

Article

A Test Platform for Managing School Stress Using a Virtual Reality Group Chatbot Counseling System

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Abstract: Student life causes many sources of stress due to the requirements of managing schoolwork, family, friends, health and wellbeing, and future career planning. Some students are overwhelmed and lack resilience to overcome stress, especially if they are inexperienced in managing setbacks, fail to achieve expectations, or lack skills to independently manage social skills, recreation, and study time. The long-term accumulation of stress has a negative impact on students' physical and mental health, and may lead to a range of symptoms such as depression, anxiety, headache, insomnia, and eating disorders. Although most universities provide psychological counseling services, there is often a shortage of professional psychologists, which leads to students suffering from stress for longer than necessary without immediate assistance. The build-up of stress can lead to tragic consequences including abnormal reasoning, anti-social behavior, and suicide. There should never be a need for a student to wait more than a month to make an appointment for counseling services and every request for help should be immediately addressed and assessed. In this research, we designed a unique test platform for an immersive virtual reality group chatbot counseling system so students can receive psychological help and stress management counseling anytime and anywhere. First, the research used questionnaires to measure the stress levels and identifies how stress affects their lives. An immersive virtual reality chatbot was developed using professional psychological counseling knowledge that can provide answers during individual or group counseling sessions. Students can log in to the platform as avatars and ask the chatbot questions or interact with other students on the platform. This research provides college students with a new technology-based counseling environment designed to help relieve stress and learn new ways to improve student life quality from others. The platform provides a test base for future clinical trials to evaluate and improve the automated virtual reality chatbot counseling system.

Keywords: virtual reality; immersive technology; group counseling; school stress; virtual therapy; chatbot



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1. Introduction

According to statistics from Taiwan's Suicide Prevention Center [1], more than 6000 young people aged 15 to 24 in Taiwan attempt suicide each year, and the number of suicide attempts has continued to increase, especially if there is no intervention. In 2020, the number of suicide deaths on university campuses reached the highest level in the last ten years. The psychological distress of college students comes from academic pressure, interpersonal relationships, individual personality traits, career plan ambiguity, family relationships, and so on. Among the reported factors, academic performance is the most important source of stress, followed by interpersonal relationships and individual personality traits [2].

Beginning in the year 2020, the COVID-19 pandemic has changed the ordinary life patterns of everyone in society. According to surveys [3], more than one-fifth of people

are dissatisfied with the changes in their lives caused by the pandemic. People selected their top five emotional states as calm (44%), worried (38%), anxious (23%), nervous (22%), and panicked (9%), four of which are negative emotions which can lead to long-term symptoms of hopelessness, depression, and anxiety. Failure to treat these ongoing symptoms increases the risk of suicide attempts. Most universities lack sufficient numbers of counseling psychologists, cannot satisfy the number of student appointments, and are unable to recommend students to seek treatment off campus at medical centers if the symptoms are severe. Several companies have launched online consultation services to assist in managing remedial cases and less severe psychological symptoms. At present, the relatively large-scale startups include Woebot, Wysa, X2 and Youper. All of these systems use artificial intelligence for training neural networks with background knowledge related to mental health problems. The above consultation services are chatbots that understand human conversation and provide remote one-on-one private consultation services for less severe mental health symptoms. The consultation services are limited to spoken words and text and lack the critical function of interacting with a person or other people. This aspect is particularly important if the symptoms are severe and require immediate on-site psychological counseling at a medical facility.

Virtual Reality (VR) technology has developed rapidly, and many studies have included VR in psychotherapy research. VR helmets provide advanced visual simulation effects that are not used with traditional treatment methods. VR can be tailored to match individual patients' needs by adjusting system settings to create targeted and realistic stimuli. Existing research on the application of VR to the medical field has focused on systemic desensitization, pain relief, and rehabilitation methods. VR technology makes health care more efficient and provides increased access to treatment for more people. This research develops a test base consultation system that combines psychological knowledge with VR technology. A test base system means the design has not undergone medical clinical trials, but is the first step toward delivering a certified and approved system. The initial design is for students in non-life-threatening situations in need for psychological aid and consultation. The system can interact with students in a virtual environment using avatars. An avatar chatbot acts as a psychological counselor to lead group consultations. The chatbot can also identify responses that indicate life-threatening responses and notify clinical psychologists for immediate intervention. The initial research does not fully test the reliability and validity of the design and implementation of the system using clinical trials. Future research is scheduled to improve the system and the knowledge base of the chatbot so that different group therapy sessions may be tested and evaluated. A future clinical trial comparison would be to construct groups where students with high resilience to stress interact with the chatbot and students that are rated poorly on their ability to manage stress. Likewise, students that, as a group, manage stress poorly will only interact with the chatbot will be compared. The comparative knowledge obtained will be a valuable addition to the future development of a fully functional immersive VR group chatbot counseling system. The working hypothesis is that the chatbot, working in combination with resilient students and non-resilient students will learn faster and accumulate peer-based solutions for effective treatment of school-based stress.

