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Using VR in Science Subjects: Popularity and Public Attitudes on Twitter

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Abstract—Following their surge in popularity during the height of the Covid-19 pandemic, e-learning and virtual education remain a noteworthy and rapidly developing part of the educational landscape. Still relatively immature in its development, virtual reality in particular promises extraordinary potential for positive educational outcomes. Given this potential, it is essential to deepen our understanding of the needs and attitudes of the public regarding its use. Based on Twitter data, our research focuses on the use of virtual reality in biology, chemistry and physics education, providing an analysis of popularity and other trends, along with public attitudes. Major results of our study include the finding that the application of virtual reality in chemistry was the most discussed among these three subjects between July 2016 and July 2022, and the discovery of a strong positive correlation between the frequency of tweets and the launch of hardware and software products. Our overview of the traffic on these three subjects is likely to be of particular value to software developers and virtual reality content creators.

Keywords—*virtual reality, science education, social media, public attitudes, Twitter*

I. INTRODUCTION

In the post-pandemic situation, eLearning and virtual education have become a noteworthy part of education [1], which requires us to rethink the manner of teaching. Our previous research found that public interest in using virtual reality in education has grown tremendously over the last couple of years; however, this adaptation was limited by the availability of high-quality content [2]. Public demand for virtual reality in education is still unknown.

Virtual reality (VR) can be considered an immersive interactive experience based on real-time computer-generated 3D graphics images [3]. Users can experience the virtual world through a helmet (HMD) or multi projections rooms (caves) and interaction devices [4]. Virtual reality is immersive, interactive, and involved and can provide more motivation for learning [3]. Many research workers evaluate that virtual reality has extraordinary potential for positive educational outcomes [5]. The application of virtual reality in education can stimulate students' enthusiasm to participate in learning activities and improve their ability to explore and express their own opinions [6]. For example, in a study of the impact of VR on science education, the students participating in the experiment were divided into three groups: one control group and two experimental groups. The control group followed traditional teaching methods, while the other two groups adopted VR learning system. The control group learned chemical reaction experiments through traditional teaching methods, and the experimental groups participated in

chemical reaction experiments in person through a system based on the HTV Vive VR system [7]. The experimental results demonstrated significantly better motivation, learning outcomes, and positive impacts on students' scores. According to the report by fortune business insights, the global VR in education market size in 2018 was USD 656.6 million, and it is expected to reach USD 13,098.2 million by 2026 [8]. However, due to problems such as software usability [9], the actual application of VR in education is not ideal. The lack of software in VR education and the dull content make the final satisfaction of students not high. For example, Arden: Shakespeare's World, a VR game designed to introduce the works of Shakespeare, ultimately failed due to lack of funding and player dissatisfaction with gameplay [10].

Therefore, it is essential to understand the needs and attitudes of the public towards the application of virtual reality in education. Twitter is a microblogging and social networking platform where users can post "tweets" and interact with other "tweets". Twitter has 396.5 million users worldwide and 206 million daily active users in 2022 [11]. Twitter brings together people's discussion of events, and as a low-cost and rapid dissemination medium of information, it can well reflect public attitudes. For example, research on the analysis of political discourse on Twitter affirmed the correlation between the public opinion on elections and the sentiment and topics discussed on Twitter [12]. Therefore, we can capture some public attitudes by analyzing tweets about the application of VR in education.

This research hopes to obtain the public's attention and attitudes toward the application of virtual reality in three science subjects, including biology, chemistry, and physics, from tweets by observing the discussion of VR-Science-related posts. In this study, we examined VR-Science-related tweets over 72 months, from 1 July 2016 to 1 July 2022, and hope to provide an overview of the traffic on these three science subjects to offer a new perspective for software developers and virtual reality content creators. We thus started with two research questions:

1. What trends existed among all tweets related to the application of virtual reality in these three science subjects during the 72-month window?
2. What are the public's attitudes and experiences about the application of virtual reality in science subjects on Twitter?

