



You Are Not Alone: How Trending Stress Topics Brought #Awareness and #Resonance on Campus

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People experience various stressful events in their daily lives. Receiving social support, especially from peers who went through a similar experience, helps individuals cope with such stress. We propose StressTrendmeter, a mobile application that targets college students for anonymously sharing the source of stress via the form of hashtags, viewing stress topics based on trends, and providing social support through the empathy button and hashtag-based chat. We deployed StressTrendmeter to 222 students from two universities for five weeks. With hashtags and trending features, students found StressTrendmeter (i) helpful to spontaneously yet concisely articulate their stress topics and (ii) easy to browse through and become aware of issues around the campus. Our study reveals that social sharing with StressTrendmeter brought awareness, resonance, and accountability as students empathized and expressed support. Based on our study, we share design implications for social support systems with community awareness.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI); Interaction paradigms; Social media; Empirical studies in collaborative and social computing; Collaborative interaction.**

Additional Key Words and Phrases: Community awareness, resonance, social support, stress, social media, university students

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1 INTRODUCTION

Stress is part of everyday life. There are different types of stress, ranging from annoyance and minor temporary issues to life changing events that could impact mental health. Letting out or socially sharing ones' negative emotions to others could help people relieve stress as they receive social support [61, 67, 90, 121]. While any social support is encouraging, empathy from peers who

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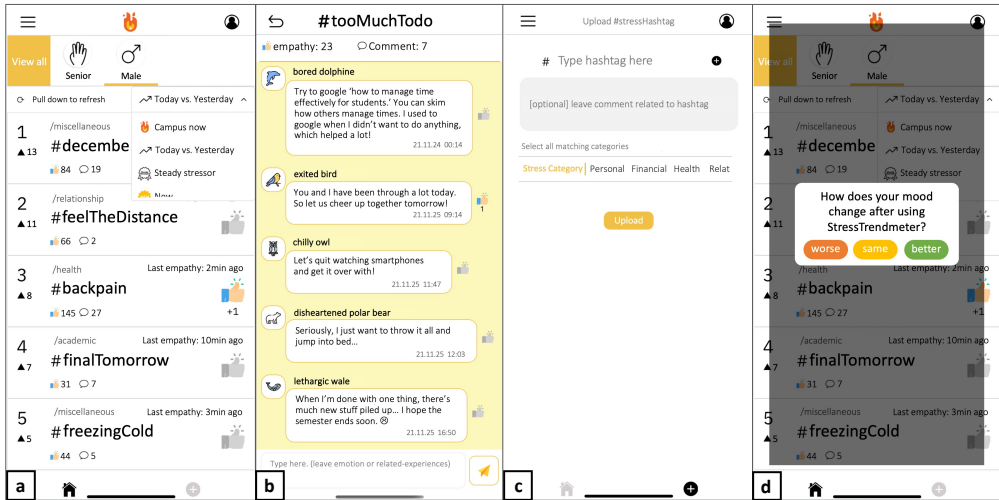


Fig. 1. StressTrendmeter app snapshots; (a) university stress trends, (b) stress topic-based chat room for a hashtag (e.g., tooMuchToDo), (c) a new hashtag post tab, and (d) prompt survey asking mood changes for experience sampling.

can relate to or have experience with the problem could carry more weight [10, 16, 64, 76, 122]. Nonetheless, the exploration of designs for technology-mediated peer support has lagged and a recent study sheds light on the need for the exploration [2].

While stress could wear down any walks of life, university students undergo high levels of stress [42, 54, 84, 85], as they experience academic pressure, financial problems, relationship issues, and job prospects [66, 100, 101]. The stress could be tougher during the COVID-19 pandemic as students can't have face-to-face interactions and often feel they are alone [110]. We believe university is an ideal venue for investigating peer support practices as students from the same university share many experiences and understand their concerns [29, 64, 86, 122].

Increasingly, university students are turning to social media, such as Facebook, Instagram, Twitter, SnapChat, and TikTok, to simply vent negative emotions or disclose their vulnerable and stigmatized experiences, as well as to post positive and pleasant news [9, 18, 73, 114, 115, 122]. However, these identified social media are not known to be appropriate outlet to relieve their distress because of concern about perceived stigma and impression management [1, 12, 60]. Thankfully, there are online peer support networks such as TalkLife/TalkCampus [113], Empath [62], and Facebook Groups [80]. However, in most existing platforms, individual posts with similar contents are separated and could be lost in a large number of posts from diverse set of users. Therefore, a post that needs timely responses could often be neglected and not receive prompt attention and engagements [46, 69].

How can technology be leveraged to support people recognizing and acquiring attention and engagements from peers who are experiencing or have been through similar stressful events? To this end, we present *StressTrendmeter* (Figure 1), a mobile application for university students to anonymously share the source of stress via the form of hashtags (#) and follow stress trends based on students' empathy for each hashtag. With anonymous posting and comments, users can freely express and vent their thoughts or concerns without revealing the identity, while still respecting the members within the same community [29]. Furthermore, the community-centered design captures the hyperlocal experiences, making it easy for users to empathize. With the "hashtag" format, members can instantly and frequently post stress topics concisely without the

high burden of posting [53]. Users can write details of the stress topics as comments under the hashtag, and other members can also anonymously leave comments to further discuss or express support. The use of hashtags in StressTrendmeter would abstract and generalize the stress topic. While this yields the benefit of being able to quickly browse through the topics, it would be difficult for users to articulate complex and difficult situations. We thus expect StressTrendmeter users to mainly discuss daily stress events and express negative emotions for instant ventilation, instead of serious, complex stressful events requiring professional's interventions. StressTrendmeter offers an "empathy" button for users to click for hashtags that they relate to and resonate with. With the empathy counts, we compute and show the "trending" stress topics. With the hashtag format, users' attention and engagement could be focused on few hashtags of their interest, thus increasing the chances of receiving timely attention and support. In addition, the trending hashtags represent timely stress topics and signal opportune attention and support to those topics.

In this study, we aim to understand people's reaction and perception on current designs of StressTrendmeter. In particular, we examine how the design of StressTrendmeter facilitate social sharing of stressful experiences and reap the benefits of social sharing negative emotions. We deployed StressTrendmeter to 222 students from two universities in Korea for five weeks, with each subject participating in the study for at least four weeks. We collected 444 hashtags, 2,112 comments, and 11,815 empathy button clicks. Through our qualitative analysis, we discovered that (i) topic-based interactions (e.g., sharing and empathizing stress topics) allow instant venting of stressful experiences without hesitation and enable support among students with similar experiences, (ii) trending stress topics based on students' empathy could develop awareness of stress factors surrounding the campus members, and (iii) the awareness could lead resonance and accountability of supporting others. The cognitive process of a series of awareness, emotional resonance, and accountability in StressTrendmeter echoes Ekman's definition of compassionate empathy, which suggests emotional resonance raises cognitive appraisal, empathic response, and compassion in order [33]. By extending compassionate empathy, Ekman calls such a cognitive and behavioral process 'reactive resonance' [32]. StressTrendmeter enacts not only cognitive appraisal and empathy but also a desire to care for others, which we call reactive resonance.

The key contributions of our study are as follows:

- We introduce a topic- and trending-based community design for building awareness of stressful experiences and for supporting social interactions among peers with similar experiences.
- We provide empirical findings from a large in-the-wild deployment study (N=222) on how stress topic trends and topic-based social groups affect individuals and the community through quantitative and qualitative analysis.
- We present design implications on how topic- and trending-based social interactions could foster community awareness, resonance, and accountability that can facilitate social support.

2 RELATED WORK

2.1 Social Sharing of Negative Emotional Experiences using Online Channels

When people experience emotional events, they naturally want to share the experiences with people around them [98, 99]. The practice of social sharing of emotions can reduce the feeling of loneliness [97], facilitate emotional recovery [96], lead to perceived benefits of emotional expression [120], and enhance social integration (e.g., greater proximity to the listener) [34, 82]. In particular, venting negative emotions offers an opportunity to ease the feeling momentarily and build supportive relationships with other people [8].

Sharing one's negative emotional experiences, however, is often associated with social stigma [1, 87], impression management concerns [40], and fear of social rejection [109], making people avoid

socially sharing such experiences. One solution to these barriers is to use ‘anonymous’ online channels that hide users’ identities [56, 65, 71]. There have been various forms of online channels where users can anonymously share negative emotional experiences. For example, TalkLife [112, 113], Empath [62], and social media (e.g., Facebook [15, 122], Instagram [18], Reddit [3, 27, 114]) allow users to anonymously and publicly disclose their negative emotional experiences and share warm responses. Some online channels (e.g., Alcoholic Anonymous [44], The Dinner Party [88]) group people with shared experiences and allow them to have a conversation either offline or online. Other channels (e.g., 7Cups [79], Koko [83]) match two users to support one another. These online channels facilitate communicating one’s negative emotional experiences by helping users vent emotions anonymously, learn other’s coping strategies, and reach out to elicit support from other users. Further, such experiences shared on anonymous online channels have been leveraged to measure and infer individual and community mental health status [6, 28, 103, 104].

