The shifting classroom: impact of heightened seasonal heat in education through sentiment and topic modeling

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Article Info

ABSTRACT

This research applies text mining techniques to examine sentiments and themes among Filipino students adjusting to full in-person classes after pandemic-driven flexible learning, focusing on their experiences during April to June 2023–a period usually marked by vacations due to intense heat. By applying the natural language toolkit (NLTK) for sentiment analysis and Scikit-learn for topic modeling, the study gathered data from Filipino students on their in-person class experiences during this unique calendar shift. Post data cleaning, NLTK was used for sentiment analysis and latent Dirichlet allocation for topic modeling. The findings indicate that the high temperatures adversely affected students, as evidenced by frequent references to terms such as "room," "focus," and "hard." The study identified a mix of positive and negative sentiments and highlighted key issues like academic challenges and the learning environment's impact. This study also offered insights into students' coping strategies during extreme heat. These results stressed the importance of considering environmental factors in educational planning and provide actionable insights for institutions to enhance the in-person learning experience, particularly in challenging weather conditions. Moreover, this study demonstrates the effectiveness of sentiment analysis and topic modeling in understanding and unraveling student experiences in specific contexts.

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1. INTRODUCTION

As the global climate continues to evolve, its pervasive impact is felt across diverse sectors, particularly in education [1]–[3]. The rising temperatures and heightened heatwaves pose distinctive challenges, necessitating the creation of robust educational environments capable of withstanding such climatic extremes [4]. This study delves into the realm of education under the stress of escalating temperatures, a critical issue brought to the forefront by several recent researches [4], [5]. The increased frequency and severity of heatwaves disrupt not just routines but also strain the capacities of educational systems to provide effective learning spaces [6], [7]. In this context, our research aims to dissect the intricate interplay between climatic conditions, student emotional well-being, and educational outcomes, a necessity underscored by previous studies [1], [8].

In response to these emerging climate-related challenges, the adaptation of educational institutions is of importance [9]–[12]. This study transcends mere observation of the direct effects of heightened summer conditions on student experiences by harnessing the power of advanced analytical techniques. By utilizing sentiment analysis and topic modeling, this study seeks to explore and offer fresh insights into the complex student sentiments and experiences amid these challenging climatic conditions. This research brings to the forefront several innovative aspects. This study zeroes in on the Philippines, a region with distinct climatic challenges, thus contributing new insights into the impact of high temperatures on student experiences in this specific geographic context. Additionally, the study navigates the uncharted waters of the educational landscape in the post-pandemic era, examining the shift from blended to fully in-person learning–a critical and yet under-explored domain in current educational research. Methodologically, the incorporation of sentiment analysis and topic modeling represents a fresh approach to educational research, especially in the context of climate change [13]. This research also contributes to the understanding of adaptation and resilience strategies within educational settings, a pressing need in the face of global climate change.

Moreover, by bridging the gap between climate science and educational research, this study offers an understanding of how environmental factors directly impact educational processes and outcomes. This interdisciplinary approach is relatively nascent and paves the way for further research in this field [13], [14]. The timeliness and relevance of the study are further enhanced by its focus on data analysis from dry season in the country, ensuring that the findings are immediately applicable to current educational policy and practice [13]. Furthermore, this study explores the subtleties of conducting in-person classes in the Philippines during the intense heat period between April and June, a critical issue in the context of students transitioning from blended to fully in-person learning in the post-pandemic era. This shift, coupled with the challenges posed by the climate, necessitates a deep dive into student perspectives. The study addresses the gap in understanding the interplay between climate change and education, focusing specifically on the impact of heightened heat on learning environments and student experiences. Through sentiment analysis and topic modeling, this study aims to capture the nuanced experiences of Filipino students during this intense summer period, providing pivotal insights for the formulation of adaptive educational strategies. This research stands as an inquiry into student attitudes towards in-person classes in extreme heat conditions and their first encounter with regular instruction post-pandemic. Guided by key research questions, this study endeavors to uncover the predominant words used by students to describe their experiences, the prevailing sentiments expressed, and the thematic patterns that emerge from their responses.