II. METHODS

This research mainly analyzed the popularity, trends, and public attitudes of VR-Science education posts on Twitter and selected three subjects in GCSE Science, including biology,

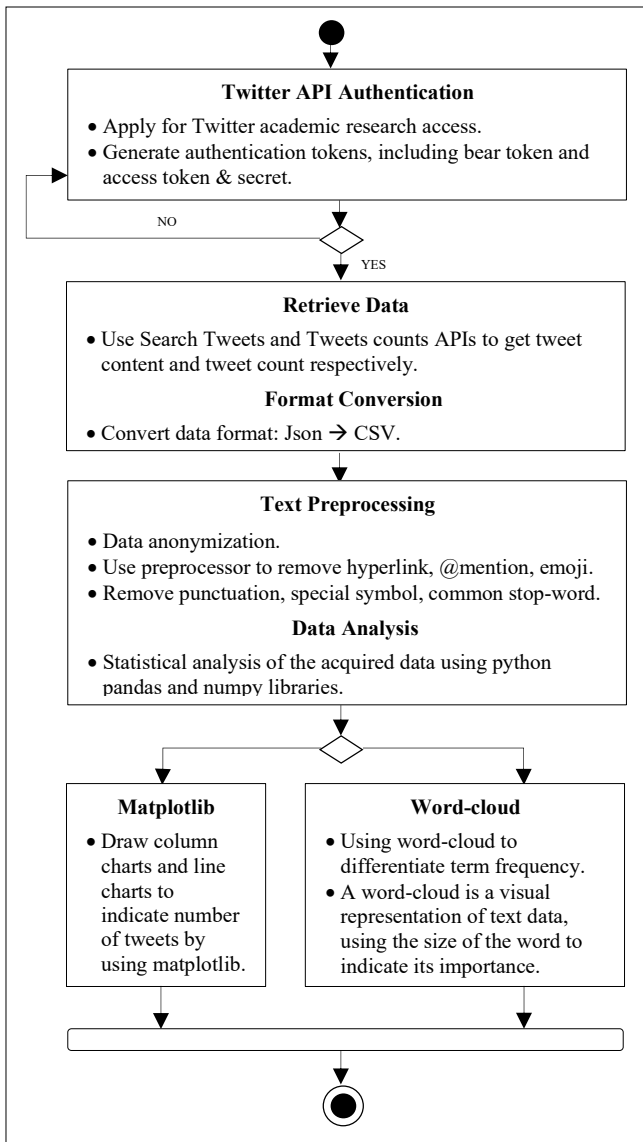


Fig. 1. Flow chart of data processing

chemistry, and physics, as the research objects. Twitter posts containing VR and these three subjects from July 1, 2016 to July 1, 2022 were obtained using Twitter's official API [13]. There was a total of $n = 25,897$ posts (including original tweets and retweets) containing these terms during this time.

A. Data Collection

Data were collected by utilizing Twitter API v2. We utilized python-twitter-v2, an open-source python wrapper, for API calls. The interface of searching tweets allows us to search for historical tweets and refine our search criteria. The query keywords were set as VR and subject names. The interface of tweet counts allows us to retrieve the numerical count of tweets for a specific query. We set the granularity to 'day' and did statistics on a monthly basis. All tweets, including VR and subject name, within 72 months were counted (Please note: the counts will always be higher than the number of tweets searched from the search endpoints because the search endpoints need to go through additional compliance [14]).

B. Data Processing

To improve the accuracy of textual analysis, we did text preprocessing. All collected tweets were normalized through lemmatization [15], data anonymization, converted to lower case, and processed by deleting stop words [16] (e.g., words that are so commonly used that have little practical information, such as 'the', 'a', punctuation and special characters). Preprocessor, a preprocessing library for tweet data, was used in the process.