Recent studies underscored the importance of peers who have similar experiences in communicating negative emotional experiences. Karusala et al. [57] deployed WhatsApp-based peer support groups for youth living with HIV. Exchanging support between peers formed a sense of normalcy that helps to overcome difficulties stemming from not having people around them in similar situations. Andalibi et al. [2] conducted an interview study called Buddy Project to figure out considerations in designing digital peer support for mental health. They revealed that shared interests facilitate communications, and shared identities help ensure being understood when discussing mental health. Besides, some people do not share negative emotional experiences with people who cannot understand due to not having the experiences [1]. However, finding peers with similar problems and seeking support from them online is still challenging because of the information overload with redundant posts on similar topics and users’ supports scattered over many posts [105].

When negative emotional experiences are disclosed in anonymous online channels, recent studies identified the major concerns associated with audiences’ responses; for example, people hesitate to disclose experiences as they worry about their posts being dismissed, ignored, or glossed over [1]. Since the responses are the most significant benefit of sharing one’s negative emotional experiences, prior studies also suggested incorporating features to facilitate warm reactions using a simple interaction method [11, 63].

In summary, current literature on social sharing of negative emotional experiences through online channels highlights the importance of (1) anonymity [56, 65, 71], (2) peer support with similar experiences [1, 2, 49, 57], and (3) reactions for the act of disclosing experiences [11, 63, 72, 78]. However, existing work shed lights on each design feature in a compartmentalized manner and there is a lack of in-the-wild empirical studies that examine the effect of negative emotional experience sharing online. Existing empirical studies mostly focused on offering one-to-one interactions [2, 79, 83], but this approach may engender sharing unhealthy coping strategies and wrong experiential knowledge [2]. Our work extends these prior studies by developing a new form of online interaction techniques that allows users to anonymously share stress factors and empathize with one another at a community level. We report in-the-wild empirical findings from the deployment of StressTrendmeter, by building an online community of university students undergoing similar stressful experiences.

2.2 Community Awareness of Negative Emotional Experiences

Enhancing community awareness of negative emotional experiences, such as distressing events [36], depression [89], and suicidal thoughts [77], is crucial to increase self-disclosure, change a negative attitude to professional service, and foster community support and integration. Therefore, there have been various attempts to promote community awareness of negative emotional experiences.

In HCI and social computing communities, digital technologies for promoting community awareness of emotional experiences have been designed to understand how people connect and interact with each other using such technologies. MoodSqueezer [39] allowed office workers to express various moods by squeezing color balls and shows the squeezed balls' color distribution on a floor display and a website. It evoked self-reflection, initiated conversations between workers, and enhanced community awareness of the workplace. MoodTracker [70] is another technology for community awareness of emotional experiences in workplace. Using public tablet PCs, workers reported emotions by pressing a cartoonish face icon and checked mood statistics for each floor of an office building. It revealed various mood patterns in the workplace.

Some studies explored technologies to encourage community awareness of emotional experiences within a local community. Hernandez et al. [45] deployed MoodMeter that counted smiling instances of college members and visualized the instances across campus on public displays and a website in real-time. It brought on more smiling instances by providing joyful experiences and revealed correlations between the smiling instances and campus events. EmotionMap [48] is a mobile social application in which users log and share their emotions publicly. It shows emojis associated with logged emotions on a map and allows users to provide feedback to others.

Overall, these technologies not only enhanced community awareness of emotional experiences but also initiated social interactions between community members and uncovered correlations between emotions and community events.

Existing research on promoting community awareness of emotion mainly focused on only emotion [39, 45, 70], collecting people's current emotional status and publicly displaying the information. More detailed information can be annotated in an interactive map (e.g., location and activity) [48]. These approaches help users to understand community-level emotion states and associated contexts, but it is challenging to quickly track the major topics and to freely discuss emotion states among community members. Existing approaches of displaying community-level emotions are less suitable for building a community that shares stressful experiences and empathize with community, possibly due to information overload. Our system helps members to quickly express their stress related topics in a hashtag format and visualizes the *trends of stressful experiences*, thereby helping them to anonymously interact with one another on such topics.

3 STRESS TRENDMETER DESIGN

3.1 Design Goals and Iterative Design Process

StressTrendmeter is designed to create a lighthearted online platform for university students to share and manage stress, together with peers who might have experienced or are going through similar issues. In developing StressTrendmeter, we took an iterative design process. The design process consisted of two phases; (i) a formative study and (ii) small-scale pilot deployments. As the formative study, we conducted semi-structured interviews with the associate vice president (VP) of student life and a therapist of the stress clinic of the university the authors are affiliated with. The goal of these interviews was to identify current online channels in which students express stressful experiences and the challenges and concerns in understanding students' stress and supporting the students. Interview questions included online channels they monitor to understand students' current stress, how students utilize such channels, and their opinions on deploying StressTrendmeter, an online channel for students to share stressful experiences and browse popular stress topics on campus.

Through the interviews, we found that the main challenge in understanding students' stress and supporting the students is the need for human effort to laboriously monitor and identify the prevalent stressful experiences. For example, the associate VP of student life has periodically

tracked posts on many online channels such as Facebook and EveryTime [37] to recognize students' troubles, so that she can address them in a timely fashion. Therefore, while it is important to track students' current stressful experiences, there is no strategic approach to efficiently monitor and identify prevalent stressors.

Both interviewees stated that offering collective information about students' stressors could help students relieve stress and college administrators identify issues on campus. The psychotherapist stated, "*Being aware of the fact that other students have similar stressful experiences helps students feel relieved. However, when students get stressed, they tend to focus only on their own state. Thus, it could be difficult to consciously recognize it even when they unconsciously understand that others suffer from similar stresses. Therefore, helping students realize others are under similar stress could contribute to them relieving stress*".

In addition, the associate VP of student life said, "*identifying stress trends could help us provide instant and tangible support to specific students, such as students in a certain dormitory or students taking a particular course*." With the findings from the formative study, we developed the following two design goals.

First, StressTrendmeter should **facilitate social sharing of stressful experiences** by incorporating three important factors, (i) anonymity [56, 112, 113], (ii) peer support with similar experiences [1, 2, 57], and (iii) sympathetic reactions [11, 63]. Second, StressTrendmeter should **enable users to easily be aware of common stressful experiences on campus at that period of time**.

In order to achieve these goals, we first went through the overall workflow of the system using a low-fidelity paper prototype; we then developed a mobile application with React Native that runs on both Android and iOS. In StressTrendmeter, university students can (1) anonymously share stressful experiences or stress topics in the form of hashtags with categories of stress (Section 3.2.1), (2) express support to peers by pressing the empathy button and/or leaving encouraging comments (Section 3.2.2), and (3) browse the trending stress topics composed of hashtags that many users empathized with (Section 3.4) among peers with similar experiences based on sub-communities (Section 3.3).

To examine the application's overall usability and user experience, we conducted three pilot studies, refining the app based on the results from each study. The first and second rounds were for quickly identifying any technical problems in the app (one week each), and the final round was for examining the app's overall usability and user experience (two weeks). We called for participants in pilot studies, announcing that the purpose of the StressTrendmeter is sharing, recognizing, and empathizing with stressful experiences among community members. A total of 10 university students (5 females and 5 males; age: mean=24.8, stdev=2.82) participated in the pilot studies and were asked to provide feedback on the overall interface design.

We drew upon the preliminary findings from the pilot studies to improve StressTrendmeter. Two main suggestions from the pilot studies with high-fidelity prototypes were reflected on StressTrendmeter: (1) adding the *Health* category in posting hashtags, which is a significant stress factor, especially during the COVID-19 pandemic; (2) providing multiple sorts of stress trends such as a hashtag ranking by accumulated empathy counts in addition to a real-time empathy-based stress trend.

3.2 Spontaneous and Instant Sharing of Stressful Experiences

There have been several attempts to encourage conversation about topics (e.g., mental illness [5, 17, 75], LGBT [7]), which are regarded as sensitive, to reduce fear and stigma associated with discussing such topics. In the same token, we aim to facilitate sharing stressful experiences by leveraging hashtag format and providing a button as a simple, empathetic reaction to shared experiences.

3.2.1 Hashtag-based Sharing of Stressful Experience Topics. In StressTrendmeter, users post their stressful experiences in the form of hashtags with optional microblogging, as shown in Figure 1 (c). We focused on enabling spontaneous and instant sharing of stressful experiences, inspired by previous explorations on microblogging. Microblogging is a form of online communication in which users can describe their daily experiences, opinions, and commentary in short posts [53, 81]. Microblogging supports faster communication by reducing users' thought investment and time consumption for content generation than general blogging. In popular microblogging platforms (e.g., Twitter), users post microblogs with optional hashtags, topic markers of a microblog [19]. On the other hand, StressTrendmeter users post hashtags with an optional microblog, or a comment in our context.

Sharing stressful experiences through hashtags in StressTrendmeter has four main expected benefits. First, the hashtag format facilitates instant, frequent posting, lowering the burden of posting [53]. Second, viewers can browse through the topics quickly without having to read long descriptions (Figure 1 (a)) as information becomes concise and abstract. Third, sharing personal experiences in a hashtag format strengthens anonymity as the abstractness and conciseness lower the risk of revealing the poster's identity or personal information. Hashtags do not contain any information about the poster as well. Lastly, while abstract hashtags would lose the details of individual experiences, abstractness increases the likelihood that a wider range of users would empathize with the topic instantly. If desired, they could choose to engage further with other users through comments in a hashtag-based anonymous chat room (described in detail in Section 3.3.2) under the hashtag, shown in Figure 1 (b).

