The pandemic semesters: Examining public opinion regarding online learning amidst COVID-19

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Abstract
The current educational disruption caused by the COVID-19 pandemic has fuelled a plethora of investments and the use of educational technologies for Emergency Remote Learning (ERL). Despite the significance of online learning for ERL across most educational institutions, there are wide mixed perceptions about online learning during this pandemic. This study, therefore, aims at examining public perception about online learning for ERL during COVID-19. The study sample included 31,009 English language Tweets extracted and cleaned using Twitter API, Python libraries and NVivo, from 10 March 2020 to 25 July 2020, using keywords: COVID-19, Corona, e-learning, online learning, distance learning. Collected tweets were analysed using word frequencies of unigrams and bigrams, sentiment analysis, topic modelling, and sentiment labeling, cluster, and trend analysis. The results identified more positive and negative sentiments within the dataset and identified topics. Further, the identified topics which are learning support, COVID-19, online learning, schools, distance learning, e-learning, students, and education were clustered among each other. The number of daily COVID-19 related cases had a weak linear relationship with the number of online learning tweets due to the low number of tweets during the vacation period from April to June 2020. The number of tweets increased during the early weeks of July 2020 as a result of the increasing number of mixed reactions to the reopening of schools. The study findings and recommendations underscore the need for educational systems, government agencies, and other stakeholders to practically implement online learning measures and strategies for ERL in the quest of reopening of schools.

KEYWORDS
COVID-19, online teaching and learning, Emergency Remote Learning, reopening, schools

1 | INTRODUCTION

On 11 March 2020, the World Health Organization (WHO) declared COVID-19 a global public health pandemic (Cucinotta & Vanelli, 2020). Since then, the virus has crossed multiple borders, which has led to a devastating impact on government institutions, businesses, and households across the globe. As of 6 August 2020, the total numbers of world COVID-19 related cases have reached a total of 19,189,737 since the first reported case in Wuhan, China in December 2019 (Wang et al., 2020; Worldometer, 2020).

Due to the highly infectious rate of the virus, many countries have agreed on temporarily closing various business sectors to control the spread of the virus. Educational institutions were among the most affected by this action. A report by UNESCO revealed that schools in over 106 countries remain partially and fully closed due to the pandemic. This has affected over 1 billion (60%) of the
Among the many requirements and suggestions provided by health departments across the globe, wearing of mask and social distancing have proven to reduce further outbreak in public spaces. Social distancing, or 'physical distancing', ensures a safe space of at least 6 feet between interacting individuals not from the same household. Unfortunately, social distancing in the educational settings have proven to have negative impact on teaching and learning.

As educational sectors strive to find solutions to the current pandemic challenges, considerations for a more pragmatic approach in decision-making by government, educational policymakers, educators, parents and other stakeholders have led to the surge in technology investment and online teaching and learning recommendations (Adedoyin & Soykan, 2020; De’ et al., 2020; Hodges et al., 2020). Despite the significance of emergency remote and online learning adoption across most educational institutions, there are wide mixed perceptions about online learning during this pandemic (Agarwal & Kaushik, 2020; Deepika, 2020; Hasan & Bao, 2020; Unger & Meiran, 2020). Hence, this study aims at examining public sentiments and the major topics of discussion pertaining to online teaching and learning during COVID-19 using dataset gathered from Twitter platform.

The microblogging service, Twitter, was chosen for the purpose of this study due to its large base of active users around the world. Thus, the affluence of publicly available data shared through this social media site has encouraged many researchers to examine sentiments on several topics. Given the surge in global online teaching and learning and the current debate on when and how schools should reopen in the wake of the COVID-19 pandemic, there is an abundance of content to study this contemporary phenomenon to better understand and address COVID-19 and online learning related issues. Stemming from this background are the following questions posited for this research:

Q1: What are the most frequent words related to COVID-19 and online teaching and learning? Q2: What are the major topics of discussion about online teaching and learning during the COVID-19 pandemic? Q3: What are the relationships of COVID-19 and online teaching and learning (Cluster Analysis)? Q4: What are the trends in topics identified during the studied periods?

The rest of the paper is organized as follows: In the next section, we present related and recent works on e-learning and blended learning. Section 2 details the role of e-learning during the Coronavirus pandemic. Section 3 describes the mixed reactions on plans of reopening of school around the world amid the pandemic. Section 4 presents the research methodology, which entails data gathering and cleaning. Section 5 presents the empirical results of the study, including word cloud, identified themes, sentiment analysis, cluster analysis, and the correlation between COVID-19 and online learning. Section 6 presents a discussion of the results with theoretical and practical recommendations. Section 7 discusses limitations of the study and future research considerations.

2 | LITERATURE REVIEW

2.1 | Related works on Twitter platform as a data source

Twitter has become one of the most popular microblogging providers after it was launched in 2016. The platform has since been a vital source for data for social media research for both academicians and industry professionals. The platform has been used by researchers to examine public sentiments and opinions on various topics such as the current COVID-19 global pandemic (Kabir & Madria, 2020; Samuel et al., 2020), supply chain, (Chae, 2015) and public health, (Abd-Alrazaq et al., 2020; Medford et al., 2020; Nemes & Kiss, 2020). Most of these researchers applied various machine learning techniques in analysing or examining data collected from Twitter and other social media platforms.

