

Exploring Public Sentiment on Online Learning During Covid-19: A Twitter-based Analysis

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Abstract: This study investigates the evolution of public sentiment toward online learning during the COVID-19 pandemic, utilizing Twitter data collected between April 2020 and December 2021. By using MDCOR for topic identification and SENA for sentiment analysis, the study examined changes in affective responses across major online learning platforms including Zoom, Udemy, Canvas and Coursera. It was observed that positive emotions were most prominent in the early stages of the pandemic, as online learning became crucial due to social distancing. However, while platforms relying on synchronous interactions, such as Zoom, were associated with negative emotions like frustration and fatigue, more flexible, skill-based platforms like Coursera and Udemy consistently received favorable feedback. The findings reveal the varied emotional responses to different online learning features, providing insights into the factors shaping user experience. These insights can inform the future development of online learning platforms and strategies aimed at improving educational effectiveness.

Keywords: Online learning, COVID-19, Data analysis, Social media, Twitter.

1. Introduction

In December 2019, the world's first highly contagious coronavirus case was diagnosed in Wuhan, China. According to the World Health Organization, as of March 11, 2020, there were more than 118,000 cases and 4,291 lives lost in 114 countries worldwide. The World Health Organization declared COVID-19 a pandemic on the same day after assessing the rapid spread and severity of the deadly virus globally [1].

Countries worldwide have adopted specific policies that refer to social distancing to curb the spread of the virus from person to person. Social distancing is a conscious effort to increase the physical distance between people to curb the spread of disease [2]. The policy resulted in the closure or suspension of many of society's regular economic, social, and political activities [3]. Public areas such as parks, cafes, schools, universities, and other centers of assembly and interaction are closed. The education sector has been significantly affected by the pandemic. In the wake of the pandemic,

schools have rapidly shifted to online learning to further protect their students' health [4]. As a result, most higher education institutions had to rethink their teaching and assessment methods [5]. The Responses to Educational Disruption Survey revealed that most schools were closed in response to the COVID-19 pandemic [6]. According to UNESCO, more than 1.5 billion students in schools and universities around 165 countries have been affected by the restrictive measures, which have forced them to turn to online learning to keep the quality of education and educational progress on track [3].

Online learning refers to delivering training and education via networked interactivity and other knowledge collection and distribution technologies. Utilizing the Internet and other essential technologies to develop materials, provide instruction, and administer programs for educational purposes [7]. Teachers had to teach virtually, using digital technology during the pandemic [8]. Using websites to upload materials and live recordings has become the norm, and educational activities are carried out through technological means, such as online quizzes, to ensure that students can learn effectively at home [9].

Before the coronavirus outbreak, online learning was seen more as an adjunct, suitable to adult learners seeking higher education opportunities. In addition, colleges and universities used online learning as an innovative means of personalized instruction [10]. With online learning becoming the main form after the pandemic, differences in educational scope, effectiveness, and interactive characteristics have been shown. Interaction in many courses is more active and more frequent than before [4].

As Online learning prompted the exploration of more efficient distance learning methods during the pandemic, the educational community focused more on effective teaching practices to ensure quality [11]. Online learning allows for more frequent interactions between teachers and students, enabling teachers to assess understanding and mastery more quickly. Therefore, teachers can tailor subsequent instruction to an individual's behavior and response [12]. Online classrooms can be monitored, recorded, and tracked in real time, enabling teachers to view student learning feedback and classroom effectiveness and to give support to specific educational resources [13]. Continuous evaluation and continuous improvement through constant data feedback [14].

Students require 40-60 % less study time when learning online because students can learn at their pace, return and reread, skip, or accelerate concepts of their choice [15]. Such customized learning enables more study time to be applied to more challenging problems so that students learn more in the same amount of time and classroom interactions become more efficient [16].

After stepping into the second half of 2021, The Regulation on Digital Green Certificates proposed by the European Commission was formally adopted in June [17], contributing to the recovery of tourism and the economy. WHO reports that, as of 21 June 2021, 2.6 billion vaccines have been administered globally, exceeding initial vaccination targets, mainly in high-income countries, laying the foundation for a return to everyday life in these countries [1]. Subsequently, vaccination significantly reduced the need for hospitalization and emergency care from June to August when the delta virus became the predominant strain, especially among fully vaccinated populations [18]. According to KFF's follow-up study, 65% of Americans had received at least one dose of vaccine or were about to do so in June, growing to 67% in July, a steady increase from 61% in March [19].

That was also the time of the new school year. As of 3 May 2021, schools in 53% of districts across the United States have opted for person-to-person education, as more and more people were asking for schools to be completely open [20].

Research shows that social sciences continue to see an increase in online learning utilization and interaction rates when the pandemic situation improves. Online learning comes closest to the synchronization and pedagogical adaptability that traditional modes of teaching can provide [21,22]. Given the high rate of adoption of online Learning during the COVID-19 pandemic, it is likely that schools will integrate online learning to some extent, even during regular school hours [13].

However, there is an imbalance in the pace of the global transition to online learning, with research showing that 85 % of institutions in Europe are quickly replacing traditional education with online learning, while only 29 % of institutions in Africa are meeting online education requirements [6]. High internet costs, aging equipment, and technical problems have dampened the learning experience for some Filipino students [23]. A report from Filipino medical students describes the limitations of online learning in terms of medical skills, as they need something tangible to practice clinical ophthalmology [24].

Because online learning can lead to a lack of motivation and retention of online study habits, some students believe there is no substitute for traditional modes of teaching [25]. Not only that but it has also been noted that online learning lacks interpersonal interaction. For college students still in their formative years, this absence can be psychologically and emotionally devastating and is a significant source of mental health problems for college students during the quarantine of the epidemic [26]. Research states that up to 90 % of students worldwide must study at home. The mental health of university students is generally poor, with high rates of depression, anxiety, and stress [27].