In order to compensate for the lack of context in hashtag-format sharing, StressTrendmeter enables users to select a relevant Stress Category for their hashtag (Figure 1 (c)) among 'personal', 'academic', 'health', 'relationship', 'financial', and 'miscellaneous', which are reported as common stressors for college students [66, 100, 101]. A user must select at least one corresponding category when generating a hashtag.

3.2.2 Empathy Button. In StressTrendmeter, users can express their empathy for each hashtag and each comment in a hashtag chat room by clicking the empathy button with the thumbs-up look (Figure 1 (a-b)). Empathy is crucial in the social sharing of emotional events [20] as a representative of emotional support [92]. In addition, empathetic reactions can grant relief by forming a sense of normalcy and a sense of community [57]. However, recognizing empathy from others online is much more difficult than in face-to-face interactions [21] because empathy is often recognized from conversational partners' nonverbal and facial expressions that are invisible online [50]. StressTrendmeter employs empathy buttons to facilitate users express and recognize empathy through a lightweight interface [11, 63].

StressTrendmeter shows the number of empathy button clicks for each hashtag (Figure 1 (a)). We allowed an individual user to click the empathy button multiple times for a hashtag. If a user clicks the button multiple times with a certain time duration in between, the clicks are all counted towards the displayed empathy count below each hashtag (Figure 1 (a-b)). This means that the empathy count could be greater than the number of people who pressed the button. Consecutive clicks below the time duration will only count as one. We allow the users to check how many times they clicked the empathy button on a hashtag or comment by showing the number below the empathy button (e.g., "+1" below the empathy button for "#backache" in Figure 1 (a)). Our design for instant expression of empathy and visualization of others' empathy is an effort to make empathy recognizable online. We believe it could lead to active social sharing of stressful experiences by satisfying the desire to receive attention and empathy.

3.3 Social Interactions among People with Similar Experiences

It is known that shared identity promotes active interaction and interpersonal bonds in online communities [2, 95]. People are thus likely to interact with and prefer gaining social support from similar people [105]. People who had a similar experience show more empathy than people who had not [10, 64]. People who are in a similar place in life and experience common challenges, such as university students, immigrants, or cancer patients, are easy to build affinity and empathize with each other [16, 76, 122]. We designed StressTrendmeter for members within the identity-based communities and deployed it to university students as they are considered to be representative community members who have high levels of stress with common stressful experiences. StressTrendmeter also provides sub-communities reckoning with a variety of university students and an anonymous chat room for each hashtag to gather students with similar stressful situations.

3.3.1 Identity-based Sub-community Formation. StressTrendmeter provided sub-communities based on university (we deployed it at two different universities), class standings, residence (remote or on-campus), and gender. Within a given community (e.g., a university), there could be multiple sub-communities that share common experiences, such as major or class standings (e.g., freshmen in Computer Science). In addition, surveys on university students' stress have revealed slight differences in stressors according to their demographics [13, 22, 31, 111].

Users can subscribe to pre-defined sub-communities that they are interested in, and the subscribed sub-communities are shown at the top of the main screen (Figure 1 (a)). Users can check the hashtags that the sub-community members frequently empathized (i.e., trending) by clicking the sub-community icon at the top of the stress trends tab or on the sub-community list, which appears when clicking the top-left menu icon.

3.3.2 Hashtag-based Anonymous Chat Rooms. StressTrendmeter provides an anonymous chat room for each hashtag to enable users to discuss and comment about a topic (Figure 1 (b)). Topic-based anonymous chat rooms would gather similar experiences, experiential coping strategies, and encouraging comments, while one-to-one chats are prone to engender sharing unhealthy coping strategies and wrong knowledge [2], and general online bulletins are likely to disperse users' contribution to multiple redundant posts [69].

To reduce the fear and stigma associated with disclosing one's negative emotional experiences, we made users communicate anonymously in the chat room to help participants frankly share their stories and opinions. For each comment, a random nickname is given because we wanted to minimize identity disclosure. Even when a specific user leaves multiple comments in a single hashtag chat room, a different random nickname is given for each comment the user makes. A nickname was given by StressTrendmeter as a combination of a randomly selected word from 48 adjectives (e.g., positive, courageous, wise) and a randomly selected word from 50 animals (e.g., rabbit, turtle, dog).

Anonymity, however, could sometimes lead to aggression as users experience reduced inhibition and accountability [74]. The anonymity on social media, with an associated lack of accountability, encourages unrestrained commenting [26, 123]. We expected that although anonymous, members of the same community are less likely to make disparaging comments to each other as social-tie and shared identity strengthens the commitment in online channels [106]. Nevertheless, to minimize offensive postings or comments, StressTrendmeter employed a word-filter by referring to the vulgarism dictionary from a large Korean online community called Instiz [51]. When we moderate posted content, we presented a message, '*Do not use defamatory remarks or make false statements against others in StressTrendmeter*', when a user engaged in StressTrendmeter. In addition, during our user study, three of the authors monitored uploaded hashtags and comments to manage any

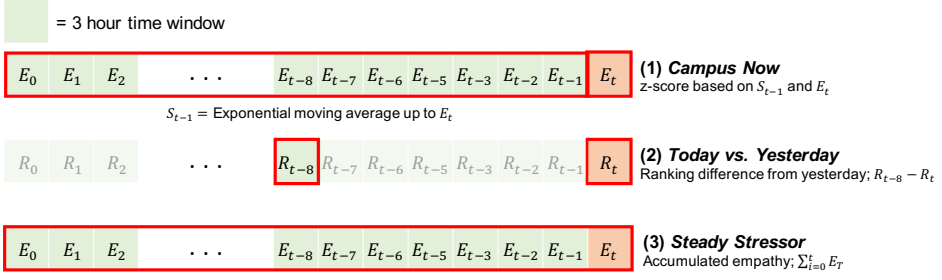


Fig. 2. Diagram of (1) *Campus Now*, (2) *Today vs. Yesterday*, and (3) *Steady Stressor* trending algorithms. With a given time window t , E_t is each hashtag's empathy count.

inappropriate expressions that are not included in the Korean vulgarism dictionaries. While this manual monitoring was possible in our study, for a larger scale deployment, a much sophisticated method would be required.

3.4 Trending based on Empathetic Reactions

StressTrendmeter ranks hashtag-based stress topics based on empathy counts from users. We believe that displaying trending topics help users to easily recognize which stressful experiences are empathized now by the community members. We developed four categories of trends, namely (i) *Campus Now*, (ii) *Today vs. Yesterday*, (iii) *Steady Stressor*, and (iv) *New*. Users can check trending hashtags for the entire community and each sub-community. The *New* option simply shows the latest hashtags but the other categories utilize different methods and criteria for trend rankings. Figure 2 visualizes how different trending algorithms work, and Figure 3 shows example results of the algorithms given the same data.

Campus Now (Figure 2 (1); Figure 3 (a)) shows the current stress trends in a given community. *Campus Now* prioritizes the topics that experience sharp temporal increases based on the calculated z-score [47] in a 3-hour window ($t = 3$). Each hashtag's empathy count E_t at the time window t is used to calculate the exponential moving average S with $\alpha = 0.9$ (Equation 1). The z-score for time t , Z_t , is calculated by dividing the subtraction of the average S_{t-1} from the empathy count E_t by the standard deviation of empathy counts over the recent period (Equation 2). To account for recent empathy counts, the *Campus Now* option calculates the z-score every minute and re-ranks the hashtags.

$$S_t = \begin{cases} E_1 & t = 1 \\ \alpha E_t + (1 - \alpha) S_{t-1} & t > 1, \end{cases} \quad (1)$$

$$Z_t = \begin{cases} 0 & t = 1 \\ \frac{E_t - S_{t-1}}{\text{Standard Deviation of } E} & t > 1. \end{cases} \quad (2)$$

Today vs. Yesterday (Figure 2 (2); Figure 3 (b)) sorts hashtags by the difference between the trend rankings of the *Campus Now* today yesterday. *Today vs. Yesterday* thus compares the *Campus Now* ranking R_t in the current window and the ranking 24 hours ago. Basically, hashtags with the biggest rise in rankings are trending in this category. *Steady Stressor* (Figure 2 (3); Figure 3 (c)) on the other hand, ranks the hashtags according to the accumulated empathy counts since the beginning of the deployment.

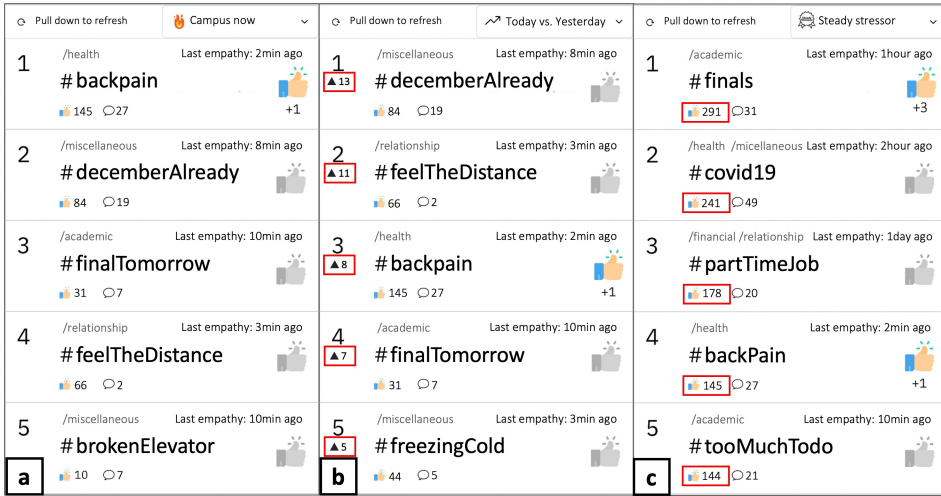


Fig. 3. Trending examples of (a) *Campus Now*, (b) *Today vs. Yesterday*, and (c) *Steady Stressor*.