2. LITERATURE REVIEW

Sentiment analysis and topic modeling are essential techniques in educational research, enabling the exploration of sentiments and themes in both structured and unstructured texts [15]–[25]. Within sentiment analysis, practical relevance is clear, as highlighted by Avvaru and Vobilisetty [26], who emphasized its growing importance in natural language processing (NLP), covering sentiment prediction and categorization [27]. This relevance is demonstrated in studies like Bringula *et al.* [16] which used sentiment analysis to evaluate student expectations of data science courses, revealing positive outlooks. Similarly, Crisostomo and Miranda [28] found optimism among students regarding online teaching during virtual practicums. Even during the pandemic, sentiment analysis depicted a positive attitude toward online learning [15], [23], although another studies [29], [30] found differing negative sentiments on Twitter about the pandemic and online learning. Moreover, sentiment analysis extends to online education attitudes [31] and draws insights from student reviews in MOOCs [30]. Additional studies employing sentiment analysis include Garcia and Cunanan-Yabut [32], who analyzed public Twitter data on the Russian invasion of Ukraine, revealing prevailing negative sentiments and sadness. Garcia [33], on the other hand, analyzed Twitter to gauge public sentiment on the COVID-19 pandemic across different Philippine timelines.

In contrast, topic modeling finds relevance across various aspects of education research. Research by Botha *et al.* [34] demonstrated this by analyzing themes in South African higher education research. Similarly, Wang *et al.* [35] employed probabilistic topic modeling to uncover latent thematic structures within the research literature. Maphosa *et al.* [36] used topic modeling to explore student preferences in STEM fields, while Kim and Im [37] visualized the evolution of virtual reality-based educational research. Bringula [38] utilized topic modeling to explore publications related to ChatGPT. Chen *et al.* [39] expanded topic modeling to educational technologies, identifying key contributors and prevalent topics for future research. Tsumagari *et al.* [40] applied it to understand first-year students' learning experiences, and research by Gülzau [41] mapped paradigm shifts in German family policy.

Within research review, topic modeling plays a significant role. Shen and Ho [42] merged bibliometric analysis with topic modeling to identify vital subgroup topics in technology-enhanced learning. This aligns with Ozyurt and Ayaz [43], who extensively reviewed an education journal using both analyses to

pinpoint important topics. Ekin *et al.* [44] employed topic modeling to navigate 55 years of work, revealing the evolution of game-based education. Similarly, Paek *et al.* [45] used topic modeling to uncover research trends in competency-based education, revealing essential topics related to competency development approaches. Miranda and Bringula [46] employed topic modeling to identify themes in Philippine presidential addresses, highlighting a focus on economic development, public service enhancement, and addressing challenges.

3. RESEARCH METHOD
3.1. Study design and data collection

The study adopted a descriptive cross-sectional qualitative design, utilizing a single, carefully developed and validated survey question. The survey was conducted across seven campuses of a public university in Central Luzon, Philippines, resulting in a total of 653 responses. These responses comprised 5,883 words and 124,054 characters. Data collection occurred from April to early June 2023, aligning with the warm, dry season in the Philippines. The sample size in this study was considered adequate for qualitative analysis, offering a detailed analysis and view of students' experience [16]. The adequacy of this sample size aligns with the guidelines proposed by previous researchers [47], [48] in their study on choosing a suitable qualitative research sample size [49].

Regarding the validity and reliability of the survey instrument, the single survey question was developed in collaboration with an English professor specializing in survey design. This collaboration ensured the question's relevance, clarity, and ability to elicit detailed and pertinent responses [50]. The question underwent a rigorous validation process, including a pilot test with a small group of students to assess comprehension and response consistency [51]. Feedback from this pilot test was used to refine the question, further enhancing its validity and reliability. The consistent and relevant responses received during the actual survey emphasized the effectiveness of this validation process [52], [53]. This approach aligns with the best practices in survey instrument design for qualitative research [54].

3.2. Data preprocessing and analysis

Topic modeling is an automated technique within NLP, designed to uncover latent and abstract themes in extensive textual datasets [16], [46], [55]–[61]. This approach employs probabilities to assign likelihoods to distinct topics extracted from documents, facilitating a clear comprehension of the document's core message [55], [58]–[62]. In essence, when utilized to explore responses regarding the feasibility and experiences of attending in-person classes during hot summers, thematic analysis may assist researchers in accurately identifying pivotal concepts. These recognized concepts may subsequently form the basis for proposing actionable insights derived from the research findings [59], [60], [63].