In today's digital age, the role of ethnography as a critical methodological and analytical approach has become more significant in understanding the impact of digital media on people's daily lives [28]. The advantage of the internet, such as online learning platforms, has made it possible to reach difficult or impossible communities to engage with during the period. Nevertheless, examining the evolving public sentiment toward online learning is essential to enhance user experiences and advance educational strategies. Monitoring sentiment trends over time during COVID-19 allows us to identify patterns, assess the effects of new initiatives or policy modifications, and utilize digital ethnography to address any product-related issues promptly.

Leveraging social media for digital ethnography study, which fosters online engagement, has emerged as a vital strategy for effective online learning communications. Social media, characterized as "a set of Internet-based applications that leverage the principles and technology of Web 2.0 to facilitate the creation and exchange of User Generated Content" [29], plays a pivotal role in shaping modern interactions. As noted by Knoll [30], the rise of social media in the digital era has fostered a novel dynamic between organizations and the public, serving as a powerful tool for reputation management. Platforms such as Instagram, Twitter, and TikTok have become primary sources for information communication and public interaction. Therefore, when studying shifts in public sentiment toward online learning during the COVID-19 era, leveraging social media to cultivate brand image, amplify brand influence, and enhance platform features is crucial in attracting potential users.

In studying shifts in public sentiment toward online learning during the COVID-19 era, analyzing social media is crucial for several reasons. In this scenario, utilizing social media data to gauge shifts in public sentiment toward online learning is highly effective due to its features of real-time insights, extensive reach, and diverse data formats, encompassing text, images, hashtags, and memes. These platforms offer immediate access to various perspectives and incredibly emotional responses. Furthermore, user engagement metrics, such as likes, shares, and comments, provide quantitative indicators of sentiment change. This study selected Twitter as the primary data source for several reasons: 1. Its text-centered nature makes it ideal for conducting sentiment analysis using the MDCOR tool; 2. Its concise data structure lends itself well to analyzing shifts in public sentiment compared to platforms like Instagram, which focus on image-based content; 3. Twitter's user base is projected to exceed 368.4 million in 2022 [31], with 500 million tweets sent daily [32].

2. Research question

RQ1: How did the sentiment towards online learning evolve over the different phases of the Covid-19 pandemic?

1a: pre-pandemic

1b: middle-pandemic (breakout period)

1c: late-pandemic

RQ2.1: How did the sentiment towards online learning vary from different platforms?

RQ2.2: What features gain relative positive reflection, and what features gain negative reflections?

3. Research methods

This study employed a qualitative approach to explore online learning sentiments and topics during the COVID-19 pandemic. The method gave the advantage of gaining a deeper, more nuanced understanding of these sentiments, allowing for exploring themes, patterns, and variations in people's experiences. The data was derived from the tweeter and analyzed through thematic and sentiment analysis methods by tools (MDCOR and SENA). This approach allowed us to capture the changes over time and quantify the outcome to make it readily comprehensible. Later in this section, more explanation of the method being used will be explained.

3.1. Data collection and selection

The data for this study was derived from Twitter with a focus on four hashtags: #onlinelearning, #remotelarning, #elearning, and #distancelearning, which were representative of the discussion around online education during the COVID-19 pandemic. The data collection spanned from April 29, 2020, to December 31, 2021, and only English-language tweets were selected. The academictwitterR package was used to retrieve the tweets, which were saved in CSV format for further analysis. The query returned relevant features such as tweet content, author ID, and public engagement metrics (e.g., likes and retweets). This resulted in a dataset of 1,437,792 tweets, with duplicate tweets removed. Emojis in the tweets were replaced with corresponding words using the replace_emoji function from the lexicon package. Due to computational resources and time limitations, the study employed a stratified sampling method, with each stratum representing a different month. This resulted in a stratified dataset that comprised approximately 2% of the original dataset, totaling 32,570 units. This stratified sample was designed to ensure that the new dataset accurately reflects the monthly distribution of discussions in the original dataset.

3.2. Topic identification and sentiment

3.2.1. Most frequency words

The MDCOR software was used for thematic analysis to classify text responses in longitudinal and cross-sectional surveys and social media research [32]. The stratified data was divided into subsamples by month, and each subset was uploaded into the software to generate the initial text mining output. Figure 1 provides an example of the analysis from the first month "April 2020", displaying the top 20 most common words in the tweets, such as 'remote-learning,' 'learn,' 'distance learning,' 'student,' 'learning,' 'online learning,' 'much,' 'have,' 'online,' 'work,' 'teacher,' 'education,' 'school,' 'time,' 'today,' 'covid,' 'great,' 'join,' 'free,' and 'home.' Next, frequent words related to the hashtags and other meaningless terms were removed to improve the accuracy of the topic analysis. In this case, words like 'remote learning,' 'distance learning,' 'learning,' 'online learning,' 'much,' and 'have' were excluded.

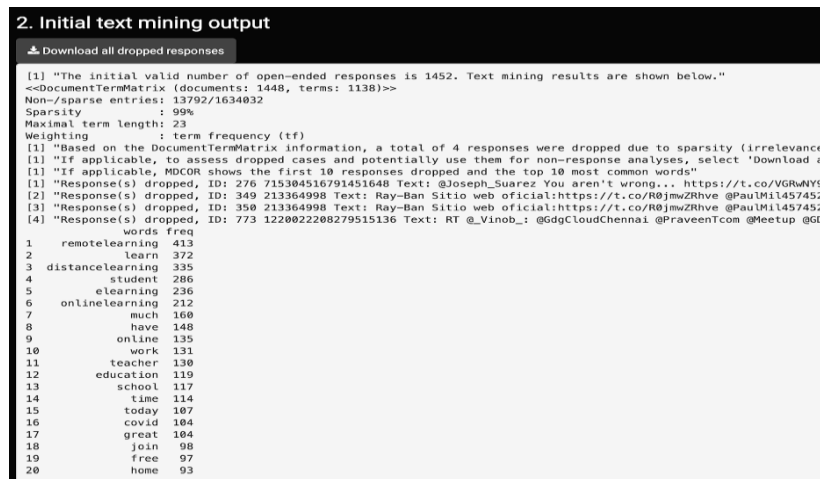


Figure 1: Top 20 common words

3.2.2. Matrix plot

The third step involved using the parameters suggested by the paper “Machine driven classification of open-ended responses (MDCOR),” with burn-in samples of 500, MCMC/Gibbs resampling of 5000, an Alpha prior of 50, and a Beta prior of 0.1 to run the metrics and determine the optimal number of topics, as shown in Figure 2. The x-axis represents the number of topics, and the optimal number is indicated by the convergence point in the plot. The optimal number of topics for this dataset was determined to be [2].