A study by Dubey (2020) used sentiment analysis techniques such as subjectivity and polarity to examine sentiments of tweets across various countries. The researcher further conducted emotion analysis of tweets from each country. The results of the study revealed that whilst majority of the world population are taking a positive and optimistic approach in fighting the virus, there were also fear, anger, sadness, disgust, and surprise.

Further, Sharma et al. (2020) in their study designed a dashboard to track misinformation on Twitter platform by collecting streaming data using Twitter API. The dashboard helped the researchers analyse social media discussions on COVID-19 related topics and the quality of information shared on the platform. The analysis provided user accounts and the misinformation spread across countries. The researchers further analysed public sentiments over countries on preventive measures such as social distancing and working from home.

Similarly, Abd-Alrazaq et al. (2020) analysed data collected from Twitter platform by performing word frequencies, and topic modelling using Latent Dirichlet Allocation to identify major topics of discussion.

In the quest to analyse early changes in Twitter activities, and sentiment about the COVID-19 epidemic, Medford et al. (2020) extracted data from Twitter using hashtags related to COVID-19. Using infection preventive measures, vaccination, and racial prejudice as related keywords, the authors identified emotional valence and prevalent emotions. They further performed topic modelling to identify the various topics of discussion over time.

Further, the authors in Dickinson and Hu (2015) predicted a sentiment value using stock related tweets from Twitter platform. They demonstrated a correlation between the sentiment and the trends of a company’s stock price in a real time streaming environment. The study also revealed significant correlations between price and sentiment for various individual companies.

Whilst there are several sentiment analysis studies conducted using data extracted from Twitter on various related topics there is little to no research on public sentiments about online learning leveraging on Twitter platform, hence this study would be the first of its kind.
to examine public sentiments about online learning during the current COVID-19 pandemic using machine learning techniques.

### 2.2 E-learning and blended learning

E-learning, which falls under online learning, is defined as the use of various technological tools such as computers, laptops, and internet connectivity to deliver both synchronous and asynchronous teaching and learning in an online environment (Sambrook, 2003). Budu et al. (2018) defined e-learning as the integration of Information Communication Technology (ICTs) systems that enhance and support the delivery and application of knowledge in teaching and learning. In e-learning environments, educators and learners connect and interact remotely with one another to perform various academic activities (Singh & Thurman, 2019).

Blended learning is defined as a combination of distance learning and on-campus learning. In blended learning, there is a fixed class schedule where learners will have to attend as part of on-campus classes. However, most courses in a blended learning program will still be online, allowing learners to do coursework and assessments online (Bervell & Umar, 2020; Herman et al., 2019; Pop, 2020).

#### 2.2.1 Synchronous and asynchronous learning

The two types of online learning environments are synchronous and asynchronous. In the synchronous learning environment, students attend live lectures using learning management systems (LMS) such as Blackboard, D2L, and Moodle. This learning environment enables educators to have real-time teaching interactions, and collaborations with their learners through scheduled class hours (Chen & Huang, 2019; Ng et al., 2012). Also, students are able to access all teaching and resources and submit assessments through LMS in real-time (Çakröglü & Kiç, 2020).

Asynchronous learning, on the other hand, defines an unstructured online teaching and learning environment. Although teaching and learning resources and the submission of assignments are made available 24/7 on LMS, learning contents are not available in the form of live lectures or classes (Dhawan, 2020; Kear, 2004).

Comparatively, synchronous learning provides a lot of opportunities for effective teaching and learning through social interaction (Chao et al., 2012; Mcbrien et al., 2009; Pfister & Oehl, 2009). The fact can never be disputed that the global pandemic has resulted in the use of both synchronous and asynchronous teaching and learning strategies. This has enabled educators to connect with their learners through various learning technologies, and application of pedagogies to keep online classes organic (Dhawan, 2020). As a result of the above-mentioned, many educators and learners have been able to complete their academic semesters successfully despite the ongoing crisis.

### 2.3 The role of e-learning for emergency remote learning during COVID-19 pandemic

The quest for educational institutions to stay agile and adaptable to the current crises caused by the virus has led to the rise of EdTech and online learning systems adoption by most academic institutions across the globe. Evidently, online learning has become a vital solution in teaching and learning with approximately 90% of the world’s wealthiest nations such as US, Canada, UK, Germany, France, China,
Online learning also saw a spike in most Asian countries after WHO declared COVID-19 as a global pandemic on 11 March 2020. Education ministries across most Asian countries such as China, Vietnam, Japan, Malaysia, and the Philippines have pushed for the adoption and utilization of online teaching and learning systems through Microsoft services. This initiative has enabled millions of students to learn and complete their semesters from home at their own pace. Besides, through the use of online learning systems, educational institutions in these countries could facilitate real-time collaborative training among administrative staff, teachers, and students (Microsoft, 2020b).