4 USER STUDY

We describe the setup of our user study, including the mobile app development, participant recruitment, and study procedure. In addition, we detail our data analysis methods.

4.1 Implementation

We implemented the StressTrendmeter mobile app with React Native running on both Android and iOS. The log data of every user in StressTrendmeter (e.g., access time, self-generated hashtags, comments) were stored in the cloud data storage, Google Firebase. All data were anonymized with a random identifier to preserve user privacy. A computer in our lab served as an external StressTrendmeter server that fetched the collected data from the cloud data storage every minute and updated stress trends data. The StressTrendmeter mobile app showed stress trends by fetching the stress trends data from the external StressTrendmeter server.

4.2 Participants

We recruited 222 university students (120 females, 102 males) from two universities (denoted as A and B) in Korea. Table 1 describes the demographics of our study participants. Calls for participation in the user study were posted on each university's online bulletin boards. Each participant was required to use the StressTrendmeter for at least four weeks and received approximately 17 USD as a reward. Participants who were selected for and took part in the post-interview received an additional 8.5 USD.

4.3 Study Procedure

The deployment and data collection of StressTrendmeter were approved by the Institutional Review Board of University A. All phases of the user study were conducted remotely due to COVID-19. Prior to the study, we asked the participants to respond to a preliminary survey through e-mail. The preliminary survey included questions about the awareness of other community members' stress, perception of social support in the university, and the membership construct of the psychological sense of community (PSC) [52]. Note that, in PSC, we only asked questions corresponding to the membership construct as the other constructs (i.e., self and entity) are not closely related to our study.

Table 1. Participant demographics.

| | Univ. A | | Univ. B | | Total | |
|------------------|---------|-------|---------|-------|--------|-------|
| | Number | % | Number | % | Number | % |
| Gender | | | | | | |
| Male | 45 | 63.4 | 57 | 37.7 | 102 | 45.9 |
| Female | 26 | 36.6 | 94 | 62.3 | 120 | 54.1 |
| Class standings | | | | | | |
| Freshmen | 13 | 18.3 | 12 | 7.9 | 25 | 11.3 |
| Sophomore | 11 | 15.5 | 16 | 10.6 | 27 | 12.2 |
| Junior | 10 | 14.1 | 22 | 14.6 | 32 | 14.4 |
| Senior | 8 | 11.3 | 30 | 19.9 | 38 | 17.1 |
| Super Senior | 8 | 11.3 | 9 | 6.0 | 17 | 7.7 |
| Graduate student | 21 | 29.6 | 62 | 41.1 | 83 | 37.4 |
| Age | | | | | | |
| 18-19 | 16 | 22.5 | 13 | 8.6 | 29 | 13.1 |
| 20-24 | 39 | 54.9 | 72 | 47.7 | 111 | 50.0 |
| 25-29 | 15 | 21.1 | 55 | 36.4 | 70 | 31.5 |
| 30-34 | 1 | 1.4 | 11 | 7.3 | 12 | 5.4 |
| Min | 18 | | 18 | | 18 | |
| Max | 33 | | 34 | | 34 | |
| Mean | 22.2 | | 24.0 | | 23.5 | |
| Stdev | 2.9 | | 3.6 | | 3.5 | |
| Residence | | | | | | |
| On-Campus | 26 | 36.6 | 64 | 42.4 | 90 | 40.5 |
| Remote | 45 | 63.4 | 87 | 57.6 | 132 | 59.5 |
| Total | 71 | 100.0 | 151 | 100.0 | 222 | 100.0 |

After completing the preliminary survey, participants, both iOS and Android users, installed the StressTrendmeter app on their own smartphones. Participants were given a week to start using StressTrendmeter—for each day of that week, 47, 38, 22, 18, 12, 7, and 83 participants joined StressTrendmeter. Before users engaged in StressTrendmeter, we informed users that StressTrendmeter is an online community to share stressors with peers and browse stress trends on campus. In addition, as a moderation strategy, we announced ‘*do not use defamatory remarks or make false statements against others in StressTrendmeter*’. During the user study, we did not provide detailed guidelines for content posting, as we wanted to explore users’ behavior and experiences with StressTrendmeter as it was the first deployment. To encourage continued app usage, StressTrendmeter sent a notification with varying messages (e.g., “Check out what’s trending in StressTrendmeter!”) everyday during the user study period. For experience sampling, participants were asked to optionally respond to the prompt survey reporting the mood change after using StressTrendmeter on three-point scale (i.e., worse, the same, and better) when they closed the app (Figure 1 (d)).

After using the StressTrendmeter for at least four weeks, every participant was asked to respond to a post-survey that consisted of the same questions as the preliminary survey as well as additional questions about their usage experiences. Out of 222 participants, 213 submitted the post survey response. For the follow-up interview, we invited 30 participants (18 females and 12 males; age: max=26, min=20, mean=24.3, stdev=3.9). We first divided participants into three groups based on the number of visits to the app during the user study period: *high* ($N > \mu + \sigma$), *middle* ($\mu + \sigma \geq N > \mu - \sigma$), and *low* ($\mu - \sigma \geq N$), where mean $\mu=17.9$, and std $\sigma=13.1$ (max=67, min=1). We then recruited 18, 9, and 3 participants from each group, respectively. In each group, we

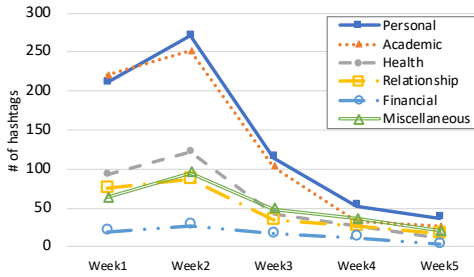


Fig. 4. Number of hashtags by stress categories.

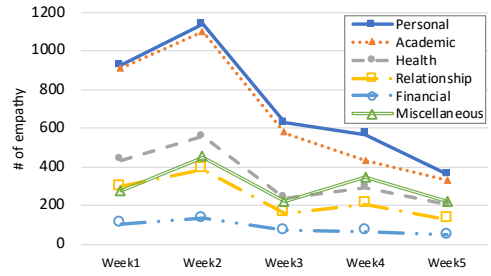


Fig. 5. Number of empathy counts by stress categories.

selected participants with varying numbers of empathy button pushes, hashtag uploads, and comments. We invited more active users as we expected that they had rich experience to share insights on their interactions on StressTrendmeter. Every interview was audio-recorded and transcribed. Interviews lasted between 30 to 60 minutes and were conducted online with Zoom.

4.4 Analysis

4.4.1 Quantitative Analysis. To explore the impacts of StressTrendmeter use, we conducted Wilcoxon signed-rank test [116] for analyzing changes in scores of PSC [52] and questions about the awareness of the community members' stress and perceived value of empathy from community members, between before and after the study. We also analyzed the experience sampling results; the responses to prompt survey asking mood change on three-point scales by after using StressTrendmeter (i.e., worse, same, and better). To reveal usage patterns in StressTrendmeter, We performed two-tailed paired t-tests on the log data of users, including the number of hashtag uploads, empathy button clicks, and comments.

4.4.2 Qualitative Analysis. We conducted inductive thematic analysis [55] of the responses to the descriptive questions in the post-survey, asking the overall experience of using StressTrendmeter. We also performed open coding of the post-survey responses to examine how users utilized and assessed StressTrendmeter's designs (e.g., empathy button and anonymity) and how StressTrendmeter influenced the users' perceived availability of social support in the community. The first and third authors of this paper conducted an initial coding of hashtags' to understand participants' stress over the user study period. The first and second authors conducted initial coding of comments' contents to examine social interactions in StressTrendmeter. For each open coding process, different authors discussed any differences to iteratively revise the themes together. The first author analyzed the interview transcripts using an inductive thematic analysis [55] to determine and extract themes. All authors met regularly to go through themes and discuss potential themes throughout the process.

5 RESULTS

We first present the interaction patterns in StressTrendmeter (i.e., usage behaviors over time, types of hashtags, and comments under hashtags) and experience sampling results about mood change after usage (Section 5.1). We then explain how StressTrendmeter helped to increase stress awareness and self-care at the individual level (Section 5.2). Lastly, we present how such empathetic understanding establishes a sense of accountability to offer social support within a community (Section 5.3).

| Stress category | Hashtag | |
|-----------------|------------|--------------|
| | N | % |
| Personal | 253 | 57.0 |
| Academic | 251 | 56.5 |
| Health | 112 | 25.2 |
| Relationship | 66 | 14.9 |
| Financial | 28 | 6.3 |
| Miscellaneous | 94 | 21.2 |
| Total | 444 | 100.0 |

Table 2. The distribution of user-selected categories of the posted hashtags (N=444). Multiple categories can be selected for a hashtag.