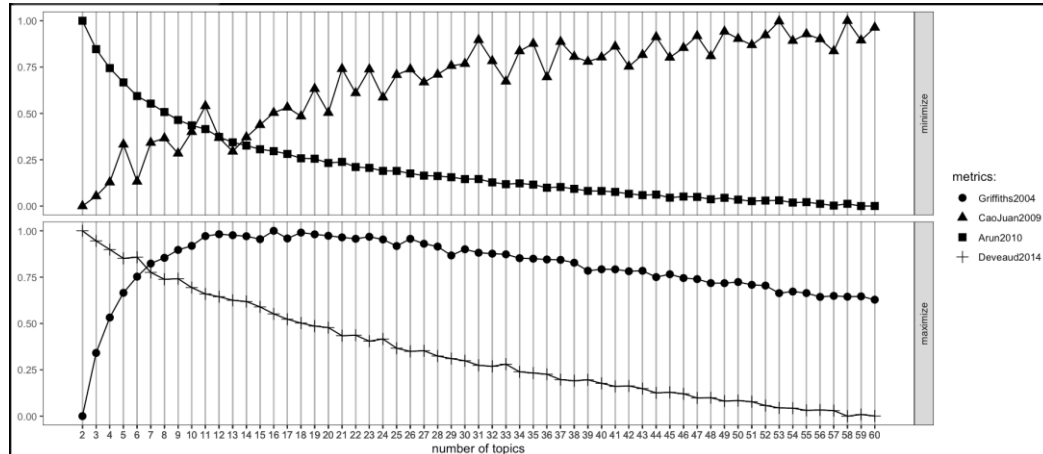


Figure 2: Optimal number matrix

3.2.3. Classified text and inter-topical distance map

In the fifth step, the team selected two as the optimal number of topics and executed MDCOR, generating a fully classified dataset and an intertopical distance map. Each tweet was assigned a code corresponding to one of the identified topics, as shown in Table 1. Figures 3 and 4 display the top-frequency words related to each topic. The team better understood the classified topics by analyzing the tweets and the frequent words. For example, as shown in Figure 3, topic one is primarily related to student engagement, while Figure 5 represents a topic focused on remote learning resources. The output was then saved and prepared for further analysis.

Table 1: Full-classified text (partial excerpt)

code	relative_text_contribution	relative_group_fit	quote	ID	row_num
V1	0.882	0.993	Thanx to #Savancia group for giving @AudenciaMECE students the opportunity to work on design of innovative hybrid food products Coaching & Final presentations #distancelearning @audencia https://t.co/2zssscWhPa https://t.co/236Af7aL0l	625661977	1
V1	0.881	0.993	Communication is one of the most important thing in our business and social life. Learn Intercultural Sensitivity stages and easily communicate with people from different cultures. The full course is available: https://t.co/GHt71I0SyC #becazlearning #elearning #StayAtHome https://t.co/rcJLLIqGTV	1173254053209530368	2
V1	0.829	0.993	RT @RayWalshe: Just finished last session with my students from Cloud and IoT Classes in @DCU this afternoon. We had a good session and wis	52772574	3