In this study, all necessary preprocessing techniques were explicitly applied [19], [64]–[69]. This encompassed procedures like the removal of stop words, conversion to lowercase, and lemmatization, among others [16], [32], [33], [46], [70], [71]. This process established the corpus for this study. The preprocessing and topic modeling procedures were executed using well-established Python tools, including the Scikit-learn and natural language toolkit (NLTK) libraries [72], [73]. NLTK was instrumental in preprocessing tasks before topic modeling, while Scikit-learn was employed for functions encompassing feature extraction, vectorization, decomposition, visualization, and the application of the latent Dirichlet allocation (LDA) method. The *CountVectorizer* technique was employed to create the document matrix, with specific parameters (max_df=0.85, max_features=1000) fine-tuned for optimal results. Subsequently, the preprocessed texts underwent the fit_transform process using the configured *CountVectorizer*, transforming the textual data into a structured numerical matrix for further analysis. This comprehensive approach helped in the identification of three distinct themes within the corpus. Additionally, sentiment analysis was utilized to gauge respondents' attitudes as reflected in their responses. Specifically, the *Bing* lexicon corpus was utilized to categorize the words (i.e., positive and negative) used in the corpus [15], [74].

4. RESULTS AND DISCUSSION
4.1. Overview of the corpus and the most common words

The top five words in this study are "room," followed by "focus," "classes," "feel," and "hard," with "room" appearing 218 times, as seen in Figure 1. One possible explanation for these results is the context of the educational setting during hot weather conditions. The frequent use of the word "room" emphasizes the significant impact of high temperatures on classrooms. This word often indicates that respondents consistently highlight the conditions inside classrooms and how these conditions negatively affect their learning experiences. Statements like "the heat is sometimes unbearable inside the classroom" and "the heat in the room makes it difficult to pay attention or participate in discussions" reflect this trend. The word "focus" is

directly linked to the challenges students face in maintaining their concentration and attention in hot weather. This aligns with the common theme of discussing classroom situations. Research also supports this idea, as hotter temperatures can make it harder for students to concentrate on their studies. Statements like "sometimes people are more focused on dealing with the heat inside the classrooms than on the actual lectures or lessons" and "the high temperatures make it tough to focus and concentrate, and it's a struggle to stay motivated to attend classes when it's so hot outside" support this observation. The word "classes" is the third frequently used word that highlights the overall impact of hot temperatures on the educational process. This is backed by responses discussing the challenges of attending in-person classes during hot weather. One respondent noted, "attending in-person classes during the summer heat has been a challenging experience for me."

The word "feel" reflects the emotions and sensations conveyed by respondents in relation to the hot weather. These sentiments are expressed in their reactions, including frustration, discomfort, exhaustion, and worsened health issues due to classes being held in hot conditions. Statements like "the heat is too draining and makes students feel tired or fatigued faster than usual" and "I felt dizzy because of the extreme heat" illustrate this sentiment. The word "hard" reflects two scenarios in the study. In particular, it highlights the difficulty students face in managing both hot weather and their educational responsibilities. Furthermore, it encompasses various challenges arising from attending classes in such weather conditions. An example statement reads, "It's hard to concentrate during discussions because of the extreme heat." In addition to the previously mentioned words, other words like "students," "electric," and "fan" also emerge, providing a possible explanation how hot weather potentially shapes the experiences and challenges encountered by Filipino students in their educational journey.
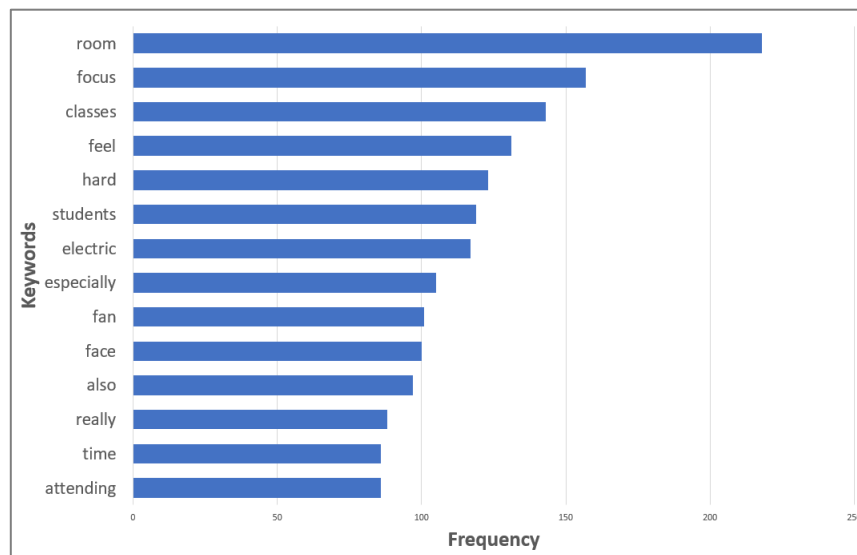

Figure 1. Most common words found in the corpus

4.2. Sentiment analysis results

Figure 2 presents the result of the sentiment analysis conducted in this study. The findings reveal that out of the total responses, 253 were categorized as positive, while 233 were deemed negative. The most frequently occurring positive word is "like," whereas the leading negative word is "hard." The positive words shed light on the respondents' positive sentiments despite the challenges posed by the hot weather on attending in-person classes. This suggests that despite the difficulties, there is a sense of enjoyment and satisfaction in being present for these classes. Moreover, these positive words indicate the opportunities for the school to further enhance the learning experience even amidst the hurdles of elevated temperatures.