In mid-February 2020, the Chinese education ministry instructed a quarter of a billion full-time students to continue their learning through online platforms such as Tencent classroom and Zoom. This shift recorded the highest online teaching and learning in the history of Chinese education with approximately 730,000, or 81% of K-12 students, attending classes via the Tencent online classroom in Wuhan (Li & Lalani, 2020a; Tencent, 2020). In addition, most PhD students in China, especially international students, were able to defend their dissertation using Zoom application and attend virtual graduation ceremonies using various live-streaming platforms. There is no doubt that the disruption caused by COVID-19 and the integration of technology in teaching and learning has become an integral component of education globally as we fight COVID-19.

Despite the devastating impact of the virus on various educational sectors around the world, developing countries have had the lion’s share of the pandemic. While some schools have been delivering online learning for their students, some students have never attended class since the closure of schools in March 2020. A study by UNESCO (2020b) revealed that an estimated 297 million African students have been affected by the closure of schools as a result of the pandemic. Most higher institutions in Kenya, Rwanda, Ghana, Nigeria, Tanzania, Egypt, South Africa, and other African countries have had no choice but to move some of their programs online with the help of EdTech. On the other hand, online learning in the continent is crippled with challenges due to poor internet connectivity, expensive data, lack of household computers by students, and the urban–rural digital divide. These pose a massive threat to the educational system in Africa during these challenging times. UNICEF, UNESCO, and the World Bank have provided support to countries like Ghana, Ivory Coast, Rwanda, Senegal, Congo (DRC), and Tanzania to adopt traditional mass communication tools such as radio and television to promote remote teaching and learning for primary, secondary and vocational schools (Kuwonu, 2020).

In response to the significant demand in the online learning system for ERL, the world has seen the support of some companies who have made part of their paid services free of charge for the rest of the 2020 academic year. IBM launched Open P-TECH, a free digital learning platform that introduces students and educators to the technical and professional skills needed for the future (P-TECH, 2020).

Also, Microsoft offered educational institutions currently not licensed for Microsoft Teams, a free unlimited Office 365 AI with lifted restrictions on user limits. This offer provided academic institutions with unlimited chat, video calling, file sharing, storage, and more (Microsoft, 2020a).

Furthermore, DingTalk, which is Alibaba’s distance learning solution, hit a record high in March 2020 for rapid capacity expansion after the platform tapped into Alibaba Cloud to deploy more than 100,000 new cloud servers in just 2 hours to support large-scale remote work (Chou, 2020). Currently, the market leader in chat apps in China, DingTalk initiated to provide free services such as live streaming, online testing, and grading features to academic institutions shortly after the Chinese government announced the postponement of the start of the new academic semester in January 2020. Nearly 120 million students and 140,000 schools across China have since resumed classes through the app (Xinhua, 2020).

Also, in California, around 2000 college and high school students who have had their education disrupted due to COVID-19, benefited from three-month tuition-free three courses offered by National University. Students enrolled in any of the three courses could transfer their credit to colleges across the state (University, 2020).

2.4 Mixed reactions on reopening of schools around the world

Whilst countries are at different points in the battle with COVID-19, some global leaders have had different opinions on the decision of when and how to reopen schools for the fall September 2020 semester. Though most governments and educational agencies in various countries have issued directives to educational institutions to adopt and deliver programs online until further notice, that is not the case for other countries.

In Denmark, children up to the age of 11 went back to schools and nurseries after 1 month of closure.

In Sweden, classes remained open for kids under 16 years of age (Li & Lalani, 2020b; Taylor, 2020). Some few school facilities in Belgium and Norway remained partially open for children whose parents are essential workers. On the other hand, in South Korea, online classes are widely provided (Bicker, 2020).

Countries such as Canada and the United States have issued government directives for the reopening of schools during the pandemic which has led to mixed reactions by students, teachers, parents, politicians, and educational experts (Jarrett & Pomrenze, 2020; Lee, 2020; Young, 2020; Yousif, 2020).

In Canada, most provinces have opted for partial school re-openings except for Quebec’s Ministry of Education who has decided to fully reopen the province’s public schools, except for schools in Montreal (Yiwei Jin, 2020). A report by the Canadian Teachers’ Federation (CTF/FCE) with data collected from nearly 18,000 teachers across Canada, revealed that 8 in 10 (83%) of teachers have concerns about
retuming to school after the first phase of the COVID-19 pandemic (CTF/FCE, 2020).

The United States has seen the most mixed reactions after its president gave directives to federal states and educational institutions to reopening schools for Fall 2020 semester despite the country being the epicentre of the pandemic. Notwithstanding those directives, some major school districts are skeptical, defying state regulations and refusing to reopen until they see a decline in COVID-19 cases (Lee, 2020). Some district schools in Los Angeles, Atlanta, Dallas, and Houston have planned to start full online classes in the fall, 2020 semester. Some counties in New York, Chicago, Miami, New Orleans and South Carolina have adopted for a hybrid teaching and learning model after parents and teachers expressed their frustrations of having their students learn from home (Jarrett & Pomrenze, 2020).