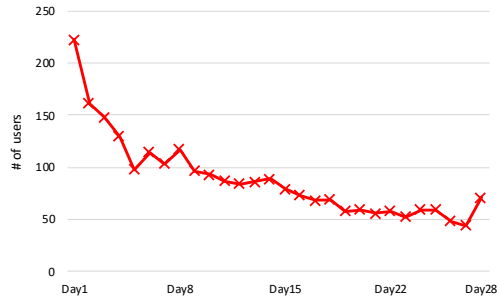


Fig. 6. Number of active users. All participants’ experimental start dates are arranged as Day1 on the x-axis.

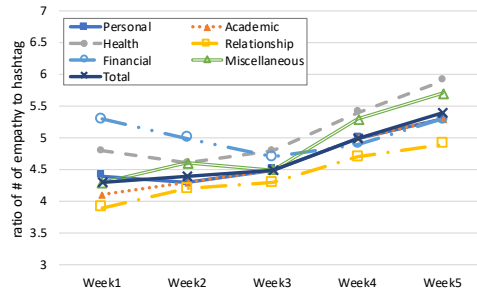


Fig. 7. The ratio of empathy counts to the number of hashtag uploads.

5.1 Interactions in StressTrendmeter

We first present the overall usage of StressTrendmeter. The number of hashtags for each category is summarized in Table 2. Note that a hashtag poster could select multiple categories for a hashtag, and the “personal” category was often chosen with other categories (71%). We can see that academic stress is the most popular topic in StressTrendmeter.

The average number of users who signed in at least once a day is 88.6 (max=222, min=44, std=39.5) per day. A total of 211 and 190 users posted at least one hashtags and comments, respectively. The average numbers of hashtags and comments posted per user are 25.0 (max=233, min=0, std=30.4) and 8.6 (max=154, min=0, std=14.3), respectively. The numbers of active users, hashtag uploads, and empathy counts per day decrease over time (see Figures 4, 5, and 6), possibly due to reduced academic stress after the final exam period (week 2). Waning of the novelty effect might have also contributed to the decrease (all 222 active users in week 1, gradually decreasing to 154 active users in the last week of study). The weekly average of empathy clicks per newly uploaded hashtag (i.e., not accumulated) gradually increased over the user study period as shown in Figure 7. At the beginning of the study, as the StressTrendmeter started with a clean slate, many users added new hashtags to vent one’s stress. As the number of hashtags increased over time, users often clicked the empathy button instead of leaving duplicate hashtags. We believe this is an indicator that despite some novelty effect, StressTrendmeter sustained empathy from the participants throughout the study period.

From the analysis of users' usage logs, we discovered two prominent usage patterns. First, users who upload hashtags more click the empathy button more ($r=0.98$, $p<.001$). Second, users who generate more new hashtags leave more comments ($r=0.41$, $p<.001$).

5.1.1 Stress Trends Categories. Across the user study, the most popular stress trend category was *Campus Now*, followed by *New*, *Steady Stressor*, and *Today vs. Yesterday*. The daily average number of accesses to stress trend, including multiple accesses in a day, is 111.69 (stdev=56.31). Participants stated that they browsed *Campus Now* because they were curious about current trending stress topics in the community, and also because *Campus Now* appears on the main page. Participants saw more brand new topics in *New*. In addition, some participants said they “*browsed New out of curiosity about the stressful experiences of concurrent users on the app at the moment (P38)*”. However, some participants said the stress topics in *New* were sometimes too random to empathize with. Participants said they could know the most popular sympathetic topics through *Steady Stressor* over the user study period. On the other hand, participants mentioned they did not frequently use *Today vs. Yesterday* because it offered no significant differences than *Campus Now*.

5.1.2 Hashtags. Most participants evaluated that StressTrendmeter reflected recently widespread stressors on campus (5 Likert-scale, mean=4.1, std=0.7) with the following question: “StressTrendmeter represents the recent stressors of university students”. For instance, academic stress peaked near and during the final exam periods (week 2) as shown in Figure 4. The academic stress was reflected on hashtags such as #FinalTomorrow and #DontWantToStudy. Hashtags related to academic stress decreased noticeably at the end of the semester. There were also hashtags related to irregular lifestyle and health concerns during the exam period (e.g., #NeckPain, #StressInducedGastritis).

Hashtags in the health category were dominated by the COVID-19 pandemic (#HateCOVID19, #WhenCanWeTakeOffMask). The relationship category contained a wide range of stressors, including family issues (#FamilyConflict), feeling lonely (#NoFriend, #FeelTheDistance), romantic relationship problems (#GotDumped), difficulties with lab mates and advisors (#UselessAdvisor), and social isolation (#SenseOfAlienation). The miscellaneous category included various topics such as required military services (#Army, #Enlistment), social issues (#ReleaseOfCriminal), joyful thinking (#DinnerMenu, #WhatToEat, #WhatShouldIDoForChristmas), and others (#DecemberAlready, #WorkingOverTimeAlone, #WannaGoToCafes).

5.1.3 Comments under Hashtags. Our participants left a total of 2,112 comments on StressTrendmeter during our user study. The categories of comments from our thematic analysis consist of three types: feelings and experiences, information-seeking, and expressing support. The comments describing feelings and experiences related to stress include negative emotions such as depression, anger, shame, fear, and pressure, empathizing with the corresponding hashtags. There were also positive emotions such as happiness from overcoming or getting out of stressful situations; e.g., “*I just finished the semester after submitting my last assignment. Ah, I'm so happy.*” Information-seeking comments mainly asked for information or experiences to peers; e.g., “*How do you maintain a long-distance relationship?*” Some participants showed empathy via short comments; e.g., “*Me, too*”. They also left encouraging comments voluntarily even when there is no help-seeking tone from the hashtags.

5.1.4 Empathy Button. We collected a total of 11,815 empathy counts during the user study. To understand the motivation and intention of pushing empathy button in StressTrendmeter, we asked the following two multiple choice questions in the post-survey; (1) select all the reasons why you pushed empathy button on *hashtags*, and (2) *comments*. Multiple selections were allowed for each question. There were 11 choices (in bold in Table 3) for each question as default, taken from the

Table 3. Post-survey results of questions about (1) the reasons for pushing empathy buttons on hashtags and (2) comments. Items in bold are the ones we provided, and items not in bold are the ones participants created by themselves.

| Items | Reasons why you pushed empathy button on | | | |
|--------------------------------------------------------------------|------------------------------------------|-------|----------|-------|
| | hashtags | | comments | |
| | N | % | N | % |
| Push empathy button on a hashtag/comment because | | | | |
| I empathized with the content | 198 | 89.19 | 162 | 72.97 |
| I was also experiencing the content | 148 | 66.67 | 108 | 48.65 |
| I was eager to console the poster | 84 | 37.84 | 75 | 33.78 |
| I felt sympathy for the content | 76 | 34.23 | 41 | 18.47 |
| the content was emotionally supportive | 68 | 30.63 | 58 | 26.13 |
| the content was humorous | 67 | 30.18 | 102 | 45.95 |
| I wanted to inform the content to others | 17 | 7.66 | 10 | 4.50 |
| I wanted to uprank the content in stress trends | 12 | 5.41 | 6 | 2.70 |
| the content was informative | 3 | 1.35 | 18 | 8.11 |
| I felt pressure to push the button | 1 | 0.45 | 2 | 0.90 |
| it was comfortable | 1 | 0.45 | - | - |
| I posted the content | - | - | 1 | 0.45 |
| the content that only grad students experience was cool | - | - | 1 | 0.45 |
| I have never pushed the empathy button on hashtags/comments | 8 | 3.60 | 23 | 10.36 |

study on the motivation of pushing “like” buttons in Facebook [68]. Participants were also allowed to write in (not in bold in Table 3).

As the button is named the ‘empathy button,’ the largest number of participants answered that they pushed the empathy button because they empathized with the content of hashtags (N=192) or comments (N=162). In addition, over two thirds of the total participants (N=148) pushed the empathy button to hashtags as they were also undergoing similar experiences, implying that our participants had many common stressful experiences. Many participants pushed the empathy buttons as they felt sympathy for the contents (N=76 and 41 to hashtags and comments, respectively) and wanted to console the poster (N=84 and 75 to hashtags and comments, respectively). An interesting finding was many participants thought the content of hashtags or comments was humorous and pushed the empathy buttons (N=67 and 102 to hashtags and comments, respectively). From our inspection, there were several witty expressions and we think such witty expressions would bring joyful experiences to participants. Some participants pushed the empathy button to react to the support they received on their posts. Some participants respond that they ‘wanted to uprank a hashtag in stress trends so that many community members recognized the stressor (P35)’.

5.1.5 Anonymous Identity. In the post-survey, we asked an open-ended question ‘What are the advantages of StressTrendmeter compared with other online platforms when it comes to sharing stressful experiences?’. Sixty-seven participants (31.6%) voluntarily reported anonymity as a strong point of StressTrendmeter. We took an inductive approach to identify the relevant themes about the reasons for preferring anonymity without pseudonyms in StressTrendmeter. Table 4 describes three categories of codes and corresponding codes: (1) Topics in StressTrendmeter (e.g., privacy, sensitive subjects), (2) engagement facilitators (e.g., less risk of identification, lighthearted environment), and (3) reactions (e.g., risks of feeling marginalized).