C. Data Analysis

This research analyzed VR-science-subjects' tweets on Twitter. The study did statistics on tweets about the application of VR in three science subjects (biology, chemistry and, physics) from 1 July 2016 to 1 July 2022, including 7,507 original tweets (OT) and 18,390 retweets (RT). Combined with the release of VR hardware devices and VR-education software products, we examine the reasons for the changing popularity of related posts on Twitter. We sorted the term frequency of related posts within six years from largest to smallest, removed common words and irrelevant words, and created word clouds of tweets about VR applications in these three subjects. Python pandas, numpy, matplotlib and wordcloud libraries were used for data analysis and visualization. Ethical approval had been obtained before data collection. All analyses were based on public, anonymized data, adhered to the developer policy, terms and conditions, and privacy policies of Twitter, and were performed under ethics approval from the authors' university and UK Data Protection Act.

III. RESULTS

During the 6-year data collection window, 7,507 OTs (29%) and 18,390 RTs (71%) were sent that included VR and one of these three science subjects, resulting in a data set of 25,897 total tweets.

A. Popularity of VR-Science on Twitter from 2016 to 2022

Regarding the popularity of virtual reality in science subjects on Twitter from July 2016 to July 2022, the application of VR in chemistry learning was the most discussed, with a total of 14,230 tweets, including 4,150 OTs and 10,080 RTs. The second is the application of VR in biology learning, with 2,196 OTs and 4,425 RTs, and the total traffic of VR-biology accounts for 26% of the total tweets. The number of tweets related to VR-physics-learning is 5,046, including 1,161 OTs and 3,885 RTs, and total traffic accounts for 19% of the total tweets.

B. Change of Popularity of VR-Science on Twitter from 2016 to 2022

From 1 July 2016 to 1 July 2022, there were 14,047,559 tweets containing the hashtag #VR, with an average monthly tweet volume of 195,105. The number of related tweets in June 2022 increased by 19.56% compared to July 2016. The number of related tweets from May 2017 to August 2019 showed an overall downward trend. The number of tweets fluctuated and increased from November 2020 to June 2022. In particular, between September 2021 and January 2022, the number of tweets containing the hashtag #VR exploded, from