On the other hand, the negative words offer insight into the broader impact of hot weather on the respondents. These negative words underscore the considerable effect of high temperatures on their overall well-being and the learning process [4], [75]. Additionally, these words highlight the difficulties they face in attending classes under such circumstances, emphasizing the substantial challenges presented by the hot weather conditions [75], [76]. In general, the positive words reflect resilience and a desire for improvement within the existing conditions, while negative words expose the substantial hurdles posed by the hot weather, affecting both the learning experience and the well-being of the respondents.
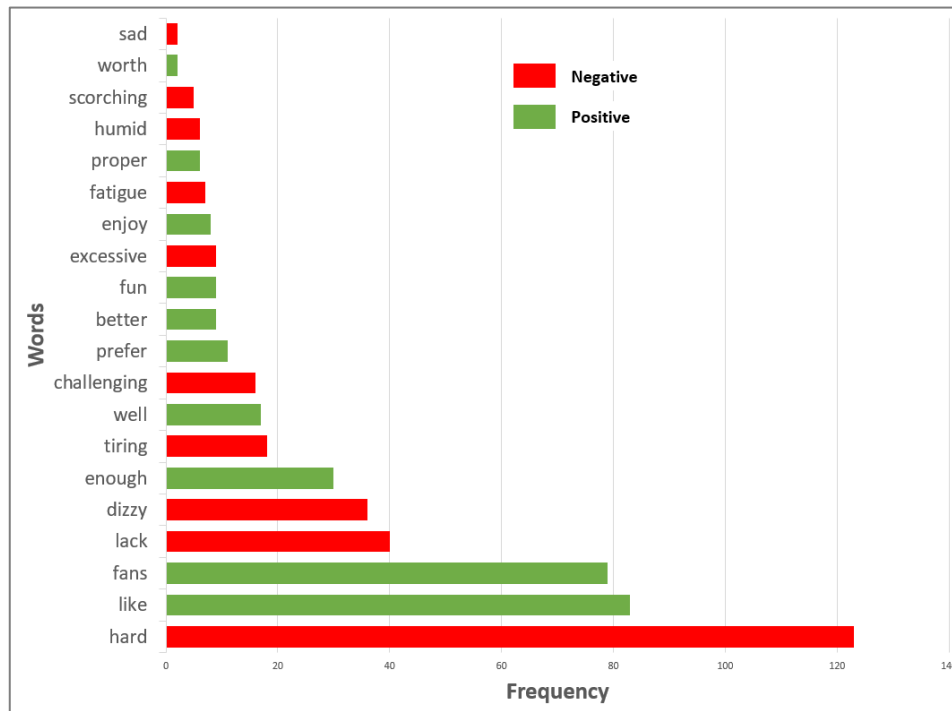
Figure 2. Categorization of sentiment using *Bing* lexicon

4.3. Topic modeling results

The study identified three key themes. The first theme explored into the academic challenges students faced in high-temperature environments, highlighting the impact of heat on their ability to concentrate and learn effectively in academic settings. The second theme explored the broader consequences of elevated temperatures on the learning environment, encompassing both the physical discomfort and the cognitive effects on students. The third theme, on the other hand, proposed potential solutions and coping strategies that students had found effective in mitigating the challenges posed by the hot weather, thereby enabling them to maintain their academic performance and well-being.

4.3.1. Academic challenges during hot weather

The first theme illustrates the challenges that respondents encounter due to elevated temperatures, particularly in the context of transitioning between indoor spaces. This theme accentuates how the collected data reflects the emotional experiences of respondents, especially when engaged in academic endeavors such as exams or activities that coincide with hot weather and necessitate moving between rooms. For instance, the heat not only exacerbates the discomfort of transitioning between rooms but also significantly obstructs effective studying. Respondents often find themselves having to venture outside, exposing them to the scorching sun, as they move to another room after a class. This outdoor exposure intensifies the heat's impact, making the experience even more uncomfortable. Particularly pronounced for individuals navigating their menstrual cycle, coping with allergies, or managing asthma, the hot weather amplifies feelings of irritability. This finding is partially supported by Kutywayo *et al.* [77], where indicated that academic challenges due to hot weather are affecting students disproportionately with females having the most frequent related symptoms. Other studies also indicated that tailoring educational strategies and approaches (i.e., curriculum) to the context-specific challenges of an institution is needed to ensure a sustainable and enhanced learning environment [9], [78], [79].