The most frequently stated reason was the stressful experiences. Our participants said that stressful experiences are personal information, and some said such experiences show their weaknesses that they do not want to disclose with their own identity. This is consistent with the finding that

Table 4. Codes applied to reasons for preferring anonymity without pseudonyms in StressTrendmeter. Participants' responses in the "Sample Response" column are paired with codes in the adjacent "Codes for Reasons for Preferring Anonymity in StressTrendmeter" column.

| Codes for Reasons for Preferring Anonymity in StressTrendmeter | | Sample Response |
|----------------------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topics in StressTrendmeter | Privacy | "Concerns are personal business, so I am reluctant to use my real name or a pseudonym." |
| | Touchy Subject | "I like anonymity because it is highly likely to share touchy contents when talking about my stress." |
| | Vulnerability | "Because stress can be one's weakness, [I prefer anonymity.]" |
| Engagement Facilitators | Less Risk of Identification | "I hope there is no risk of being exposed that the subject of a concern is me." |
| | Lighthearted Environment | "I was completely anonymous, so I could talk about stress comfortably." |
| | Encourage Sharing | "I do not express negative affections on other social media, but I dared to talk [in StressTrendmeter] because I was completely anonymous." |
| Community Integration | Being Frank | "Ensuring anonymity lead to frank disclosure." |
| | Less Risk of Feeling Marginalized | "People could feel marginalized when being identified with pseudonyms." |
| | Concern about Small Cliques | "From my experiences in the communities using pseudonyms or real names, small cliques have appeared. I think the content of stress itself may not receive any attention and responses [if small cliques take place in StressTrendmeter.]" |

people utilize anonymous online channels to disclose their sensitive or stigmatized topics [57]. Another reason was that anonymity contributes to creating a lighthearted environment that encourages engagements, sharing stress topics, and expressing empathy without having to manage one's reputation. Lastly, some participants mentioned that in an pseudonymous online community, they often witnessed small cliques of popular users and hence had difficulty in participating and felt marginalized. They said anonymity in StressTrendmeter allowed everyone to gain attention and support regardless of who the user is.

5.1.6 Focusing on Stress Topics. StressTrendmeter concentrated only on stress topics, and many participants mentioned this focus as the favorite aspect of StressTrendmeter, compared with other social networking services. P5 reported, "Compared with other social networks with many posts on happy things and good news, StressTrendmeter provides a comfort zone to frankly let out one's difficulties." Others mentioned that StressTrendmeter was an appropriate platform to anonymously talk about negative experiences that they often hesitated to share because of saving face. For example, P37 said, "It's hard to talk about trivial, personal stuff, and I can't repeatedly discuss the same problem to the same person. When I used StressTrendmeter, I could talk about the same [stress] factors, whether it's once an hour or every day. It was nice to be able to talk about things that I couldn't otherwise because I didn't want to spill too much information."

5.1.7 Mood Changes After Using StressTrendmeter. Over the user study period, a total of 206 participants responded to experience sampling reporting the mood change after using StressTrendmeter on a three-point scale (i.e., worse, the same, better) at least once. We collected a total of 2,219 responses during the user study. Out of 2,219 responses, 795 (35.8%) were better, 1,346 (60.7%) were the same, and only 78 (3.5%) were worse. The results of experience sampling show that there were a majority of cases where participants felt better or remained unchanged. Some participants said

that, unlike other online communities, they were aware of the app's purpose of stress sharing, so they rarely felt bad after seeing the negative content. To sum up, these results imply that the negative emotional contagion occurred less in StressTrendmeter due to the formed expectations.

5.2 Increased Stress Awareness and Self-Care at an Individual Level

5.2.1 Self-awareness of Personal Stress and People's Similar Experiences. Expressing stressful events with hashtags helped participants to reflect on their stress by developing self-awareness. Participants stated that the concise format of the hashtag had benefits when sharing stressful topics with others. By virtue of the brevity of hashtags, participants said that it was possible to **quickly vent their emotions**. This immediacy enabled participants to share transient emotions, which are often difficult to express. P81 said, *"When stress instantly went over my limits, I could simply post it as I don't have to write details about 'what happened and how' or describe what situation I was in."* Having to use hashtags forced participants to concisely describe complex situations into a few words, which made them reflect upon the intrinsic stressors. P22 described, *"When you're under stress, a lot of things pop up in your mind, and you're often not sure what specifically stresses you out. As I organize my thoughts, trying to shorten it in one sentence, I can figure out what's actually stressing me. It really helps you in both ways, uploading in an organized form [hashtag] and writing it down."*

The brevity of hashtags enabled them to **grasp the trending stress factors in the community at a glance**. P22 picked one advantage of using hashtags as *"being able to see various stressors on a single screen in a compact manner."* Empathy-based trending in StressTrendmeter *"highlighted the stress topics that many students can empathize with (P64)"*. As trends captured timely topics, it was likely for students to resonate with the stressors that they are also experiencing at that time. Our survey results on awareness of community members' stress, summarized in Table 5, support this by showing significant increase in perceived awareness (Q1) and curiosity (Q2) of community members' stress.

In addition, participants could **recognize that their peers are experiencing similar stress** through StressTrendmeter's stress trends. P72 described, *"When I didn't want to do my report assignment, I saw the hashtag #WritingReport. When I didn't do well on an exam, there was #ScrewedUpExams. I saw #AnnoyingCOVID19 trending when my appointment was canceled due to COVID. From StressTrendmeter I thought that members of the same university have similar thoughts and go through similar experiences."* StressTrendmeter helped especially participants who did not have many connections and interactions with other students. They realized that they were not the only ones who were suffering from stressful events. P21 who works at a hospital and attends a graduate school described, *"I thought that my concern only belonged to me because there are only few people around me who attend graduate schools as I work [at a hospital]. But when I saw that others empathized, I realized that many people were also troubled for a similar reason."* Our survey results on awareness of community members' stress, summarized in Table 5, support this by showing significant increase in awareness of other students with similar stress (Q3), perceived availability of empathy from/to other students (Q6 and Q7), and perceived comfort from the sense of peers with similar stress (Q8).

However, participants expressed some concerns that hashtags only offered **shallow understanding of complex stressful events due to the lack of details**. Some hashtags *"were difficult to understand the behind stories of them (P24)"*. Some users did not share complex and severe stresses that they think would be difficult for others to understand and empathize with. P12 said, *"It wasn't easy to deeply empathize with a short message. So that was a bit disappointing."* Some users also noted that it would be less meaningful to offer superficial comfort without deep understanding of their stress. This shows that StressTrendmeter is better suited as a social platform for sharing minor everyday issues or annoyances, rather than serious problems or mental health issues.

Table 5. Pre- and post-survey results of the questions about the awareness of community members' stress and perceived value of empathy from community members (Q10 and Q11 are asked only in post-survey). Every question is set up with five-point scale rating (i.e., 5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree). Questions in bold have significant difference between pre- and post-survey according to the p-value of Wilcoxon signed-rank test.

| Questions | Pre-survey | Post-survey | Mean diff | Wilcoxon p-value |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|-----------|------------------|
| 1. I know what kinds of stress my university students are experiencing | 3.35 ± 0.88 | 3.97 ± 0.71 | .62 | <.001 |
| 2. I am curious about what kinds of stress my university students are experiencing | 3.23 ± 1.17 | 3.68 ± 1.04 | .45 | <.001 |
| 3. There are students in my university who experience similar stress | 3.98 ± 0.73 | 4.26 ± 0.81 | .28 | <.001 |
| 4. In my university, other students can understand the cause of my stress | 3.54 ± 0.87 | 3.65 ± 0.92 | .11 | .12 |
| 5. In my university, I can understand the cause of other students' stress | 3.83 ± 0.70 | 3.81 ± 0.80 | -.02 | .89 |
| 6. My university students can empathize with my stressful experiences | 3.65 ± 0.82 | 3.96 ± 0.79 | .3 | <.001 |
| 7. I can empathize with my university students' stressful experiences | 3.93 ± 0.69 | 4.07 ± 0.73 | .13 | .03 |
| 8. It makes me comfortable to know there are other students who are experiencing similar stress as me | 3.51 ± 1.18 | 3.8 ± 1.06 | .28 | <.001 |
| 9. Knowing there are students who are experiencing similar stress as me is helpful in coping my stress | 3.38 ± 1.17 | 3.54 ± 1.08 | .16 | .09 |
| 10. StressTrendmeter helps me recognize that other students are experiencing similar stress as me | - | 4.07 ± 0.85 | - | - |
| 11. Compared with other social networking services (Facebook, Instagram, Twitter, etc.), StressTrendmeter is easier to recognize there are students experiencing similar stress as me | - | 3.87 ± 1.04 | - | - |

Table 6. Pre- and post-survey results of questions about the membership construct in Psychological Sense of Community (PSC) scale. The results showed the meaningful difference between pre- and post-survey according to the p-value of Wilcoxon signed-rank test.

| Questions | Pre-survey | Post-survey | Mean diff | Wilcoxon P value |
|----------------------------------------------------------------------------|--------------|--------------|-----------|------------------|
| I think my university students can depend on each other. | 3.26 ± 0.96 | 3.63 ± 1.04 | .37 | <.001 |
| I can get for help from other students in the university when I need help. | 3.25 ± 1.00 | 3.61 ± 0.92 | .36 | <.001 |
| I can share opinions or seek advice with other students in the university. | 3.6 ± 0.90 | 3.82 ± 0.78 | .22 | .003 |
| Total | 10.10 ± 2.40 | 11.05 ± 2.36 | .95 | <.001 |

5.2.2 *From Awareness to Self-management.* Through being aware of peers who are experiencing similar stressful events, our participants were “*comforted by the fact that there were people who have similar thoughts* (P22)”. Some participants were comforted by **comparing their situation with others** in the same community. In particular, when their current situations were not as serious as those of others, they thought that it was fortunate. P34 said, “*Among the hashtags, there were things like ‘2 hours left’ or ‘3 hours left’ for an assignment. Looking at those [hashtags] provided me a kind of a relief. I thought, ‘That person has only 2 hours left. I’m in a better situation than that person is.’*”

Participants were also encouraged to see how others were trying hard to overcome their stress. P33 commented, “*I could feel that there are many people who are under the same stressful situations. It’s not just me. Everyone is struggling, and yet we’re all overcoming tough situations and moving forward to the future. It made me think that if I just keep pushing, I’ll be able to make progress as well.*” This observation helped some users to better motivate themselves. P29 shared the personal commitment: “*Usually, I have no pressure on [academic] performance, but given the stress of [academic] performance pressure by others, I pledged myself to strive for self-improvement.*”

Some participants mentioned that StressTrendmeter provided opportunities to **learn others’ experiences that they would likely to experience in the future**. For example, a first-year student responded that she could sense the stress of preparing for graduation and employment and thought about how to be better prepared in the future.