Full data: <https://github.com/Simon221567/table/blob/main/Table%201.pdf>

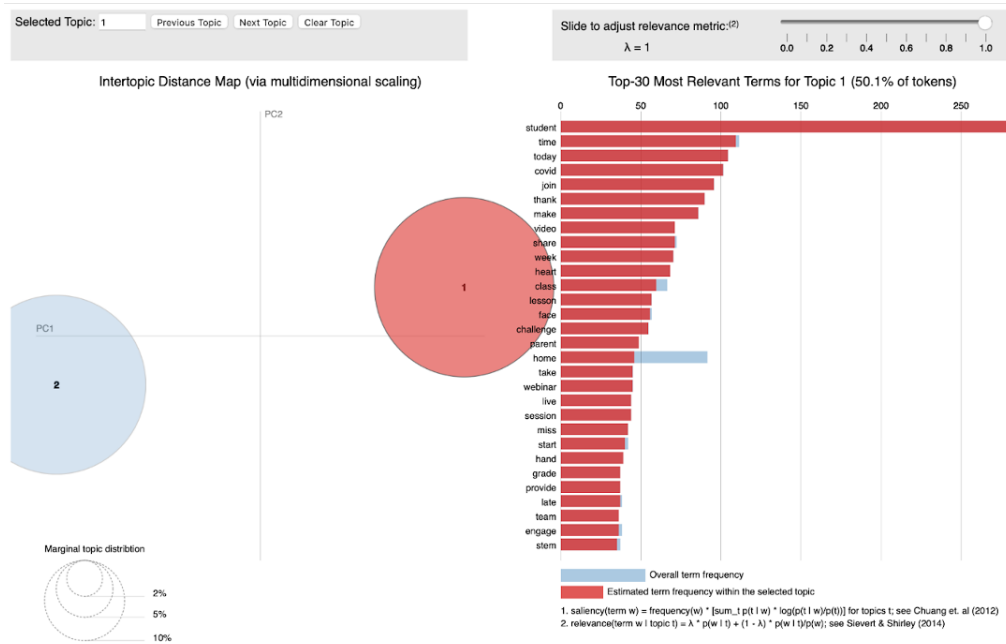


Figure 3: Inter-topic distance map - topic 1

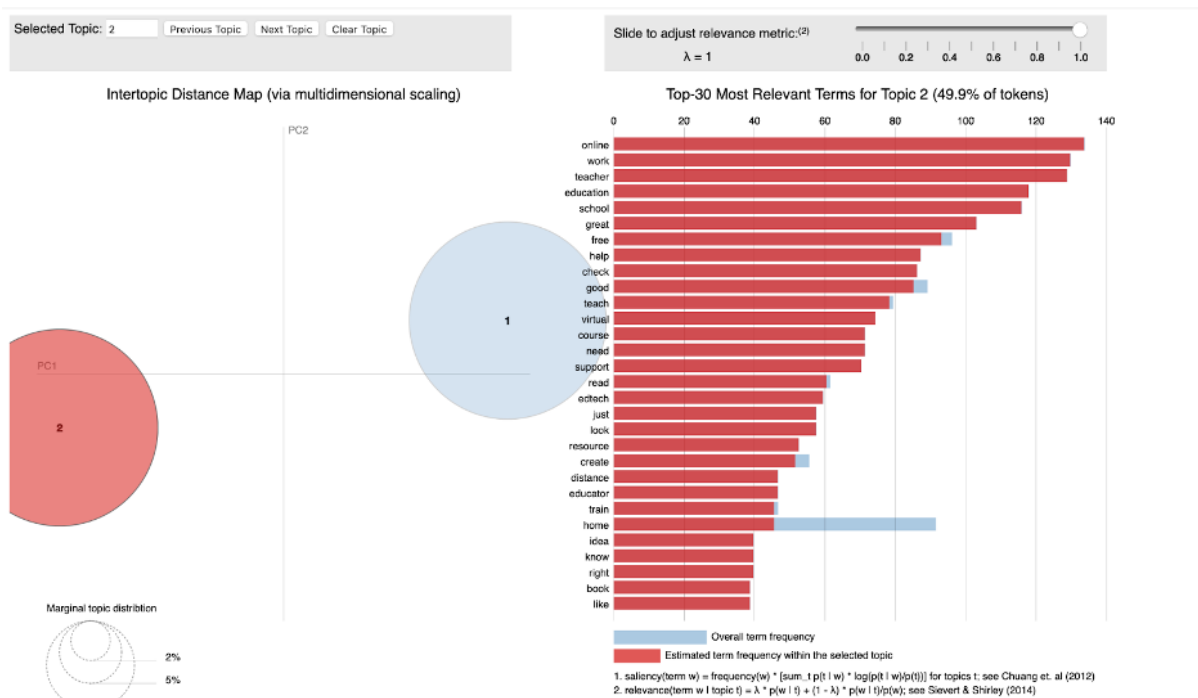


Figure 4: Inter-topic distance map - topic 2

3.3. Sentiment analysis

The SENA software, designed for Sentiment and Emotion Network Analysis, was used to perform the sentiment analysis. The team selected the CSV format for the documents and uploaded the data, specifying the ID column as “row_num,” the text column as “quote,” and the category column as “code.” Lemmatization was chosen for sentiment analysis to ensure the text remained consistent and to avoid alterations. The frequency of words was generated, and any misleading words were removed, as was done in the topic analysis. After the preparation, the team executed SENA and obtained the plot shown in Figure 5, which displays each topic's emotion and sentiment scores. In the Figure 5, V1 represents topic 1, and V2 represents topic 2, with the y-axis indicating the sentiment score.

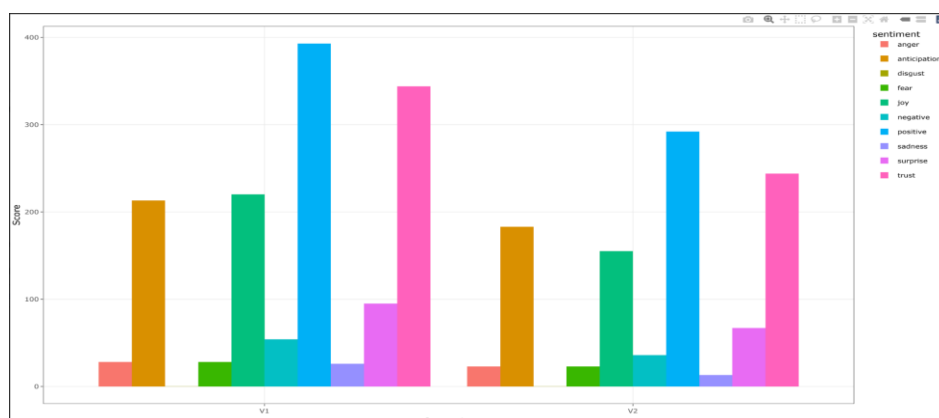


Figure 5: Sentiment distribution across categories V1 and V2

4. Results

4.1. RQ 1

The stratified dataset was divided into monthly sub-datasets to analyze sentiment changes over time. Each month's data was analyzed separately using MDCOR and SENA. The team manually reviewed the topics, highlighting similar topics across months with the same color in the table, and created a sentiment summary, as shown in Table 2 and Table 3. A detailed analysis of these sentiment trends and topic summary will be discussed in the following section.

Table 2: Online-learning topics during the COVID-19 pandemic

		topic 1	topic 2	topic 3	topic 4	topic 5
4/2020	month 1	student engagement, online learning, and education challenges during the COVID-19 pandemic	online education, teacher support, and the use of EdTech tools			
5/2020	month 2	online courses, EdTech, and remote learning	student engagement, teacher support, and remote education during the pandemic			
6/2020	month 3	online courses, skill development, and career progression	student experiences, digital learning, and challenges during remote education	education technology (EdTech), virtual classrooms, and the impact of COVID-19 on education	webinars, educator support, and online resources	

Full data: <https://github.com/Simon221567/table/blob/main/Table%202.pdf>

Table 3: Analysis table of online learning topics sentiments & emotions

Month	Topic	ANGER	ANTICIPATION	DISGUST	FEAR	JOY	SADNESS	SURPRISE	TRUST	NEGATIVE	POSITIVE
Apr-20	student engagement, online learning, and education challenges during the COVID-19 pandemic	28	213	0	28	220	26	95	344	54	393

Table 3: (continued)

	online education, teacher support, and the use of EdTech tools	23	183	0	23	155	13	67	244	36	292
May-20	online courses, EdTech, and remote learning	0	193	0	0	185	19	88	272	19	334
	student engagement, teacher support, and remote education during the pandemic	0	184	0	0	169	20	86	272	20	319

Full data: <https://github.com/Simon221567/table/blob/main/Table%203.pdf>

4.2. Sentiments summary

This research observed the following detailed trends after conducting the topic analysis on Online Learning data from April 2020 to December 2021 and sentiment analysis on public emotions related to different topics.

