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Exploring the Digital Landscape of STEAM Learning Discourse: Insights from GPT-4 based Twitter Data Analysis

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Abstract

Twitter, now known as X, is a leading social networking and microblogging platform that serves as a prolific data repository, capturing conversations on various topics through its extensive collection of user tweets. This diverse dataset provides new perspectives and valuable information about science, technology, engineering, arts, and mathematics (STEAM) education across various educational levels. However, the high complexity, unstructured format, and large volume of this data often pose significant challenges for researchers seeking to extract meaningful insights using qualitative or quantitative approaches.

To address these challenges, we leverage the Generative Pre-trained Transformer 4 (GPT-4), an advanced multimodal large language model (LLM), to analyze tweet data. GPT-4's advanced natural language processing capabilities allow it to understand and interpret the nuances of human language, including slang, abbreviations, and context-specific language often found in tweets. GPT-4's ability to infer meaning from limited text makes it ideal for analyzing such concise and sometimes cryptic messages. Additionally, GPT-4 can perform semantic analysis, identifying themes, topics, and sentiments within tweets. Finally, GPT-4 has been trained on a diverse large text corpus, which includes content from various cultures, enabling it to understand and analyze tweets from a wide range of global users, which is critical given Twitter's international user base.

Overall, this research provides two contributions: (i) a view of the new perspectives and topics related to STEAM education and (ii) a novel approach to education-related tweet data analysis using GPT-4. The data analysis findings provide pedagogical guidance to STEAM education researchers, faculty members, administrators, and policymakers on the latest trends and main topics related to STEAM education. The generated tweet dataset can also support linguists and computer scientists working in the areas of artificial intelligence and large language models.

Keywords: *Chatbot, GPT-4, Twitter Analysis, STEAM Education, Social Media Network*

1. Introduction

1.1 Motivation and Background

Globally, each day witnesses the dispatch of millions of tweets, encapsulating vast quantities of information across diverse subjects. Among this digital chatter, a significant portion pertains to the domain of (Science, Technology, Engineering, Arts, and Mathematics) STEAM education. Originating from various sources such as students, academic institutions, governmental bodies, and policymakers, these tweets encompass a broad spectrum of content. This includes updates on daily occurrences, pivotal announcements, educational materials, discussions on pertinent topics, geographical data, and more. Furthermore, these tweets facilitate user interaction through retweets, comments, and likes, weaving a tapestry of communicative exchanges that can unearth patterns or themes worthy of exploration. Recognizing the potential of this rich repository, preserved by X, previously known as Twitter, as a treasure trove for scholarly inquiry in STEAM education, we embarked on our analysis to mine tweets related to this field using GPT-4. Our endeavor not only involved a thorough analysis of the collected data but also extended to making the datasets accessible to the academic community, thereby enabling further scholarly investigation.

1.2 Contributions

This study offers two key advancements: first, it reveals insights and themes within STEAM education, enriching the academic discourse with novel perspectives. Secondly, it introduces an innovative methodology for analyzing educational tweets, leveraging the capabilities of GPT-4, thereby setting a new precedent in data examination within the educational sector. The outcomes of this analysis serve

as a valuable resource for a broad spectrum of stakeholders in STEAM education, including researchers, educators, administrative personnel, and policymakers, offering them strategic guidance on prevailing trends and core subjects within this field. Additionally, the curated dataset of tweets emerges as a significant asset for linguistics and computer science professionals, particularly those specializing in artificial intelligence and advanced language models, facilitating further exploration and development in these cutting-edge areas.

2. Related work

Scholars across various disciplines have tapped into Twitter as a valuable resource to shed light on their respective fields, ranging from marketing [1] and healthcare [2][3] to activism [4], education [5], cybersecurity [6], sports [7], and responses to natural disasters [8]. This approach has been adopted in the engineering education sector as well. For instance, one study [9] leveraged Twitter to monitor engagement and discussions surrounding a campaign to foster interest in STEM education among the general populace. Another research [10] utilized the platform to enhance students' design thinking capabilities, enabling them to articulate their ideas with increased clarity and emotional depth.