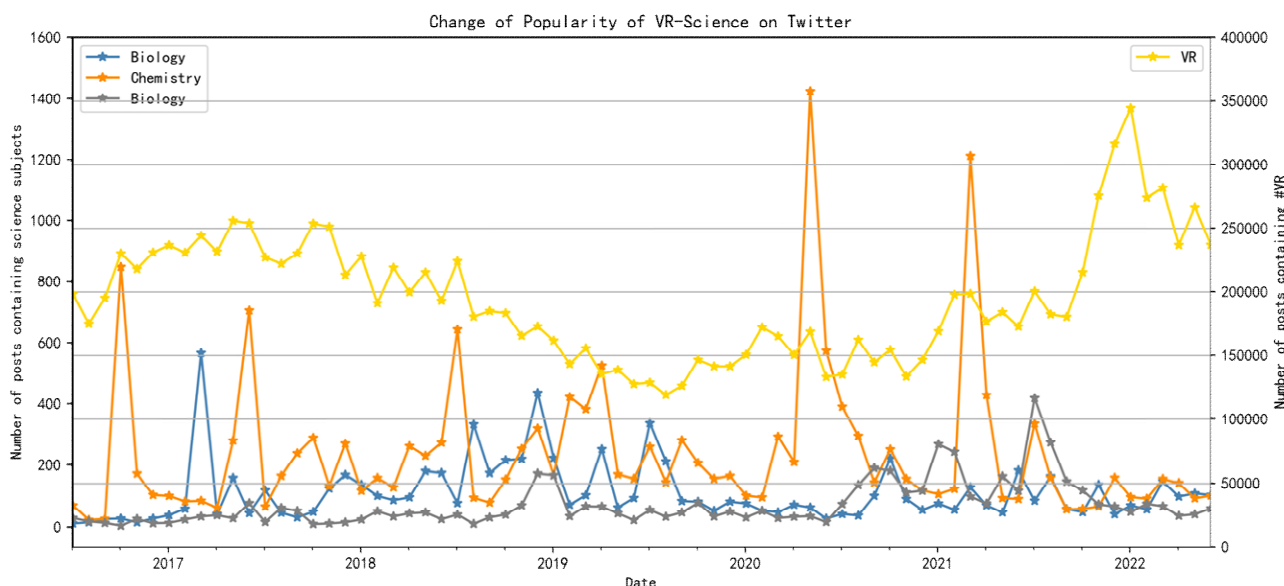


Fig. 2. Change of popularity of vr-science on Twitter

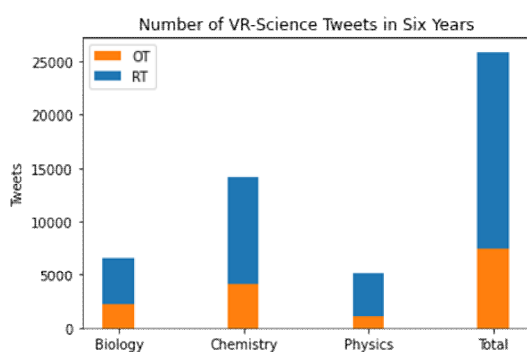


Fig. 3. Number of vr-science tweets in six years

180,294 tweets per month to 344,582 tweets per month. VR-Biology's average monthly number of tweets peaked in March 2017 ($n = 567$). The average monthly tweets from July 2016 to June 2022 was 112. VR-Chemistry's monthly tweet volume varied significantly. There were local peaks in October 2016 and June 2017 and a global peak in May 2020; the monthly tweets were $n = 849$, $n = 706$, and $n = 1424$, respectively. From 1 July 2016 to 1 July 2022, the average number of related tweets per month was 238. The number of VR-Physics related tweets per month did not change much, with an average of 73.

C. Launch Time of Several Popular VR Headsets

TABLE I. LAUNCH TIME OF SEVERAL POPULAR VR HEADSETS

Index	Headset Name	Release Date
1	Sony PlayStation VR	13 Oct. 2016
2	HTC Vive Pro	4 Apr. 2018
3	Oculus Quest 1	21 May 2019
4	Valve Index VR	28 Jun. 2019
5	Oculus Quest 2	13 Oct. 2020
6	HP Reverb G2	1 Nov. 2020
7	HTC Vive Pro 2	4 Jun. 2021

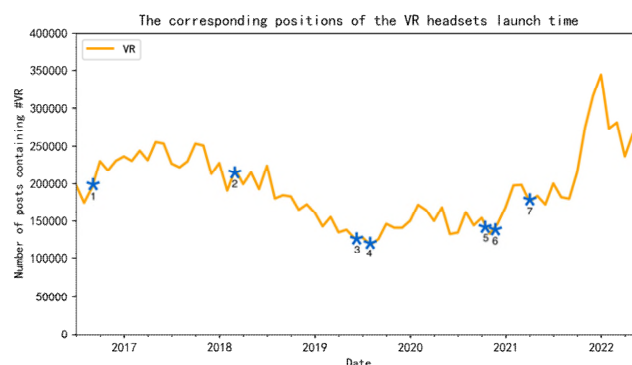


Fig. 4. The corresponding positions of the VR headsets' launch time

D. Release Time of VR-Chemistry Software by MEL Science

Since we observed a relatively large change in the popularity of VR-Chemistry tweets, we selected MEL Science, a well-known virtual reality teaching products company, that appeared frequently in VR-Chemistry tweets, and sorted out the release time of their products, trying to find some reasons for the change in popularity.