5.3 Resonance and Accountability at a Community Level

5.3.1 From Awareness to Action for Social Support. As stress topics could be different across students' demographics corresponding to sub-communities in StressTrendmeter [13, 22, 31, 111], sub-community stress trends enabled users to understand what their sub-community members empathized with, which helped form a large identity-based community of university students. It also helped users to notice the stress of other sub-communities that they have never experienced.

Beyond participants being aware of others' stressful experiences, participants **empathized with others**. Participants mentioned the hashtags were quite abstract and general due to the condensed form of writing, which allowed them to empathize easily. Participants who have experienced similar stress factors to a hashtag tended to empathize with each other and discuss through comments. For example, in #TestScore, there were comments such as 'I got bad scores' and 'The test scores are still not released, and I'm nervous', sharing different experiences related to the hashtag.

Although other sub-community members never experience certain stress, we observed that they could still empathize with it. For example, *male* participants expressed their empathy on #PeriodCramps. P32 said, "I put myself in the shoes of the people who wrote that. Even if it's none of my business, it can be my friend's or my girlfriend's. I might not know them in person, but I thought of them as my friends. I pressed the empathy button thinking 'my friends experience it too'." We often found participants empathized with the topics from other sub-communities in StressTrendmeter. We hypothesize that this pattern is attributed to the unique characteristics of a university where personal social networks cover multiple sub-communities, and there are natural transitions between sub-communities such as class standings. Finally, our study results did not reveal any notable differences in stress trends from different communities or across two universities.

Some participants **felt the accountability of caring and supporting others** because they worried that the hashtag posters would feel left out and discouraged when their hashtags that did not receive many empathy counts and comments. For example, P21 said, "When I saw a hashtag that no one empathized with or has few empathy counts, I thought the poster might be disappointed." As the sense of accountability formed in the platform, supportive comments were voluntarily provided by the participants. Participants pressed the empathy button and left encouraging comments in hopes of helping and struggles did not receive enough attention. Some participants decided to serve as a supporter after seeing that other peers' stresses and struggles did not receive enough attention. For example, P42 intentionally opened to the app frequently, searched for hashtags with few responses, and empathized and encouraged them.

Beyond emotional support, we also observed informational support patterns, although this happened less frequently than emotional support. Participants sought information support by asking others about effective ways of relieving and resolving stress. For example, P91 left a comment: "I'm a graduate student in the first semester, and I still don't know how to write a paper such as writing footnotes, conducting plagiarism tests, and so on. I want to learn the way to do them correctly. Where and how did you learn it for the first time? I will appreciate your recommendations."

Participants often voluntarily offered advice or suggested solutions by sharing how they alleviated and resolved the stress based on their similar experiences, although the poster did not seek it. For example, a user who suffered from slipped disc in neck uploaded a hashtag, #NeckPain, with a comment saying 'It hurts so much. Save me from looking at the computer every day!' Although the hashtag poster simply shared his stress without asking for a solution, multiple users offered solutions, such as 'I recommend foam roller stretching' and 'The inflatable prosthetic neck support is quite helpful! If you search the internet, there are many types with affordable prices.'

With StressTrendmeter, users not only became aware of other sub-community members' stress, but also empathized with each other and developed accountability to support each other, providing both emotional and informational support. This pattern aligns with the concept of *social translucence* [35] where making social behavior visible in a computer-mediated environment raises awareness, and this awareness creates accountability for each other. StressTrendmeter, as a socially translucent system, executed reactive resonance that forms compassion and accountability to others beyond feeling of empathy.

5.3.2 Resonance and Accountability Strengthen Community Attachment. Through StressTrendmeter use, participants could witness empathy sharing and experiential advice between the participants. To examine how StressTrendmeter impacts on participants' sense of community, we asked the questions about the membership construct in psychological sense of community scale. From the pre- and post-study surveys, we saw significant improvements in community membership (see Table 6).

Participants valued the empathy sharing between students via the empathy button. P20 said, "*Beyond merely venting feelings, I like receiving great empathy. The feeling of 'I'm not the only one' played a pretty big role in relieving stress.*" Some students who posted hashtags felt the support and thankful when the hashtags were trending with many empathy counts. P179 reported, "*I posted a hashtag in a terrible mood. Unexpectedly, the hashtag was highly ranked. I was thankful and felt I was not alone.*"

By allowing participants to be aware of and understand peers' stress, StressTrendmeter created reactive resonance, a series of cognitive process of awareness, emotional resonance, and accountability, among community members. Participants felt a sense of kinship and affinity, exemplary of social network support [25], with peers who were suffering from similar stress. Participants also said witnessing empathy sharing and experiential advice between students in StressTrendmeter makes them perceive "*positive impact, such as companionship, from socially sharing negative emotions (P31)*". P12 commented, "*The experience of learning that people can empathize with other people's stress makes me believe that a stress-based app [like StressTrendmeter] could be actively used and be helpful for people to relieve stress.*"

6 DISCUSSION

6.1 Social Interaction Design to Promote Community Resonance

Our qualitative results showed that social support interactions through a scaffolded form of empathy exchanges (e.g., the empathy button and comments) facilitated participants' spontaneous experience sharing. The structured emotional support helped users to sense the attention and care from peers, satisfying one of the important expectations of socially sharing experiences [30]. Users engage with StressTrendmeter first by browsing through an overview of trending hashtags in their sub-community, by expressing empathy through a click, and then by sharing more detailed accounts of related experiences in the hashtag chat room, or sharing their own hashtags. We discuss how the structural component contributed to forming reactive resonance in StressTrendmeter.

6.1.1 Hyperlocal Stress Trends in Hashtag Format. We observe that StressTrendmeter enhances community awareness by utilizing the short hashtag format as a vehicle for sharing community-wide stress topics. The equivocality, or deliberate ambiguity, of concise hashtag elicits community-wide understanding and empathy. The hashtag format befits succinctly sharing emotional experiences rather than describing complicated situations. Most experiences shared on StressTrendmeter were minor daily hassles rather than severe or complex problems explored in previous CSCW research [3, 15, 118]. As discussed in Section 5.2, the hashtag format, on the other hand, may not capture proper context behind the experience and hamper a deep understanding of the experiences.

Therefore, further designs should consider both the advantages of conciseness and the downside of shallow understanding when exploiting the hashtag format.

While allowing diverse interpretation of hashtags, the subcommunity-centered design preserves hyperlocality of the content discussed in the platform. StressTrendmeter features sub-communities based on different demographics (e.g., universities, class standings, residence, and gender) and shows empathy-based hashtag trends among each sub-community. These trends based on empathy counts of sub-community members enhance the visibility and awareness of popular stress topics that exist in the sub-community. The hyperlocality makes it easier to relate and share empathy among people with similar experiences. It further contributes to enacting reactive resonance, i.e., forming compassion and enhancing accountability to care for other community members beyond empathy.

Increased accountability through more visibility and social awareness of others' negative emotional experiences echoes the concept of social translucence [35], suggesting to make social behavior visible, or *translucent*, in computer-mediated environments to raise awareness and accountability for one another. Our new design for community-level online social awareness and accountability provides new insights of *what* information needs to be visible and *how* to make the information translucent within a community.

Future studies could further assess different design choices and formats to convey individuals' experiences and social events in a community and investigate how such designs contribute to community awareness. For example, one can examine different visualizations of individuals' emotional experiences, such as an emotion map that can promote a sense of proximity or an emotion thermometer.

6.1.2 Reactive Resonance through Timely and Instant Interaction. StressTrendmeter facilitates the transition from emotional empathy and compassion into instant expression of the empathy and care through empathy buttons and hashtag-based chatrooms. Our trending hashtag-based interaction provides an organically formed space for timely and instant interaction and support. The trending hashtag-based interaction enables impromptu interactions around several stress topics that are currently empathized by many community members. This is different from other online channels, such as subreddits on Reddit that are devoted to more long-lasting, constant topics of interest.

This result aligns with the implications of existing studies that an interface with structured emotional support facilitates the social sharing of emotions online [11, 58, 63]. However, while participants valued simple support sharing interactions in StressTrendmeter, some acknowledged their perceived level of support was shallow. A recent study on challenges of university students' mental well-being suggested that different support that are aligned with the perceived severity of the problems are needed [87]. Therefore, designers should carefully balance the simplicity of user interactions and the contextual specificity of social sharing. For example, one can provide phased social interactions, starting from lighthearted to in-depth interactions depending on a user's needs.