In China, a detailed timeline released for local schools to reopen in June came as a mixed feeling for parents who struggle between work and taking care of their children, however, concerned about the high risk of infection at school (Hui, 2020).

Similarly, the Kenyan Education Ministry’s decision to postpone the reopening of primary education to January 2021 or till a flattened curve of the spread of the virus was met with mixed reactions. This came after medical experts in the country announced that the pandemic might peak in August 2020, a month before schools reopen (Kimani, 2020).

While some feel it is better to be safe than sorry, others have expressed concern that the decision will affect the morale of learners and educators. For most people around the world, the decision to reopen schools or continue with fully online learning remains silent despite the ongoing debate on when and how the governments should reopen the educational systems. In the state of Mecklenburg-West Pomerania, Germany, two schools were forced to close down due to coronavirus infections, weeks after classes reopened (Pleitgen, 2020).

In the United States, more than 250 employees in Georgia’s largest school district have been barred from work after testing positive for the virus. This came just a day after the Gwinnett County Public School teachers began in-person pre-planning at the 141 facilities throughout the county (Broady, 2020). A high school in Indiana had to quarantine students and shift to online learning just 2 days after reopening (Eliza Shapiro, 2020).

Evidently, the new academic year began with a chaotic start in most countries as schools reopen amidst the pandemic. As the number of daily cases keep rising steadily, temporarily switching face-to-face teaching and learning experience to the online environment seems to be an optimal solution. Thus, it is important for governments, policymakers, and the public to gain an in-depth knowledge and understanding of the current situation of schools’ reopening to determine the viability of online learning as a delivery modality. Social media websites such as Twitter, Facebook, and Instagram, have been excellent sources to capture and analyse public opinion, especially on COVID-19 related issues. In recent times, social media platforms have been one of the quickest means for people to express their thoughts, emotions, and activities about immediate social phenomena such as education, finances, health, natural disasters, social trends, and so on (Samuel et al., 2020). Consequently, researchers have been using data generated from social media platforms such as Twitter to identify opinions and emotions on a number of public and social related issues (Shu et al., 2017; Kretinin et al., 2018).

There have been many sentiment analysis research studies on the issues such as healthcare, hospitality, misinformation and other related COVID-19 pandemic topics (Abd-Alrazaq et al., 2020; Chen et al., 2020; Dubey, 2020; Gilpin, 2020; Kabir & Madria, 2020; Melford et al., 2020; Nemes & Kiss, 2020; Samuel et al., 2020; Sharma et al., 2020). Despite the growing number of sentiment analysis on COVID-19 related cases, none of these studies have explored the area of COVID-19 and online learning to identify word frequency, public sentiment, essential topics of discussion, the relationship between identifying themes, correlation and trend analysis related to COVID-19 and online learning.

3 | METHODOLOGY

3.1 | Data gathering

Twitter is one of the largest global social network platforms, with a total of 330 million monthly active users. Out of these users, over 40% log into the platform daily (Twitter, 2019). Twitter users mostly utilize the platform to share their thoughts, opinions and disseminate information. The wealth of shared views on this platform has encouraged many researchers to gather data from the platform to examine sentiments on numerous social issues (Blank, 2017; Chae, 2015; Kretinin et al., 2018; Peoples et al., 2016; Sinnenberg et al., 2017). To leverage the significance of data on the Twitter platform, the researchers scrapped tweets from the Twitter platform using Tweepy and Twitterscraper library along with Twitter developers API (Twitter, 2020) in Python language.

Data was gathered from 10 March 2020 to 24 July 2020. These dates were selected since most schools in the world were closed and forced to find alternative delivery modalities to complete their academic semester. By July 2020, most educational and government institutions have had to develop plans and strategies for reopening of schools for Fall 2020 semester. These dates helped the researchers gain insight into public opinion and perceptions on online learning and COVID-19 during the early and peak stages of the virus. The data was extracted using the keywords: ‘covid and elearning’, ‘covid and online learning’, ‘corona and e learning’, ‘corona and online learning’, ‘covid and distance learning’, ‘corona and distance learning’. These keywords were selected since they mostly represent online learning and COVID-19. In total, 31,009 tweets were collected from Twitter. Additionally, the researchers collected COVID-19 time series data set on new daily COVID-19 related cases (Ritchie et al., 2020). Figure 2, presents some of the tweets that were collected.
3.2 | Data cleaning

The data cleaning process was conducted after obtaining the complete dataset. The dataset from Twitter posts between March 10 and 25 July 2020 was noisy and unstructured in nature. Therefore, URLs, mention and tagging, noisy words (i.e., R.T.), white spaces, punctuation, stop words, and non-ASCII characters, were used to form a search pattern and remove unwanted characters using Python’s built-in package called ‘re’.