4.2.1. The general sentiment of the public is predominantly positive

Throughout the analyzed period, positive sentiment significantly outweighed negative sentiment, indicating a generally optimistic public perception of online and remote learning. In terms of time, positive sentiments were more significant in April and May 2020, as well as in October and November 2021. Among all positive emotions, Trust, Anticipation, and Joy are the main ones. Occasionally, there may be a significant increase in surprise emotion in specific topics during certain months, but trust, anticipation, and joy consistently emerge as the most dominant emotions.

4.2.2. Volatility of negative sentiment

Negative sentiments exhibit volatility over time. Starting from April 2020, there was a relatively high negative sentiment value, which gradually decreased, rose again, and so on. From this, it can be inferred that people have always had certain negative sentiments towards the epidemic and online education, and there will be a relatively significant increase when encountering specific topics or periods. In addition, the value of Neangere's fear is higher in harmful anger and fear emotions.

4.2.3. The significance of trust emotion

The Trust emotion was significant throughout the analysis, consistently being the most highlighted emotion across all topics. Moreover, topics with high Trust emotion value were concentrated from April to October 2020. When linking the Trust emotion value to the corresponding topic, it is found that the topics with higher Trust emotion value tend to be associated with "Support," with five of the ten topics with the highest Trust emotion value involving "Teacher Support" and "Student Support."

4.2.4. Emotional diversification in some months and topics

Of all the emotions analyzed in the SENA, the three least occurring emotions were Disgust, Anger, and Fear. Disgust did not appear in any of the topics, while Anger and Fear consistently co-occurred and concentrated in individual months. In 2020, Anger and Fear appeared in all topics in April, June, October, and December. In addition, in February 2021, there were four topics, three of which had these emotions. This shows that public sentiment towards Online Learning is more complex in these periods. When observing these periods of the year, it can be seen that these months are more concentrated at the beginning and end of the semester.

5. Semester topic summary (semester)

After thematically analyzing and summarizing the online learning data from April 2020 to December 2021, this research came up with the following trends (which will be discussed based on the semester):

Both 2020.4 and 2020.5 present topics in the early stages of the epidemic in this period. The main focus is on the challenges faced by students already engaged in online educational learning. There is less discussion about the tools used to teach online. The result found that in 2020.4, only discussions of using EdTech tools appeared, and in 2020.5, discussions of online courses appeared.

From September to December 2020, there was more discussion about technology for online education. The data shows that the number of topics also increased in 2020. Nov and 2020. Dec. Between September 2020 and December 2020, digital learning tools and environments for online education have attracted attention, and distance learning plays a vital role in this phase. In December, STEM Education & Professional Development will also be discussed.

Between February 2021 and May 2021, the number of topics increased significantly, with four topics in February and May, and stabilized at three topics in March and April, where it became clear that there was a great deal of discussion about innovations and challenges related to technology and development in online education. In addition to this, online education platforms have made strategic adjustments. As can be seen from the chart, online education has expanded, such as remote work and international distance learning.

The overall number of topics decreased from 2021. Sep to Dec. During this period, people paid more attention to the interplay and impact of traditional, online, and education technology as the epidemic developed.

5.1. RQ2

In defining the platforms to focus on, the team searched up to 20 popular online learning platforms using their names as keywords to search through tweets. Each keyword tweet was considered one unit of discussion related to that platform. The frequency of each platform's mentions was calculated, as shown in Table 4. It was found that limited mentions of some platforms made it challenging to analyze user sentiment changes over time. As a result, the team selected the top five platforms, the platform "Brilliant" due to noisy data where "brilliant" was often used as an adjective rather than referring to the platform. To avoid this issue, "Brilliant" was excluded, and the analysis focused on five platforms: Zoom, Udemy, Canvas, Coursera, and MasterClass.

However, only Zoom and Udemy had sufficient data to track sentiment changes over the defined periods. The team defined four periods corresponding to academic semesters: the first period (April 2020 - May 2020) represents the immediate impact of COVID-19, followed by three more periods: September 2020 - December 2020, February 2021 - May 2021, and September 2021 - December 2021. Topic and sentiment analysis was conducted for each semester. An overall analysis of topics and sentiment was performed for the other three platforms. The team also created topic and sentiment

summary tables based on the outcomes. Further analysis of these results will be presented later in the section.

Table 4: The frequency of each platform in the dataset

Platform	Count
Zoom	481
Udemy	452
Canvas	101
Brilliant	86
Coursera	70
MasterClass	48
edX	42
Skillshare	35
FutureLearn	29
Udacity	17
Pluralsight	12
Thinkific	7
LinkedIn Learning	6
Khan Academy	5
CreativeLive	5
DataCamp	2
Codecademy	1
Treehouse	1
Blackboard Learn	1
Gradescope	1
360training	0
Mindcalley	0
Absorb LMS	0

5.2. Topic summary

5.2.1. Canvas

Student engagement: assignments, online courses, interactions (with fellow teachers).

Platform design and features: e.g., access to assignments, peer support in Zoom, multimedia features for student videos, clickable grading rubrics.

Shared materials: easily accessible and well-organized course materials.

virtual communities: providing a virtual communication platform and support for restoring deleted content.