TABLE II. LAUNCH TIME OF SEVERAL VR-CHEMISTRY PRODUCTS BY MEL SCIENCE

Index	Events	Release Date
1	MEL Science launched MEL Code: new way to learn chemistry	26 Sep. 2016
2	MEL Science won Audience Award at SVOD	30 May 2017
3	MEL Chemistry VR lessons released	12 Jun. 2017
4	Mel Science launched VR chemistry lessons for kids on Google Daydream	16 Jun. 2017

Index	Events	Release Date
5	MEL Science mixed up VR chemistry lessons for UK schools	21 Jun. 2017

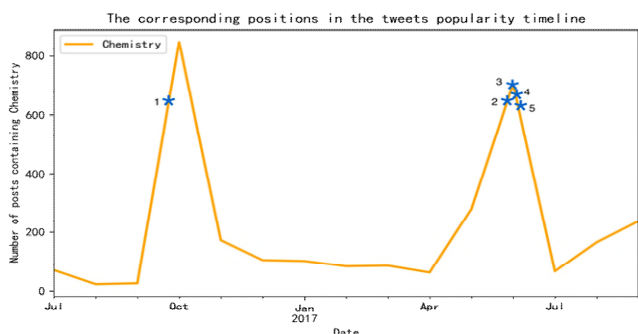


Fig. 5. The corresponding positions in the tweets popularity timeline

E. High-frequency words in VR-Science Related Tweets

We removed common stop-words from six years of tweets, selected 40-60 high-frequency words related to the topic for each subject, and drew them into three word-clouds. The higher frequency of occurrence, the more significant proportion of fonts in word-cloud. Learning, brain, science, education and, edtech appeared 185, 179, 149, 130 and 106 times in VR-Biology related tweets, respectively. MEL (573 times), molecules (412 times), twist (258 times), lab (180 times) and, models (176 times) are the five most frequently occurring words in VR-Chemistry tweets. In VR-Physics related tweets, the top five words with higher frequency are experience (48 times), science (23 times), interaction (22 times), simulation (21 times) and, fun (18 times).



Fig. 6. Word cloud of VR-Science tweets

IV. DISCUSSION

A. Findings

This research aims to explore the current popularity and public acceptance of VR applications in the teaching of three science subjects by observing VR-Science related posts on Twitter.

As can be seen from figure 3, from 2016 to 2022, VR-Chemistry was the most discussed on Twitter, and the number of tweets containing corresponding keywords reached 14,230,

accounting for 55% of VR-Science tweets, the OR to RT ratio is 41:59. This confirms the view of virtual reality's advantages in simulating dangerous environments to a certain extent, and immersive technology provides solutions for this type of teaching content [17]. It can be seen from figure 2 that the prevalence of VR-Chemistry had changed the most, with the number of posts reaching local peaks in September and October 2016, June 2017, May 2020, March and April 2021, respectively. From figure 5, we can observe that the launch of the VR-Chemistry software strongly correlates with the prevalence of VR-Chemistry content on Twitter. We noticed a global peak in May 2020, with 1,424 tweets related to VR-Chemistry. Therefore, we obtained the tweets during the period of May 2020, performed term frequency statistics, and drew the word cloud.

By looking at the tweets during this period, we found lots of tweets related to Covid-19. The role of virtual reality is more evident in the context of epidemics. From 1 July 2016 to 1 July 2022, the total number of tweets related to VR-Science was 30,465. Please note that the total number of tweets here is greater than the number of collected tweets due to the inclusion of unfiltered tweets. However, the total number of tweets containing the hashtag #VR is 14,047,559. The former only accounts for 0.22% of the total, reflecting the current lack of VR-Science software. The characteristics of virtual reality make it have great potential for teaching and learning VR-Science; therefore, this phenomenon is worthy of the attention of software developers and content creators.

Another interesting phenomenon is that after Facebook announced at the end of October 2021 that it would be renamed Meta [18], the number of VR-related tweets surged. In November 2021, December 2021, and January 2022, the numbers of tweets containing the hashtag #VR were 275,682, 316,317, and 344,582, respectively, much higher than the average ($n=195,105$).