The complexity, unstructured format, and large volume of tweets often pose significant challenges for researchers seeking to extract meaningful insights [11]. Social media content's short and text-heavy nature makes collecting and analyzing data difficult [12]. Additionally, the ambiguity and complexity of natural language content further complicate the processing and retrieval of useful information [13]. However, recent advancements in topic modeling techniques, such as latent Dirichlet allocation (LDA), non-negative matrix factorization (NMF), Top2Vec, and BERTopic, have shown promise in analyzing Twitter data [14]. These approaches, along with transformer-based sequence modeling, have demonstrated improved performance in understanding and classifying topics in tweets. Overall, these studies highlight the need for robust and efficient methods to overcome the challenges posed by the complexity, unstructured format, and large volume of tweets to extract meaningful insights.

In this paper, we utilize GPT-4 to analyze collected tweets. Related works have shown that GPT-4 can perform semantic analysis and identify themes, topics, and sentiments within tweets. It has been found that GPT-4 performs well in detecting psychological constructs such as sentiment, discrete emotions, and offensiveness in various languages, achieving high accuracy across many languages without the need for training data [15][16]. Additionally, GPT-4 has been shown to perform on par with well-trained law student annotators in analyzing court opinions to interpret legal concepts, making it a valuable tool for tasks requiring specialized domain expertise [17][18]. Additional findings show that GPT-4 achieves higher accuracy, reliability, and equal or lower bias than human classifiers in annotating political tweets, suggesting its potential impact in enabling interpretive research at scale in the social sciences [19]. Furthermore, related works show that Chatbots utilizing GPT-4 can improve cybersecurity awareness in the workplace by providing information security training and enhancing security awareness among employees [20].

3. Methodology

The study employed a thematic analysis approach, utilizing the advanced capabilities of GPT-4 to analyze the collection of tweets related to various subjects. The initial step involved gathering tweets through the Twitter API, ensuring a rich and diverse dataset pertinent to our areas of interest. After the collection, the research team reviewed the tweets to ascertain their relevance to the designated subjects, resulting in a curated dataset specific to each subject under investigation. Each dataset is stored in a separate CSV file containing each tweet’s content, timestamp, number of likes, replies, retweets, and user information.

Upon establishing the relevant datasets, we engaged GPT-4 as a linguistic and computational tool to facilitate the thematic analysis. This process, described in Fig. 1, was initiated by providing GPT-4 with a structured prompt, instructing it to function as a qualitative researcher tasked with analyzing the content within the uploaded CSV files. We specifically indicated that the tweet content was housed under these files' "text" column, guiding GPT-4's focus toward the primary data of interest.

GPT-4's analysis commenced with generating initial codes derived from the tweet content. This coding phase was crucial for breaking down the data into manageable segments that reflected key concepts and ideas present within the tweets. Following the coding process, we reviewed the generated initial codes for relativeness and correctness, and we directed GPT-4 to sift through the coded data to identify overarching themes and delve into each theme to uncover sub-themes, thereby providing a layered understanding of the data.

Finally, for each identified theme and sub-theme, GPT-4 was tasked with conducting a detailed analysis to elucidate the nuances and complexities within the data. This involved presenting sample

tweets that exemplified the assigned codes, offering tangible insights into how the thematic framework was applied to the tweet content. Through this iterative process, GPT-4 facilitated a comprehensive thematic exploration of the tweet datasets, enabling the research team to uncover and interpret the prevailing patterns, themes, and sub-themes that emerged from the data.