Educational technology applications: traditional and online teaching and training through technology.

5.2.2. Coursera

Online learning platform: offers free courses, and the platform is used to promote and sell courses.

Programming and Certification: specializing in programming skills (especially JavaScript) and online certification for beginners.

Education & Career Development: educational opportunities for career development, especially offering certificate programs.

5.2.3. MasterClass

General Online Learning Experience: Participate in side courses to learn development-related knowledge.

Industry-specific learning: specialized learning related to the pharmaceutical and biotechnology fields.

5.2.4. Udemy

Semester 1: Discounted (coupons) and free courses available, focusing on technology, programming (e.g., HTML, JavaScript, Python), AI, and educational technology for beginners and intermediate learners, as well as professional development for developers.

Semester 2: Course creation and delivery, focusing on skills development (e.g., learning HTML, JavaScript, machine learning, and Python). Courses involve training programs, websites, and educational services and offer low-cost courses and certifications.

Semester 3: Course enrollment and learning, especially programming, Python, and career development, focusing on acquiring new skills through Udemy vouchers, primarily in technical areas.

Semester 4: Focus on technology-related courses (e.g., JavaScript, Python), certificate programs, and Udemy coupons and discounts, especially programming and business training courses for beginners.

5.2.5. Zoom

Semester 1: Educational activities are transferred to a virtual platform where students and teachers conduct online classes, engage in live video interactions, and maintain personal social connections through Zoom, especially during remote periods, replacing face-to-face interactions.

Semester 2: Zoom serves as the leading platform for the virtual classroom, and users discuss its use in teaching and organizing meetings, especially for online learning during the pandemic. Features such as breakout rooms and contextualization options were particularly used in education.

Semester 3: Discussions focused on online learning and activities during the outbreak blockade, especially using the platform in music learning and Zoom meetings. The challenge of “Zoom fatigue” is also mentioned.

Semester 4: The use of Zoom in homeschooling, online education, and parent-teacher communication, involving webinars, screen time management, and the exploration of digital education alternatives.

5.3. Sentiment summary

The results have made the following findings by analyzing users' emotional responses to different themes on various online education platforms. Overall, The data shows that positive sentiments are generally higher than negative sentiments on most platforms, as shown in Table 5. The expression of positive emotions is particularly significant on Canvas and Coursera. When analyzing the sentiment trends across individual platforms, distinct patterns emerge, highlighting varying emotional responses depending on the platform's features and user experiences. Specific sentiment analyses on different platforms are as follows.

Table 5: Platform topic sentiment & emotion

platform	topic	ANGER	ANTICIPATION	DISGUST	FEAR	JOY	SADNESS	SURPRISE	TRUST	NEGATIVE	POSITIVE
Canvas	V1	0.00%	16.85%	0.00%	0.00%	10.11%	0.00%	3.37%	20.22%	0.00%	49.44%
	V2	0.00%	15.56%	0.00%	0.00%	13.33%	0.00%	0.00%	26.67%	0.00%	44.44%
Coursera	V1	0.00%	22.00%	0.00%	0.00%	12.00%	0.00%	0.00%	17.00%	0.00%	49.00%
	V2	0.00%	20.87%	0.00%	0.00%	20.00%	0.00%	0.00%	17.39%	0.00%	41.74%
	V3	0.00%	25.37%	0.00%	0.00%	8.96%	0.00%	7.46%	16.42%	0.00%	41.79%

Full Data: <https://github.com/Simon221567/table/blob/main/Table%205.pdf>

5.3.1. Canvas

Users' emotional responses on the Canvas platform were milder, which showed high positive emotion values of 0.494 and 0.444, respectively. It is worth noting that no negative emotions were present in the data analyzed, and the overall emotional intensity was not as strong as on the other platforms. This is particularly important on educational platforms as it may indicate that the user's learning experience on the platform is stable and controllable.

5.3.2. Coursera

The Coursera platform also focused on displaying positive emotional responses in different themes, with positive emotional values ranging from 0.49 to 0.417. Among all the positive emotions, expectation and trust were the main positive emotions. Compared with V1 and V2, the emotion of Surprise appeared in the V3 theme, which indicated that users had certain expectations for Coursera's experience and they found the platform did something beyond their expectations which made them feel more satisfied.

5.3.3. MasterClass

The MasterClass platform displayed a mixed emotional response in the V1 and V2 themes, with a negative emotion value of 0.034 appearing in V1. Although V2 had a negative emotion value of 0, it also exhibited mild Anger, Fear, and Sadness emotions, among them, the Sadness emotion was even something that V1 did not possess. The positive emotion values of MasterClass (0.408 and 0.367) were lower than other platforms, but users showed a certain level of expectation and trust.

5.3.4. Udemy

The data from the Udemy platform is divided into four segments based on time and semester, and the main sentiment for all four segments is positive. However, the negative sentiment value for Udemy is higher overall than other platforms.

In topic V1 of semester 1, anger and fear have the same value, the first time negative emotion is among this study's top three emotion values. Similarly, in semester 4, topic V2 and topic V4 had negative emotions as the top three emotions in terms of emotion value, and topic V2's negative sentiment value was the highest among the topics of all platforms.

5.3.5. Zoom

Like Udemy, the data on the Zoom platform is divided into four semesters based on time. The main sentiment of all four semesters is also positive, accompanied by a certain amount of negative sentiment.

Of the four semesters on the Zoom platform, semester 2 is the only one with a Negative sentiment value of 0. Semesters 3 and 4 had the highest Negative sentiment values.

It is interesting to note that semester 3's topic V1, whose Negative sentiment value is not high, has the highest Anger and Sadness emotion values of all the platform topics.

User sentiment analyses of online education platforms show that most users experience positive sentiments when participating in courses, which may be related to the special features of these platforms. However, there are also some expressions of negative sentiments, which suggests that platforms need to pay attention to user's feedback and continuously optimize to enhance users' learning experience further.