Furthermore, this theme sheds light on the emergence of health issues such as dizziness, headaches, diminished concentration, and a sensation of suffocation. These consistently present themselves as formidable obstacles that hinder the respondents' learning process. Moreover, respondents convey that attending classes during such sweltering conditions not only induces stress and adds inconvenience but also leads to a considerable level of distraction due to the discomfort they endure during transitions. This observation is supported by the words in this theme such as "also," "classroom," "feel," "school," and "especially," underscoring the widespread nature of these challenges in the academic setting during hot weather conditions.

4.3.2. Impact of high temperatures in learning environment

The second theme delved into the consequences of heightened temperatures within the classroom environment as experienced by the respondents. Frequently, the respondents conveyed the difficulties they face, including challenges in breathing comfortably and persistent sweating while inside the classroom. These factors collectively create an environment that hinders their ability to concentrate and engage in effective studying. The issue is further compounded by the problem of overcrowding within the classroom, intensifying the discomfort. This is consistent with the previous studies posited that severe discomfort due to hot weather conditions may put a strain on students [4], [7], [80]. High levels of temperatures can undo potential advances of students, particularly those who are frequently exposed to outdoor and sports activities [81]. This observation is supported by earlier studies that indicate that high temperature in the classroom may negatively affect student academic performance in general [6], [77], [82], [83].

The impact of extreme heat is particularly noticeable within the confines of the classroom. Respondents consistently pointed out that the classroom environment tends to be significantly hotter, which exacerbates the challenges they face. Many respondents also provided specific details regarding which rooms are more affected by the heat and the times during which these rooms become noticeably warmer. The elevated temperature inside the classroom not only disrupts concentration but also contributes to a heightened sense of fatigue among the respondents. The heat's draining effect compounds the challenges they already experience, making their learning environment even more taxing. For this reason, Lala and Hagishima [4] emphasized the need and urgency to implement strategies to effectively manage classrooms due to health risks. The words "breathe," "room," "sweating," "inside," and "tiring" supported this theme.

4.3.3. Addressing multifaceted sources of heightened heat in the classroom

The third theme revolves around addressing the challenges brought about by intensified heat, which is not only a result of the prevailing season but also exacerbated by underlying issues such as broken electric fans. The strategies for coping with these challenges and the proposed solutions put forth by the respondents revolve in this theme. This theme delves deep into potential remedies aimed at effectively managing elevated temperatures. Recommendations include ensuring proper ventilation, rectifying or supplementing with additional wall-mounted fans, and addressing malfunctioning fan units. However, despite these efforts that are meant to alleviate the heat, the situation often takes an unexpected turn. Instead of mitigating the heat, these measures sometimes unintentionally contribute to its intensification.

Despite the presence of an adequate number of fans, their ineffectiveness drives individuals to resort to fanning themselves in an attempt to endure and alleviate the heat. This struggle significantly hampers their ability to concentrate on the teacher's lessons and the subject matter being discussed [83], [84]. In cases where a sufficient quantity of functional electric fans is lacking, the already demanding heat situation exacerbates. This compounded issue arises due to the simultaneous impact of external factors like the season's heat and internal factors such as dysfunctional fans and overcrowding. This observation is reflected in the consistent use of words such as "electric", "hard", "feel", "focus", "fan", "class," and "face" within this third theme.

5. CONCLUSION

This study highlights the effects of hot weather on Filipino students' educational experiences and the use of advanced technologies like sentiment analysis and topic modeling for deeper insights. Analysis showed students struggle with in-person classes during hot weather, affecting focus and comfort. Mixed sentiments were found, indicating both resilience and significant challenges posed by the heat. Three themes emerged: academic challenges due to heat, physical and psychological impacts, and potential solutions and coping strategies, such as improving classroom conditions. The study also highlights the need for policy changes, such as a weather-responsive curriculum and facility upgrades, to enhance learning environments. For future research, researchers should conduct longitudinal and comparative analyses to understand the long-term impact of weather on education and inform policy and curriculum changes. Overall, this study demonstrates the usefulness of text mining techniques in exploring educational challenges related to climate change, revealing a mix of academic and other related issues.

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