Future work could explore facilitating more diverse forms of reactive resonance. For example, our participants reported various intentions of pushing the empathy button, as discussed in Section 5.1.4. However, such intentions could not be recognized by others in the current StressTrendmeter. A broader range of support expression types, such as *'me, too'*, *'care'*, and *'hug'*, could be incorporated to allow users to express various types of supportive emotions, similar to other online platforms such as Facebook. Having multiple types of support expressions would allow trending of topics based on different types of support, thus providing a multitude of hashtag-based social interactions based on various types of support. As a result, users might gain desirable support through social interaction corresponding to their needs. Along with widening the range of expression types,

designers could also allow users to express their depth of support, for instance, by the number of button pushes or the duration of a button push.

6.2 Community-based System Design for Discussing Negative Topics

6.2.1 Anonymity and Content Moderation. StressTrendmeter adopts anonymity instead of pseudonyms for its users. Our participants showed a preference for this as anonymity mitigates social stigma when sharing negative emotional experiences with others as stated in Section 5.1.5. Consistent with findings from the literature [1, 56, 65, 102], anonymity acted as an important facilitator of social sharing of negative emotional experiences in our study. Participants tended to focus on sharing stressful experiences and providing supportive comments without identifying each other. Anonymity without pseudonyms could also reduce the risk of revealing identity via tracking previous activities, especially in community-based systems [94]. Some participants also assessed that anonymity prevented the formation of small cliques or reputed users, which could contribute to marginalization of users in online community. Our findings underscore the importance of anonymity in community-based systems where users share their personal negative experiences. Nevertheless, there remain challenges in designing community-based networks that preserve users' identity while encouraging personal experience sharing.

While lowering the barriers to self-disclosure, anonymity could weaken commitment in online communities [1, 102]. Strengthening social ties and community identity could be a way to foster commitment as discussed by Schlesinger et al. [106]. StressTrendmeter encompasses both anonymity and promotion of social ties and community identity through hyperlocal sub-community design and anonymity without pseudonyms. Users were given sub-community labels that nudge shared identities (e.g., same class standing or gender) to the users while remaining anonymous. By the same token, community-based systems could promote identity-based commitment by fostering offline identity-based commitment or granting a shared identity to users while guaranteeing anonymity within the community.

During our 5-week user study, we have not observed any defamatory or offensive statements in StressTrendmeter. However, this could be largely due to a university experiment setting, and a system for discussing negative topics should be carefully designed to avoid offensive behaviors among users. One way to proactively deal with such issues is by incorporating content moderation strategies. For example, community stakeholders could be placed as human moderators and caregivers to shape community norms [107, 108]. Furthermore, an automated model assessing the valence of users' comments could delete offensive comments or recommend rephrasing a comment [14, 59].

Further, community-based systems could make concerted moderating efforts from multiple community stakeholders [117]. In particular, the system itself enacts content moderation, and human moderators as community members provide emotional support and show a stance against harm. We expect that such concerted efforts could practice the *care-as-nature* model, emphasizing not only reactive pruning (e.g., hiding undesirable content) but also proactive fertilizing (e.g., adding desirable and supporting content) in moderation for sustainable community growth with moderation [119].

The role of caring community members could be particularly important in communities such as StressTrendmeter. Perceiving one's struggles as low severity is one of the most common reasons for not seeking professional support [4]. StressTrendmeter lowers the barrier to self-disclosure and facilitates discussion on minor and major stressors in every day campus lives. Future work could explore ways to proactively help users who exhibit warning signs of mental illness from discussions of daily stressors, possibly through engagement of community members, e.g., by recommending them to talk to health professionals.

6.2.2 Other Considerations in Designing System for Discussing Negative Topics. Another issue to consider is emotional contagion [43]. It was reported that negative emotions (e.g., depression, stress, and anger) expressed in social media are contagious to viewers [24, 38]. Thus, it is crucial for researchers to be aware of and recognize the potential risks when designing and deploying systems that contain negative topics. According to our findings, it is important for stress-related social networking services to build users' anticipation of seeing posts on negative topics. In addition, to prevent negative consequences from becoming aware of others' emotional experiences, designers should carefully consider how to collect and present individuals' emotional experiences. Safer measures and interventions could also be considered, such as prompting a user at the end of the app session on how they feel and suggesting available mental health care services if needed. Another exploration could be labeling the emotion intensity for emotional experiences and browsing others' emotional experiences labeled with different emotion degrees.

We also saw few participants who felt disappointed when they could not get any attention from others, while most participants did not mind when their posts did not receive many responses. In StressTrendmeter, the trending algorithms could engender the Matthew effect in which the popular stress topics got more attention and vice versa [91]. Although we offered different trending algorithms, including *New*, for bringing users' attention to new topics, most people persisted in the default trend *Campus Now*, as shown in Section 5.1.1. A different user interface design for showing different trends without an intentional effort to switch the trend could moderate the Matthew effect. Future works could explore different design choices for naturally drawing attention and support to marginalized topics in community-based systems.

6.3 Limitations and Future Improvement

There are several limitations in this study that could be addressed in future work. First, our stress trend design did not consider individuals' interests in stress topics. We rather showed various topics through multiple stress trends (e.g., current popular empathetic topics, new topics, most popular empathetic topics over the user study period) as we designed StressTrendmeter for enhancing users' awareness of stress topics in the community. While stress trends allow participants to browse various and popular topics, most wanted to focus more on the topics of their interest. It is in line with our key design goal, which is supporting users to easily recognize people with similar stressful experiences and interact with them. Given the need to focus on stress topics of one's interest, future work could consider incorporating features to cluster similar contents and recommend topics based on individual interests or past experiences. We believe tying similar topics would engender more discussions and social support among people with similar stressful experiences. Active interactions between individuals would contribute to the system's sustainability, as in other online communities.

Second, we designed and deployed StressTrendmeter for only university students. Our design decisions, such as categorization of stress types, using a hashtag format, and providing sub-communities by school-year, targeted university students. Similar systems for other communities could take different designs, considering their preferences (e.g., visualization of trends, anonymity, etc.). Moreover, other populations might disclose one's problem less or seek social support in social media while most university students do [23, 41]. Accordingly, the usage and impression of StressTrendmeter would vary depending on the target community. Therefore, our findings should be carefully understood when generalizing to different user groups.

Third, our study design is limited by the lack of longer-term deployment. The current study was sufficient to explore five-week usage and effects on community awareness while using StressTrendmeter. However, it might not have been sufficient for observing the long-term effects of topic-based social sharing of emotional experiences and community awareness. Nonetheless, we believe that StressTrendmeter can maintain sustainability as an online channel to vent and discuss various

stress topics ranging from minor daily hassles to life challenges. We observed StressTrendmeter's distinct benefits from other social media platforms in attracting engagements. Our participants stated that StressTrendmeter was dedicated to discussing stressful experiences, which allowed them to frankly vent their stress. They added that they often hesitated to share such experiences in other online channels with many posts on happy things and good news. In addition, they could let out daily hassles repeatedly without having to save face.

StressTrendmeter also practices reactive resonance by focusing on promoting community awareness to enact and sustain candid social support. Some participants even voluntarily engaged StressTrendmeter as supporters by recognizing the community members who are struggling with stressful situations. We also observed the increases in the ratio of empathy counts to the number of hashtag uploads over our user study, suggesting that StressTrendmeter sustains social support between students. By the same token, nudges such as periodic newsletters with stress trends could promote community awareness and draw user engagement in a longer term. Furthermore, we expect some students might engage out of curiosity or willingness to help others, as members of the same local community that have already gone through similar situations. Further research should explore designs to enact reactive resonance and how reactive resonance contributes to sustaining user engagement and contribution to community-based online channels in the longer term.

When deployed for the long term, we believe college administrators and mental health support staff could also benefit from StressTrendmeter. By monitoring and analyzing popular stress topics on campus, they could provide timely support and take actions to address issues causing students to be stressed. As stress trends reflect the current difficulties on campus, they might recognize unexpected stress peaks and stressors. In addition, they could instantly address instrumental needs outside emotional and informational support [25], such as improving Wi-Fi quality in a dormitory.

Lastly, we acknowledge that the experience sampling method to investigate how users' moods changed by using StressTrendmeter is limited. A further study could address these limitations through a more rigorous experience sampling method (e.g., sampling moods before and after usage) [93].

7 CONCLUSION

We presented a university-based online social networking service called StressTrendmeter that was designed for community members who share similar experiences to instantly and anonymously post stress topics, empathize, and discuss. We deployed StressTrendmeter to 222 students from two universities for five weeks. Students posted various stress topics including academic pressure, relationship issues, COVID, and health. By making students post their stress events in a concise hashtag, participants were able to quickly vent their emotions and become self-aware. With the empathy counts for the hashtags, StressTrendmeter computed and presented *trending* stress topics. With condensed and precise description of stress events, participants quickly became aware of the issues that other community members are experiencing and expressed support. Through the user study, we discovered that participants valued StressTrendmeter as (i) it concentrates on stress and thus can post personal issues without hesitation, (ii) participants sensed the support and empathy from peers that made them feel they are not alone, and (iii) participants developed togetherness and accountability for each other. We believe community-based online social services with focus could play a role in connecting the community members, especially in the time of the pandemic, and hope that our study could ignite other services.

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