In addition, we eliminated words from tweets that were found in the Python natural language toolkit stopwords Corpus. Moreover, the retweets were filtered out along with duplicated tweets during the data cleaning process. Likewise, all unnecessary information such as usernames, the website used, and attached links were all deleted. A total of 13,708 tweets with dates, tweets, and hashtag data, were ready for further analysis.

3.3 | Data analysis

To better answer the research questions, the researchers conducted multiple analyses using NVivo, Matplotlib and Seaborn libraries in Python. The analysis includes word cloud, identified themes, sentiment analysis, cluster analysis, correlations analysis, and trends analysis on identified topics.

4 | RESULTS AND ANALYSIS

4.1 | Word frequency

A word frequency count is the overall most common semantic based on 100 words within a dataset represented in varying font sizes. The words that are repeated in the dataset tend to have the highest frequency defined in larger fonts. (Adu, 2020). Usually, these words are the focus of the authors based on the research objectives. Word frequency counts are usually single (unigrams) that is, ‘I’ ‘enjoy’ ‘distance’ ‘learning’ and double words (bigrams) that is, ‘I enjoy’, ‘distance learning’ (Chetty, 2018; Hai-Jew, 2020).

4.1.1 | The most frequent words about COVID-19 and online learning

As depicted in Figure 3., words like ‘learning’, ‘COVID’, ‘online’, ‘distance’, ‘education’ and ‘schools’, ‘pandemic’ were frequently used. Out of these words, ‘learning’, ‘COVID’, ‘online’ and ‘distance’, got the most considerable number of words used. Correspondently, most of the tweets were related to the current online learning strategies.
and implementation across the globe due to the novel coronavirus. The above-mentioned words identified is evident in the fact that the current pandemic has mostly affected the educational system in the world. This has left the educational sector to come up with alternate teaching and learning strategies for the successful delivery of programs leveraging distance and online learning.

4.2 | Content and thematic analysis

The second phase of the analysis explored the topics of discussion from the tweet dataset based on percentages to identify the larger data patterns to help answer the research questions using a Natural Language Process (NLP) embedded in NVivo 12. Since this study is qualitative in nature, content and thematic analysis was the best approach in this study to identify the data patterns to better answer the research questions. Content and thematic analysis serve the same analytical purpose by analysing narrative materials through tokenization or breaking text into relatively small individual units of content as descriptive results (Sparkes, 2005). Although the two approaches serve the same purpose, content analysis particularly describes the characteristics of the document’s content or text. Thematic analysis on the other hand, is for identifying, analysing and reporting data patterns (Braun & Clarke, 2006).

Further, content and thematic analysis is a supervised and unsupervised machine learning technique in qualitative data analysis. These techniques enable researchers to closely identify and examine common themes, topics, and patterns within a dataset. Using supervised learning techniques, a researcher can create predefined data labels based on previous experience or existing study findings. With an unsupervised machine learning technique, a researcher is able to identify unknown patterns within a dataset (Adu, 2020; NVivo, 2020b).

The themes for the study were identified by analysing the content and the sentence structure within the dataset by following the six most commonly steps defined by (Clarke & Braun, 2013). The steps includes, getting a thorough overview of the extracted data, coding, generating the themes, reviewing the themes, defining and naming the themes (Caulfield, 2020). In the coding process, word significance was assigned to some themes over other themes using NLP algorithm based on how frequently each theme occurred in the tweet dataset. The pertinent contents coded to the theme nodes were then merged into groups and presented as a summarized node for each broad idea, with child nodes for each theme within that group (NVivo, 2020b). Despite the robustness of this NLP technique the researchers critically analysed and manually selected the topic that were generated based on the study objectives to avoid any topic allocation errors (Guo et al., 2016).

Themes were defined based on the literature review, generated word frequency, and the relevance of the most salient terms (Kazmaier & van Vuuren, 2020; Medford et al., 2020).

4.2.1 | Main topics discussed about online learning during the COVID-19 pandemic

Out of the 13,708 tweets, 24,992 codes with a total of 138,239 references were calculated based on the coding from the tweets generated. These themes captured represented pattern responses and meanings within the data set (Braun & Clarke, 2013). Figure 3 depicts the study themes which are made up of perceptions and opinions about online learning and COVID-19 recorded under auto-generated themes in NVivo. These themes consist of Learning Support (30.49%), COVID-19 (30.34%), Online learning, (18.66%), Schools (12.72%), Distance Learning (11.74%), E-learning (9.31%) Students (9.13%) and Education (6.92%). This implies that most of the public perceptions and opinions on online learning during the current COVID-19 pandemic were focused on ‘learning support’, ‘COVID-19’, ‘online learning’, ‘schools’, ‘distance learning’, ‘e-learning’, ‘students’ and ‘education’ (Figure 4).
4.3 | Sentiment analysis

Sentiment analysis was used to unearth public views on online learning during the pandemic. This process is used to identify whether the text data was positive, negative or neutral by utilizing NLP and machine learning techniques to assign weighted sentiment scores to the entities, themes and categories within a sentence or phrase’ (Sentiment Analysis Explained, n.d.).