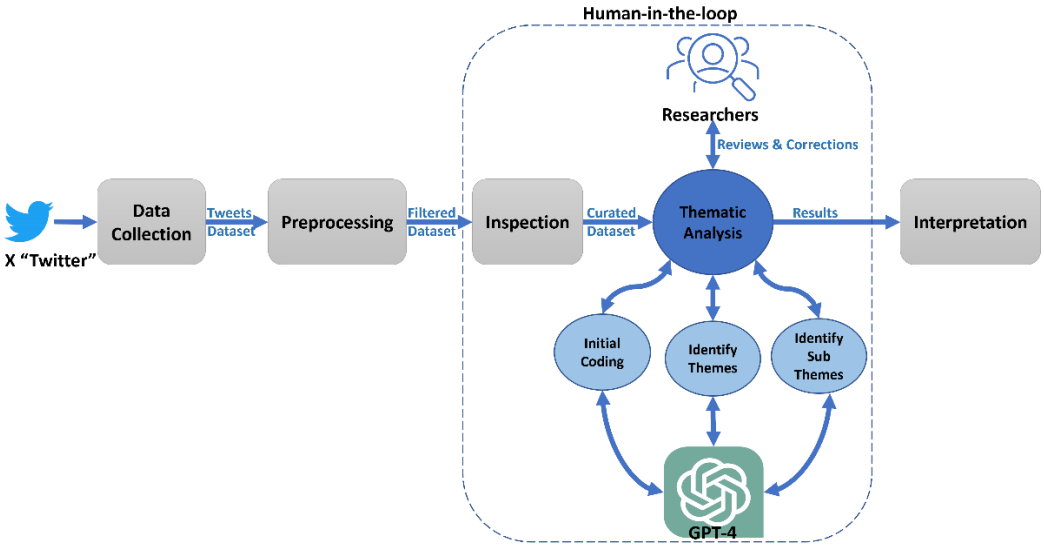

Fig. 1. The main steps of the research methodology.

The methodology implements the human-in-the-loop (HITL) approach during the inspection stage of the collected tweets and the reviews and corrections of the GPT-4 results. In HITL-based systems, human judgment is integrated into the workflow to enhance and supervise the automated processes. The HITL approach leverages the strengths of both GPT-4 data analysis for efficiency and scale and human cognitive abilities for nuanced judgment and quality control, leading to more reliable and relevant results.

4. Results and Findings

4.1 Search by Subject

The search for tweets featured specific hashtags listed in Table 1. The data gathering yielded datasets of 22,337 tweets. The primary objective of this search was to find tweets pertinent to a wide range of STEAM topics. However, this process may inadvertently capture tweets that do not align with the search criteria, known as false positives. To maintain the integrity of the study, these tweets are meticulously reviewed and filtered out to ensure the dataset's relevance and accuracy.

Table 1. The Collected Tweets' Distribution by subject/hashtag.

Subject	Number of Tweets	Hashtag
Arts Education	1002	#ArtsEd
Computer Science	1225	#CompSci
Engineering	563	#EngChat
Language	4070	#LangChat
Literacy	2414	#Literacy
Physical Education	5765	#PhysEd
Science	1558	#SciChat
Social Science	5740	#SSchat

Using GPT-4, the thematic analysis of the Language dataset, comprising tweets containing the hashtag #LangChat, revealed rich discussions centered around integrating technology in language learning, professional development, and community engagement within the educational sector. Key themes included the diverse use of digital platforms like Anki, Quizlet, and Kahoot for interactive learning activities, highlighting the significant role of technology in enhancing language education.

Professional networking emerged as a central theme, with tweets emphasizing the value of conferences and professional learning networks in fostering knowledge exchange and continuing education. Advocacy and leadership within language education were underscored, reflecting a commitment to advancing the field and supporting educational programs.

The analysis of the Computer Science-related tweets revealed a strong emphasis on Technological Advancements, highlighting discussions on AI, machine learning, and new tech developments. STEM Education Importance was the second most prevalent theme, underscoring the significance of computer science in educational contexts, teaching methodologies, and learning experiences. Educational Achievements was the third discussed topic, showcasing individual projects and the application of specific technologies like NumPy and Python. While Resources and Events had 140 mentions, pointing to sharing educational platforms, conferences, and resources, the Personal Experiences and Humor theme appeared in some tweets. This computer science data analysis highlights the diverse yet focused interests of the computer science Twitter community, ranging from technological innovations to educational practices and personal growth within the field.

For the Literacy-related tweets, GPT-4 revealed a strong emphasis on "Reading Practices and Engagement," which is the most prominent theme with occurrences in most tweets. The "Educational Contexts of Literacy" theme, evident in 511 tweets, underscored discussions around integrating technology, digital literacy, and educator strategies within literacy education. Comparatively less prevalent but still significant, the "Literacy Promotion and Advocacy" theme appeared in 239 tweets, reflecting efforts in advocacy, support for literacy initiatives, and the importance of charitable contributions to literacy.

The Twitter dataset on arts education revealed a multifaceted discourse centered around several key themes: Art Appreciation and Education, Educational Resources and Activities, and Research, Policy, and Advocacy. Art Appreciation and Education emerged as a prominent theme, with tweets highlighting individual artists, artworks, and their historical and cultural significance to foster a deeper understanding and appreciation of the arts. Educational Resources and Activities were also highly represented, focusing on practical resources, teaching strategies, and creative projects to enhance arts education. Research, Policy, and Advocacy themes highlighted the importance of supporting arts education through research findings, policy discussions, and funding opportunities.