5.4. RQ2.2

5.4.1. Zoom

Zoom is a video conferencing tool that plays an important role in online lectures, remote meetings, and interactive learning. Although Zoom itself is not a specialized learning platform, its applications in the field of education are very extensive, especially in online courses and webinars. Zoom provides features such as high-definition video and audio calls, screen sharing, whiteboard annotations, and recorded meetings, allowing teachers and students to interact anytime even when they are in different locations.

5.4.2. Udemy

Udemy is an online course platform that offers courses covering various skills and subjects. A significant feature of Udemy is that anyone can create and publish courses, which means the platform has a wide range of course options in various fields. Udemy's courses are typically designed by industry experts or experienced educators and provided in the form of video lectures, reading materials, and practical exercises. In addition, Udemy also provides a marketplace where teachers can sell their courses, while learners can choose suitable courses based on their needs and interests for learning.

5.4.3. Canvas

Canvas is a learning management system primarily used by schools and universities. Canvas provides teachers with a comprehensive platform to manage course content, publish learning materials, assign and collect assignments, and conduct assessments. Students can access course materials, submit assignments, participate in discussions, and receive feedback on Canvas. Canvas's design focuses on user experience, providing an intuitive interface and powerful customization features, allowing teachers to customize course pages according to their teaching needs. In addition, Canvas also supports various assessment tools and reporting functions to help teachers track students' learning progress and grades.

5.4.4. Coursera

Coursera is an online education platform that collaborates with universities and institutions worldwide to offer university level courses, professional certificates, and even degree programs.

Coursera's courses cover a wide range of fields, from science and technology to humanities. The courses on this platform typically include video lectures, reading materials, discussion forums, and assessment tasks. Coursera also offers professional certificates and degree programs designed and accredited by partner universities, providing learners with flexible learning options and opportunities to obtain formal educational accreditation.

5.4.5. MasterClass

MasterClass is a celebrity-led online education platform, offering courses taught by top experts and celebrities from various industries, including cooking, film production, writing, music, and more. The characteristic of MasterClass is its unique teaching method, where learners can directly learn from industry leaders. These instructors not only share their professional knowledge, but also their experiences and insights. Courses typically include video lectures, assignments, and materials, aimed at providing an immersive learning experience that allows learners to gain a deep understanding of knowledge and skills in specific fields.

5.5. Feature summary

5.5.1. Canvas

Canvas is a learning management system focused on increasing student engagement, enhancing the teaching and learning experience by providing assignments, peer interaction and multimedia features. The key features of Canvas include a point and click grading system, which allows teachers to easily grade assignments. Sharing materials to facilitate students' access to course content. Virtual communities promote communication between students and teachers. And the content recovery function can restore accidentally deleted content.

5.5.2. Coursera

Coursera offers a wide range of free courses aimed at promoting career development and skill enhancement. Especially suitable for beginners and professionals in the technical field. Coursera not only provides a platform for learners to learn and develop themselves but also offers a space for course creators to promote and sell their courses. An important feature of Coursera is its Learning Program, which provides specific programs for corresponding learning.

5.5.3. MasterClass

MasterClass is an industry-focused learning platform that offers free courses taught by celebrities from various industries, covering various professional fields including pharmaceuticals and biotechnology. The uniqueness of MasterClass lies in its ability to provide direct learning opportunities with industry leaders, who not only share their knowledge and skills but also their experiences and insights.

5.5.4. Udemy

Udemy is an online course marketplace focused on skill development, offering a wide range of free or discounted courses, as well as various coupons and certifications. Although courses require payment, Udemy's courses are relatively affordable in terms of price. In addition, it will also provide certification to users. Udemy has adopted different strategies to attract learners from different semesters, including offering courses at different levels to meet the needs of different users.

5.5.5. Zoom

Zoom is widely used as a virtual classroom and online meeting platform, particularly suitable for online teaching, real-time interaction, and home education. Zoom's educational features include group discussion rooms that allow students to engage in group work and discussions. What's more, Background options provide users with more personalized and professional settings. The ease of use and versatility of Zoom make it an important tool for educators and students to engage in remote teaching and learning, enabling effective communication and interaction even in physically distant situations.

6. Discussion

6.1. RQ1

The research mainly investigates how the COVID-19 pandemic enhanced the rapid shift to the online learning industry by analyzing the sentiment change through Twitter's user-generated data towards this change, which evolved over different phases (four semesters and two breaks) and platform-based features.

First semester (April-May 2020): the first semester that was affected directly by COVID (school shut down)

According to Table 3 it was conducted that during the initial phase of the pandemic, sentiment change towards online learning was largely positive. More than half of the sample reflect "trust, joy, and anticipation," which express optimism despite the challenges of transitioning to remote education initially. However, there still might be concerns around student engagement and the need for teacher support and resources were prevalent even though negative emotions like anger and fear remained low at around 4%.

First break (June- August 2020): first summer break

During the first summer break, this research mainly focused on the shift towards skill development and professional growth, which continued with positive sentiment. "Anticipation" grew as users explored online learning for career advancement. Discussion and interaction increasingly revolved around the importance of educational technology and virtual classrooms.

Second semester (September- December 2020): fall semester, also the first entire semester during Covid Second Break (January 2021): winter break

By the third semester, sentiment stabilized as students and teachers might adapt to online platforms. Positive sentiments continued to dominate all the discussions of student engagement, teacher support, and resources for remote learning. Meanwhile, integrating educational technology into traditional teaching methods became more advanced, and professional development opportunities further reinforced confidence in online learning.

During the first winter break, results are expected to be similar to those from the first summer break, during which the majority of sentiments were positive while focusing on professional and skill development in a better and more stable online learning environment.

Third Semester (February-May 2021) + Second summer break (June-August 2021)+ Fourth Semester (September- December 2021): Online learning stable period

During these three periods, sentiment remained positive, focusing on skill learning, professional growth, and ongoing innovations in online education platforms. The widespread use of educational technology and the introduction of more interactive resources helped maintain engagement and foster development. Although student motivation remained a challenge while using online learning, the consistent development of the online learning environment is still stable and optimistic.