To apply sentiment analysis, the researchers used TextBlob library in Python to identify the sentiments from the tweets, (TextBlob: Simplified Text Processing – TextBlob 0.16.0 documentation, n.d.). The researchers used pre-labelled data with unsupervised techniques to predict the sentiment within the dataset through ontologies, and lexicons, which is a dictionary of words for sentiment analysis. The lexicons contain a list of positive, neutral, and negative polar words with scores. The scores were then assigned to the pre-labelled data after aggregating the scores as positive, neutral, and negative sentiments.

Using the TextBlob technique, tweets’ sentiments were examined in two areas: polarity and subjectivity scores. Polarity scores are float value range from $-1$ to $1$. One in polarity score indicates positive sentiment, whereas $-1$ indicates negative sentiment. Zero in the polarity score shows a neutral sentiment. Subjectivity score is also a float value ranging from 0 to 1 with 0 indicating a fact and other values representing public opinions. TextBlob features were used to examine the clean text data by finding words and phrases that were assigned to the polarity and subjectivity as well as the average scores for longer tweets.

4.3.1 | Public sentiments on COVID-19 and online learning worldwide

Figure 5 illustrates the details of twitter sentiments during the studied periods. The scatter plot goes from red to green with the darker red shade indicating more negative tweets, and the greener shade indicating more positive tweets. Hence, there was a high number of positive tweets about online learning during the studied periods.

Figure 6 indicates that nearly half of the tweets are positive (48.9%), followed by neutral tweets with 36%, whilst negative tweets were recorded (15.1%). Moreover, Figure 6 indicates that over two-thirds of tweets were based on opinions (69.3%), whereas tweets based on subjectivity were (30.7%). In general, people expressed their views and perceptions towards online learning positively during the pandemic.

![Figure 5](wileyonlinelibrary.com)

![Figure 6](wileyonlinelibrary.com)
In addition, the sentiment analysis for each identified theme was examined. The topic of education has the highest positive tweets (61%), followed by Distance Learning and COVID-19 related topics (55%), respectively. Interestingly, the topic of Distance Learning has the highest percentage of negative tweets (24%), as revealed in Figure 7. This indicates that people are taking sides with the Distance Learning topic.

4.4 Cluster analysis

This section presents cluster analysis techniques and results used to classify the themes identified in the study. Cluster analysis was performed by consideration of the research problems. Based on the word frequency, the varying themes were explored with word similarity within the dataset using an unsupervised approach. The identified themes were then manually selected (supervised learning) and hierarchically clustered by applying code similarity and similarity metric of Pearson correlation coefficient to measure the similarity and diversity of the datasets.

The Pearson correlation coefficient (−1 = least similar, 1 = most similar) threshold of 1 was achieved, indicating the most similarity of the identified themes (NVivo, 2020a). The algorithm treated each theme as a singleton cluster. The pairs of themes were successively merged into one cluster containing all the themes.

4.4.1 The relationship of COVID-19 on online learning

The analysis reveals a connection between ‘COVID-19’, ‘distance learning’, ‘education’ and ‘e-learning’ under one cluster. Similarly, the analysis showed a parent node of ‘learning support’, ‘online learning’, ‘schools’ and ‘student’. The effect of COVID-19 on the education sector has led to the implementation and use of distance learning and e-learning systems by most educational institutions across the globe.

The second parent of cluster analysis identified was the relationship between ‘learning support’, ‘online learning’, ‘schools’ and ‘students’. Concurrent to the shift and sudden increase in online learning requirements, antecedent industries have tried to address the technological demand for this growth. Companies like Microsoft, DingTalk, IBM, zoom communications, and Amazon contributed massively to the online learning environment by providing free services for some of their paid services.

Government agencies have also taken immediate, significant, and decisive action to support educational institutions and students facing hardship. The Ontario government in Canada, for example, waived any interest on their Ontario Student Assistance Program (OSAP) loans between 30 March 2020 and 30 September 2020 to help support students. The government also allowed students to attend post-secondary education through virtual learning, in-class instruction or hybrid formats (Ontario, 2020).

In India, the coronavirus pandemic has presented an opportunity to transform their educational system. For the first time in many years, the government has allowed universities and colleges to offer fully online degree programs, a decision that could rewrite the delivery of education in the country while opening online education market opportunities for the South-Asian country (McKenzie, 2020).

In Africa, the Global Partnership for Education (GPE) has provided an initial US$60 million for five new grants to support the education of up to 30.5 million children in Ghana, Malawi, Mozambique, Rwanda and Zambia affected by coronavirus-related school closures, as well as US$7.5 million to ensure countries can benefit from learning and best

![Figure 7](https://wileyonlinelibrary.com)
practices (Education, 2020). The eight themes identified brought together tweets that addressed issues related to diverse topics but central to COVID-19 and online learning (Figure 8).