Analyzing tweets on physical education revealed that the most dominant theme was "Educational Activities," with 1655 tweets emphasizing the diversity of physical activities, sports, and educational games. Following this, "Engagement and Innovation" and "Health and Well-being" themes were prominent, indicating a strong emphasis on engaging students with innovative teaching methods and promoting health and active lifestyles. "Professional Development" emerged in 441 tweets, highlighting the value placed on educators' growth and knowledge sharing. In comparison, "Resources and Tools" were discussed in 220 tweets, pointing to the use of various educational resources and tools. The "Inclusivity and Accessibility" theme, though less prevalent, underscored the importance of making physical education accessible and inclusive for all students, reflecting a commitment to inclusivity within the field.

The thematic analysis of the science tweet dataset revealed encompasses themes such as "Technology and Innovation," "Education and Outreach," "Historical Notes," "Astronomy and Space," "Environmental Insights," "Scientific Research," and "Wildlife." Sub-themes identified within these broader categories highlighted specific areas of interest, including advancements in portable technologies, the use of educational tech, celebrating notable figures and scientific milestones, and exploring space missions. Furthermore, the analysis underscored a strong focus on environmental concerns, conservation efforts, and the implications of climate change. The dataset also reflected a keen interest in wildlife conservation, genetic research, and ecological studies, showcasing science-related conversations' wide-ranging and multi-faceted nature.

4.2 Search by Education Level

In this part of the study, we used GPT-4, a thematic analysis of tweets related to higher education, high school, and middle school. The analysis revealed distinct priorities, concerns, and discussions pertinent to each education level. In higher education, the emphasis shifts significantly toward Career and Professional Development, highlighting the importance of job readiness, interviews, and career planning. The theme of Educational Trends and Insights suggests a broader discussion about the state and future of higher education, capturing dialogues on student experiences, pedagogical approaches, and institutional challenges. The role of Technology and Privacy in Education points to the increasing integration of digital tools in learning and the accompanying concerns regarding data privacy.

High school discussions revolve around more immediate and personal aspects of the educational experience. Themes like Educational Opportunities and Achievements focus on recognizing academic and extracurricular accomplishments, which are essential for college admissions and personal development. Athletic and Extracurricular Activities underscore the importance of sports and hobbies for holistic development and community engagement. Career and College Readiness theme reflects a preparatory stage for future educational and career paths, emphasizing the significance of planning and resources like FAFSA.

For middle school, the themes tend toward foundational aspects of education and early adolescent experiences. The General Education and School Life theme captures the day-to-day realities of middle school, focusing on the roles of students and teachers in the educational process. Libraries and Librarians and Teacher Identity and Merchandise suggest focusing on the resources and identities within the school community, including the impact of social media and teacher-specific merchandise. Specific School Programs highlight discussions about unique educational initiatives and experiences at this level, often centered around exploration and discovery.

Table 2 provides a concise overview of the focal points or themes within discussions about higher education, high school, and middle school on Twitter, reflecting the unique aspects and concerns at each education level.

Table 2. The Collected Tweets' Distribution by Education Level.

Education Level	Main Themes	Number of Tweets	Hashtag
Higher Education	Career and Professional Development, Educational Trends and Insights, Technology and Privacy in Education, Academic Research and Policy, Security and Financial Aid	710	#HigherEd
High School	Educational Opportunities and Achievements, Athletic and Extracurricular Activities, Career and College Readiness, Personal Milestones and Celebrations, Support and Community, Technology and Online Engagement, Social and Political Issues	602	#HighSchool
Middle School	General Education and School Life, Libraries and Librarians, Teacher Identity and Merchandise, Specific School Programs, College and Sports	4106	#MiddleSchool

5. Conclusion and Future Work

In this study, we utilized GPT-4 to analyze Twitter discussions related to STEAM education in various subjects and at different education levels, revealing key themes such as technology integration in language learning, the significance of technological advancements in computer science, the importance of reading practices in literacy, and the role of art appreciation and physical activities in education. The human-in-the-loop approach integrated the analytical strengths of GPT-4 with human cognitive abilities for more reliable and relevant results. These insights underscore the evolving nature of STEAM education, heavily influenced by digital innovation and online communities. We will explore other social networking platforms like LinkedIn or Reddit for future work. Additionally, we will use the growing capabilities of GPT-4 with the multimodal nature of Twitter to incorporate an analysis of visual content such as infographics, videos, and images.

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