6.2. RQ2.1&2.2

The following discussion section provides insights into how platforms such as Canvas, Coursera, MasterClass, Udemy, and Zoom changed regarding emotional responses and user sentiment across different periods.

Canvas. According to Table 5, Canvas consistently received positive sentiment, with “Trust” and “Anticipation” dominating the emotion change. In V1, 49.44% of responses were positive, with “trust” 20.22% being the most prominent. The platform’s features, such as peer-to-peer support, multimedia integration, and well-organized course material, likely contributed to this high level of trust. Meanwhile, the percentage of “Joy” is 10.11%, and “surprise” is 3.37%, which further reflects user satisfaction. In Canvas V2, “trust” remained strong at 26.67%.

Coursera. Coursera could be characterized by high levels of “anticipation” and “trust,” especially in V2 and V3. The platform’s focus on professional development, certification, and technical skill-building likely fueled users' anticipation and trust. Meanwhile, “Joy” also appeared prominently in the V2 period, which indicates user satisfaction with its free course offerings and learning programs.

MasterClass. Unlike other platforms, MasterClass conducted a mix of emotions. Anticipation and trust were dominant in the V1 period, but the platform also included anger and sadness in both the V1 and V2 periods. This could reflect dissatisfaction with the platform’s course offering or its accessibility features compared to other platforms.

Udemy. Like MasterClass, Udemy offers various affordable technical skills, programming, and career development courses. Its sentiment varied little across different periods but mainly remained buoyant due to its focus on affordable education through coupons, discounted courses, low-cost certification, and accessible learning opportunities. According to the research, as the pandemic progressed, Udemy continued to attract positive sentiment through its free and low-cost features and focus on lifelong learning, particularly in technical skills and data science, programming courses, web development training, and other marketable skills during the late period.

Zoom. Zoom is an indispensable online education tool that maintains a large user base. Meanwhile, it showed the highest variation in emotional change, which presents negative sentiment and Zoom fatigue reflected in Semester 3 V1, where emotions of “anger” and “sadness” are notable. Additionally, Zoom stays with a relatively strong positive sentiment across time. Zoom’s live meeting features, breakout rooms, cooperation with education institutions, and the ability to enhance virtual classrooms during hard times contribute to this positive reception. However, there is still a concern about Zoom fatigue, and the challenge of sustained online interaction led to negative emotional fatigue for users, according to data from semester 3.

7. Conclusion

The study analyzed public sentiment toward online learning during the COVID-19 pandemic using Twitter data. Findings suggest that sentiment was predominantly positive, with trust, anticipation, and joy being the most frequently observed emotions, particularly during the early stages of the pandemic. This optimism can be attributed to the ability of platforms like Coursera and Udemy to offer flexible, personalized, and skill-oriented learning experiences, which met users' needs when traditional education was being disrupted.

However, the study also highlights some challenges. Platforms heavily relying on live, synchronous interactions, such as Zoom, showed higher negative emotions, particularly frustration and fatigue. This suggests that while online learning was a crucial tool for maintaining continuity, it also presented new difficulties related to sustained engagement and the mental toll of extended virtual interactions. Despite challenges such as Zoom fatigue and decreased student motivation, platforms

like Coursera and Udemy have received favorable feedback, possibly due to their flexibility and skill-based learning options.

Ultimately, the findings underline the pivotal role online learning played during the pandemic, revealing opportunities for improvement. By addressing issues related to prolonged virtual engagement and optimizing platform features, educational institutions, and developers can improve the effectiveness and user satisfaction of online learning models in the future.

7.1. Limitation

The reliance on social media, particularly from Twitter, may introduce demographic bias. Twitter users' demographic composition includes age, location, social status, and economic status.

Emoji Analysis is lacking because converting emojis into text sentiment analysis can not perfectly capture the complex meaning of a user's emotional change.

Reduction of sample size. This research's original dataset contained 1437792 data points, but the research only used 32570 units. Reducing the data sample may limit the scope of analysis, particularly for RQ2 analysis, which is relevant to platform-specific topics, as only those platforms with enough data could be included.

This research's analysis only focused on the text part. Still, it did not account for other engagement features such as retweets, replies, and likes, essential to reflecting public sentiment change. The result believes future studies could benefit from a targeted analysis of all engagement to refine sentiment insights.

Text cleaning could be more efficient. During the analysis, it was found that certain frequent occurrences that should have been removed were not filtered out, which caused noise in the data and reduced the sentiment and analysis accuracy.

RQ 2 platform analysis error. In platform analysis, noisy data were not able to be eliminated, such as distinguishing between the adjective "Brilliant" and its use as a platform name or clarifying instances where "Coursera" was mistaken for "Courserated." Such failure may have influenced the result of the analysis.

7.2. Future implication

It is worth knowing that the sentiment changes toward different types of platforms' characteristics can directly influence how platform developers and producers update and further develop their products and services. In this case, closely analyzing user feedback and understanding the demand for specific features could lead to platform development being more responsive to user needs, fostering user engagement, and creating a better learning environment. The widespread adoption of online learning could reduce educational inequality by offering more diverse knowledge and lowering the barriers to accessing education. These platforms can democratize learning opportunities through affordable and free courses in a global range and make education accessible to a broader range. However, this trend might cause educational inequality. The affordability of technology and access to reliable internet sources remain critical. In this case, users from less privileged backgrounds may face challenges accessing the platform, further widening the gap. Undeniably, the future of education requires a shift from traditional models to new learning patterns while embracing the digital world. Thus, the future of online education lies in creating a more balanced ecosystem that not only depends on technology development but also addresses the disparities.

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Appendix

Additional data supporting this study, including raw data files, statistical analyses, and supplementary materials, can be accessed via the following Google Drive link:

<https://drive.google.com/drive/folders/1uTfVVpSCAAxgNXYrngf5yAfUFPPGDnbl>