and Facebook could be used as a valuable source of information and opinion mining related to students' learning activities. The findings of the study also acknowledged that opinion mining approaches could also be used to understand students' sentiment in a collaborative learning environment. Meanwhile, Cirqueira et al. [15] carried out SA- based study and topic modeling for a university Facebook fan page using Latent Dirichlet Allocation to find topics that students compliment or complain about in their comments. The study's findings confirmed that SA could help decision-makers determine a high level of enjoyment or periods of the crisis based on the students' general feelings. This can also give decision-makers the ability to take the appropriate actions to handle the moment properly.

Furthermore, Altrabsheh et al. [10] applied SA to model students' feedback automatically using SVM. NB, and Maximum Entropy. The results showed that SVM and NB are the best for modeling students' feedback. However, NB can be considered a good solution for non-regular training classes, and this can be useful when there is not enough data in the neutral class. Figure 4 shows the percentage of SA applications in each domain in HE. Based on the studies surveyed, there are six main domains for applying SA in the HE context. As presented in the figure, prior studies have focused mostly on the teaching quality evaluation (23%). This indicated that this domain is very important to HE's context, and thus researchers have mostly focused on exploring and mining students' opinions in this regard. There are three domains that scored almost the same number of studies with 18% for each domain. These domains are teacher performance evaluation, institution performance evaluation and ranking, and building models. Although course evaluation (14%) and e- learning systems evaluation (9%), they are two significant parts of the online learning environment, few studies have focused on these two domains. Thus, further studies are needed to gain more insights from students' opinions, particularly distance learners, about the quality of the online courses and the services provided by e-learning systems. This will help decision-makers to recognize whether students are satisfied or unsatisfied with current materials and services.

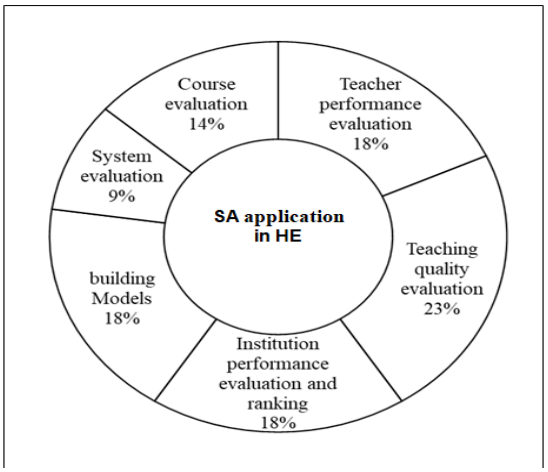


Figure 4: Sentiment Analysis application's domains in HE context

Based on included studies, the techniques commonly used in the HE context were SVM and NB [23]. They were used in many studies and different domains, as shown in Figure 5, followed by NLP, KNN, Lexicon-based SA with three applications for each. The other techniques were MLP, Stochastic Gradient Decent, sentiment classifier, VADER, Stanford Core NLP, LDA, Maximum Entropy, social media mining, a Knime

workflow, and Opinion Finder tool. More details are shown in Table 1 and Figure 5.

Social media platforms such as Twitter and Facebook and discussion forums are the most used SA platforms in the HE context with 30%, 21%, and 19%, respectively. Meanwhile, other platforms like e- learning, google forms, private datasets, and others are also used in specific domains such as course evaluation, performance feedback, MOOCs, etc. Details are shown in Table 1 and Figure 6.

V. CONCLUSION

In this paper, a systematic mapping review on the SA studies in the higher education context was presented. The review was performed according to the available guidelines for conducting systematic mapping reviews provided by [24, 25] to search and classify all existing papers on SA in higher education. During the mapping review process for the known electronic research databases, only 22 of the 840 articles were related to SA in HE and met the study's criteria. In particular, this review has focused on providing an overview of the various domain, platforms, methods, algorithms, and tools related to SA in the higher education context. Based on the findings, prior works on SA in the context of HE was classified into six main domains. These domains are teaching quality evaluation, teacher performance evaluation, institution performance evaluation and ranking, building models, course evaluation, and e-learning systems evaluation. The findings also showed that SVM and NB were the most commonly used techniques for SA in HE, followed by KNN and lexicon-based sentiment analysis, as well as social networks such as Twitter and Facebook were the most used platforms as the primary source of information. In sum, it can be concluded that the adoption of the emerging field of sentiment analysis and opinion mining in educational systems has a great potential in improving the quality of teaching and learning processes in HE institutions and assessing the situation in terms of performance, online materials, and services. Opinion mining can also guide new and international students to select the appropriate university based on the review submitted by former students on social media sites. Since this field is still in its infancy in the HE context, further studies are required on the applications of SA in HE to benefit from the massive amount of data on social media sites and various educational systems for future development.

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