### 4.5 Pearson correlation coefficient

The researchers applied parametric tests to estimate the degree of association between the two quantitative variables, COVID-19 related cases and the number of online learning tweets with the assumption that the datasets are normally distributed (Hoskin, 2010).

Correlation coefficient statistical method was used to examine the linear relationship between the number of COVID-19 related cases with the number of online learning related tweets. The Pearson correlation coefficient was calculated as the covariance of the two variables, COVID-19 related cases and the number of online learning related tweets, divided by the product of the standard deviation of each data sample, using the `pearsonr()` SciPy function. The coefficient values of Pearson correlation are between $-1$ and $1$, where $1$ indicates a perfect positive relationship, and $-1$ shows a perfect negative relationship. Whereas $0$ means no relationship between the studied variables.

#### 4.5.1 The correlations between COVID-19 cases and number of online learning tweets

Figure 9 demonstrates the correlation between COVID-19 related cases and the tweets related to online learning. The researchers observed a weak linear relationship coefficient of 0.369 between the two variables. The Y-axis displays the number of daily COVID-19 related cases, while the X-axis shows the number of daily tweets posted related to online learning.

### 4.6 Trend analysis

Trend analysis was conducted at the final stage of the analysis to identify the patterns in the study periods by collecting multiple data points of the themes identified along the time periods. The researchers applied linear trend which is systematic linear and nonlinear component that changes over time without repetition. The date data grouped the total number of tweets of each defined theme which were then plotted on a horizontal line. For better visualization, the analysis trend shows the 7 days moving average in the number of tweets for each topic.
4.6.1 | The trends in topics identified during the studied periods

As illustrated in Figure 10, there is a dynamic variation between the eight key topics during the studied periods. At the beginning of the lockdown, there were many discussions on school closure, distance learning, e-learning, and online-learning. Since most schools around the world were in the middle of the semester, this generated a lot of discussions on how students could complete the rest of their semester successfully. Interestingly, the number of tweets on online learning related topics declined from May to June 2020. During early July 2020, there was a sharp rise in ‘Distance Learning’ topics which led to mixed reactions between educational institutions, governments, students and parents, as well as other stakeholders on measures put in place in reopening schools in September 2020. As most people support the measures put in place for back to school, others believe that capitalizing on the significance of distance learning, which includes online learning serves as a viable strategy as we continue to fight the deadly pandemic.

5 | DISCUSSIONS

The significance of this study was to investigate the opinions and perceptions of people around the world on COVID-19 and online learning related issues using the Twitter platform from March 10 to 24 July 2020. Twitter was selected for this study due to its wide application and the ease of collecting tweets. Multiple analysis techniques, including world clouds, sentiment analysis, cluster analysis, correlations analysis, and trends analysis, were applied to identify useful insights. The study revealed words like ‘COVID’, ‘Learning’, ‘Online’, ‘Distance’, ‘Students’, ‘Schools’ and ‘Pandemic’ as the most mentioned words worldwide. Moreover, nearly half of the public sentiments were positive (48.9%), followed by neutral (36%). Further, most of the tweets’ data were based on opinions (69.3%) rather than facts (30.7%). This finding confirms that people expressed positively about online learning amidst the pandemic. While reopening of schools has received lots of mixed reactions, online learning appears to be a sustainable option during these unprecedented times (CTF/FCE, 2020; Jarrett & Pomrenze, 2020; Yiwei Jin, 2020). Notably, ‘Covid-19’, ‘Distance Learning’, ‘E-Learning’, ‘Education’, ‘Learning Support’, ‘Online Learning’, ‘Schools’ and ‘Students’ were the most discussed themes.

The research has demonstrated that Covid-19 has disrupted the education system around the globe which raises the increasing concern on policies and measures needed for the educational systems during these unprecedented times. Thus, ‘Learning Support’ (30.49%) was the most mentioned theme, followed by ‘COVID-19’ (30.34%), ‘Online Learning’ (18.66%), ‘Schools’ (12.72%), ‘Distance Learning’ (11.74%), ‘E-learning’ (9.31%) ‘Students’ (9.13%) and ‘Education’ (6.92%). This finding suggests the need for immediate action by

![Time series of nine topics regarding COVID-19 and online learning tweets from March 10 to 25 July 2020](https://wileyonlinelibrary.com)
education systems, governments, and stakeholders to put in place strategic measures to capitalize on the significance of online learning as schools are in the process of reopening.

Moreover, the number of daily COVID-19 related cases had a weak association with the number of tweets about the study questions. This weak relationship can be explained with the trend analysis where tweet data in each theme are laid out horizontally based on the date data. At the beginning of March 2020 when most schools were forced to close, there were several tweets about the closure of schools and the learning support available for students. However, the number of tweets gradually decreased from April to June 2020 as this was around the time the semester had ended for most educational institutions around the world, and students and their educators were taking their summer vacation. There was a rise in the number of tweets during the early weeks of July. There have been mixed reactions by educational institutions, government, educators, parents, and students on plans put in place for the reopening of schools. For that reason, as the number of COVID-19 related cases continued to increase, there was an unstable trend in the online learning tweet dataset.