This demonstrates that significant events related to virtual reality will greatly affect its discussion on social platforms. We retrieved the launch times of several popular VR headsets and mapped them to the timeline in Figure 2. We found that the launch of virtual reality hardware devices also affects the discussion of virtual reality on social media to a certain extent. Besides, the more popular VR headsets are, the greater impact on the discussion. For example, 4, 5, and 7 in Table II correspond to Valve Index VR, Oculus Quest2, and HTC Vive Pro 2, respectively. We selected chemistry, which had the most considerable change in the degree of discussion in these three subjects, as our research object, and found that launching educational software products also greatly affected the degree of discussion on social platforms. For example, we fitted the timing of MEL Science's Chemistry learning product launch to the number of VR-Chemistry tweets and found a strong correlation between them. The release of software products will increase the discussion of related subjects on social platforms.

In terms of observing public attitudes towards virtual reality applications in science, we organized the term frequency of related tweets from 2016 to 2022. High frequency words related to emotions are "awesome", "exciting", "impressive", "fun", "amazing", etc. and related to experience are "immersive", "adventure", "innovative", "engaging", "creating", etc. This shows that the public has positive attitudes toward virtual reality applications in science on Twitter and, to a certain extent, reflects the public's

optimism and openness to VR applications in teaching and learning.

B. Limits of the Current Research

a) Tweets that do not have corresponding keywords but are related to VR-Science were not covered. For example, tweets describing virtual reality applications in science without mentioning the keywords or tweets are in video format. However, because the retrieval and statistical methods of these three subjects were the same, our statistics still have reference value.

b) Commercial and non-commercial tweets were not counted separately. Although we filtered out spam and advertising content, we still could not distinguish which were the promotion information of VR-Science product companies. In subsequent studies, we can judge whether a tweet is an indirect commercial promotion by observing the homepage information and interactions with others of the user who tweeted, to differentiate between a commercial and non-commercial tweet.

C. Implications for developers and content creators

The release of VR-Science software is positively correlated with user attention on Twitter. Therefore, software developers and content creators can learn about users' attention to software products and content by observing user discussions on social platforms such as Twitter to grasp market trends faster and better meet user needs. At the same time, VR-Science teaching and learning products enjoy high public acceptance, and the relevant software and content are relatively inefficient. Therefore, the market expansion potential of VR-Science teaching products will be enormous.

D. The applicability of the research results

By analyzing the volume of tweets on Twitter, it can be observed that VR topics, which have previously declined in discussion, are gaining attention again since the outbreak of COVID-19. With the arrival of the post-pandemic era, how this trend will change can still be concluded by observing the discussion on Twitter. The research found that VR-Chemistry has received the highest attention in all science discipline, which to a certain extent indicates that VR applications in chemistry have higher commercial viability, helping virtual reality education companies and researchers to better understand the market and user needs. Besides, this research model can be used for more specific user attention and experience analysis on Twitter in the future, such as analyzing the user attitude of a specific VR software product.

V. CONCLUSIONS

This study analyzed the popularity, discussion trend, and public attitudes of VR-Science on Twitter. It found that the application of virtual reality in chemistry was the most discussed among these three science subjects. At the same time, the number of tweets related to VR-Chemistry had the most significant change over time. By analyzing the trend of changes in the number of tweets, we also found that the changes in the number of tweets were positively correlated with the launch of hardware and software products. The research also counted the high-frequency words that appeared in related tweets from 1 July 2016 to 1 July 2022 and discovered that the public has high acceptance and good experience of virtual reality applied to science subjects, which can provide ideas for software developers and VR content creators. However, the problems existing in the application of

VR in teaching, such as training, cost and input hardware usability[9], still need to be further solved.

Following this, future work will focus on helping virtual reality education companies and content creators better improve user experience by analyzing user feedback about teaching and training difficulties on specific VR educational software products on Twitter.

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