6 | PRACTICAL AND THEORETICAL IMPLICATIONS

6.1 | Practical implications

The study about online learning using Twitter platform has proven to be an excellent source to share information related to COVID-19 issues. The research demonstrated positive opinions towards online learning amidst the pandemic. In this study, eight themes were identified with ‘learning support’ being the most mentioned topic. Furthermore, the close relationship between ‘Learning Support’, ‘Online learning’, ‘Schools’ and ‘Students’, along with the COVID-19 themes, indicates the need to support our school system disrupted by the pandemic. Therefore, this study recommends that educational institutions, educators, students, parents, and other stakeholders work together to ensure efficient and effective online learning policies, implementation, and utilization as we fight the pandemic (OECD, 2020). Practically this would help overcome some of the challenges of online teaching and learning faced by students, teachers, and administrators during these hard times.

In addition, schools need to consider providing further support for educators and students by delivering workshop training on the importance and effective use of online learning system for pedagogical practices. Further, students’ and teachers’ attitudes, and dispositions are highly influenced by the support they receive from their colleagues and school administration (OECD, 2020). Hence counseling services are strongly recommended to be made available online for educators and students to increase their teaching and learning morale as well as their positive attitudes and intrinsic motivation. Government agencies are encouraged to establish financial support for educational institutions and students who are faced with hardship due to the pandemic. These financial supports could include tuition waiver for most affected students and students who are on the verge of graduation, however, hit with financial challenges due to the pandemic. Also, more affordable and subsidized teaching and learning devices such as laptops and computers should be made available to low-income households by tech giants, and governments as incentives for online learning as we move past this pandemic (Ferri et al., 2020).

Finally, more diverse and inclusive online learning technologies should be developed to curb web content accessibility issues to make digital learning resources all accessible, inclusive and diverse for accommodated students and students with disability issues (Ferri et al., 2020).

6.2 | Theoretical contributions

The COVID-19 pandemic has led to an increasing number of studies conducted within various disciplines such as healthcare, business and services industries, yet there is little emphasis on the education industry. This study is the first to contribute to COVID-19 and online learning amidst the pandemic using a dataset from social media platforms. Theoretically, this study corresponds to literature relating to COVID-19, online learning and ERL by exploring word frequency, discussed topic, public sentiments, relationships between themes, correlation and trend analysis of COVID-19 and identified themes. Accordingly, this study’s empirical results may be employed as a source of reference for other future studies interested in ‘COVID-19’ and ‘online learning’.

This study fills the gap in the literature with empirical results of some significant and intriguing findings. This study also serves as a theoretical contribution to the existing knowledge of COVID-19, online learning, and ERL. Thus, this paper serves as a benchmark for future research on online learning during these unprecedented times.

6.3 | Limitations and suggestions for future studies

Future studies could take this research further by addressing the following limitations. First, our sample was mainly drawn from the Twitter platform, leaving out other social media platforms such as Facebook, Instagram, and YouTube. Future research could expand the discourse by investigating opinions and perceptions from users using multiple social media platforms to study public sentiments about school reopening and COVID-19. Considerably, the United States could be considered for this future study due to the high level of mixed reactions on school reopening.

In addition, future studies may also conduct quantitative analysis using the themes ‘distance learning’, ‘education’, ‘e-learning’, ‘learning support’, ‘online learning’, ‘schools’ and ‘students’ to predict their relationship on teaching and learning performance. Since ‘online learning’ is here to stay (Dhawan, 2020; Mishra et al., 2020; Vander
Ark, 2016; Whiting, 2020) these themes could be thoroughly investigated using various research methods and statistical analyses such as questionnaires and Structural Equation Modelling (SEM). Further, future research should consider using the search term Emergency Remote Learning (ERL) that officially represents the COVID-19 emerged educational landscape (World Bank, 2020). Finally, a country-level analysis is recommended. This could be linked to the country related literature review presented by the authors in the study.

7 | CONCLUSION

This study aimed to analyse the public sentiments about online learning topics from 10 March 2020 to 24 July 2020. The starting time was chosen 1 day before the WHO declared the COVID-19 a global public health pandemic. Within the same month, cities around the world went into lockdown, which resulted in thousands of school closures. Using the Twitter platform, 31,009 tweets have been extracted using Python and pre-processed to unearth useful findings. Although the study revealed that people have shown positive opinions towards online learning during these uncertain times, people are urging for more learning support to ensure their continuous learning journey. The findings from the study correspond with previous studies that discussed public mixed reactions about school re-openings; thus, online learning is an ultimate choice during these times. Therefore, this study will help guide educational institutions, government agencies, individual organizations, educators, students, and other stakeholders to work closely together to make better-informed decisions on reopening of schools while considering online learning measures.

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CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

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DATA AVAILABILITY STATEMENT

The data for this study are available upon request from the corresponding author. Due to privacy and ethical restrictions the data are not publicly available.

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