2. Literature Review

To develop the group consultation system with a VR chatbot, the effectiveness of psychology counseling methods is introduced followed by a review of immersive technology applications for these treatments. The analysis of VR group counseling-related patents is used to forecast the future trends for chatbot applications. Finally, the application of chatbots in psychotherapy is reviewed and the design of systems applications in a virtual environment is discussed.

2.1. Cognitive Behavioral Therapy and Group Counseling

Psychological counseling is a purposeful dialogue and communication between psychologists and subjects which helps subjects to understand the symptoms causing discomfort with their current mental state. Psychologists assist subjects to perceive how their past experience affects them, understand their emotions and habits, and assist subjects to take better care of themselves and become more aware of their moods and behaviors and learn how to better control symptoms. Cognitive Behavioral Therapy (CBT) is a commonly used method in psychotherapy. It is a communication therapy based on understanding the effects of our thoughts, concepts, and attitudes on our emotions and behaviors. Since people tend to automatically rely on the same set of thought patterns to resolve problems, continuous negative thoughts and behavioral patterns can create a pessimistic or hopeless perspective and cause potentially damaging psychological symptoms [4]. Using CBT, the therapist will lead the patient to recognize their own views towards different situations and indicate how the situations influence their mood, behavior, lifestyle choices and instruct patients how to solve problems by correcting their thinking and behavioral reactions. Patients are asked to recall and confront feared or avoided objects or situations as the reference point of the therapy. The therapy session will start with fear activation to reciprocal inhibition. The final goal is to decrease distress and process extinction learning, stimulus discrimination, and occasion setting [5]. The focus in cognitive therapy is to achieve short- and long-term goals. In the short term, the goal is to alleviate symptoms and make patients return to normal life. In the long term, the goal is to prevent the patient from returning to the symptoms. The session will include mood checks, homework review, agenda setting, discussion of problems, homework development, and session wrap-up [6]. CBT is particularly useful for reducing anxiety arousal [7].

Group counseling can effectively use time, space, manpower and other resources to treat large numbers of patients, with economic benefits [8]. Therefore, group counseling is widely used in clinical practice. Recent literature discusses the effectiveness of group consultation. Group counseling with 64 graduate students in Indonesia was conducted to divide the students into an experimental group ($n = 32$) and a control group ($n = 32$). The experimental results showed that group counseling can effectively reduce students' anxiety and stress [9]. Another study on group counseling for high school students with high stress found that group counseling significantly reduced their measured levels of stress [10]. One study demonstrated ways to change students' learning insight thought processes during COVID-19 through group counseling. Many students were forced to change their learning mode (e.g., in-class teaching) due to COVID-19 and opposed new distance learning methods which affected their academic performance. The study recruited fifteen junior high school students who had negative views about the learning system during the COVID-19 pandemic to participate in group counseling [11]. After providing group guidance over several meetings, ten students (about 67%) changed their minds and agreed with the new learning system, while the remaining five students maintained their original negative views. Because of the foregoing advantages of group counseling, we decided to focus on this counseling method as the technology adopted for this research.

Some studies apply CBT to group counseling. Common counseling methods taught to academics and future professionals in psychotherapy often include methods to reduce psychological stress and anxiety by improving personal self-efficacy. Self-efficacy refers to the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations. It is generally believed that self-efficacy has an impact on people's avoidance selection, behavior, and sustainability [12]. Betz proposed methods to improve self-efficacy [13] including performance accomplishment, vicarious learning or modeling, emotional arousal, and verbal persuasion. He observed that improving students' self-efficacy can effectively reduce students' academic and career pressure. A sample of 16 students selected by Aliem's study [14] used cognitive reconstruction technology for group counseling, which effectively improved students' sense of self-efficacy and confidence, thereby reducing students' learning anxiety. Since group counseling methods

with CBT appear effective to reduce negative psychological responses to stress, it is essential to consider how to apply immersive VR technology as a component treatment and test the effectiveness.

2.2. Immersive Technology Applied as a Psychological Treatment

Some studies have demonstrated the advantages of immersive virtual environment technology in the field of psychological treatment. In Persky's research, the Scopus database was used to conduct a literature search and the results show that immersive technology has more advantages than traditional treatments including easier use of experimental control and higher realism to users [15]. Common immersive technologies, such as VR and augmented reality (AR) environments, have been applied in healthcare research.

For an AR environment applied in healthcare research, an iPad can be connected with Kinect sensors to form a highly convenient clinical consulting system [16]. Patients can seek medical consultation as long as they are at home. Such low-cost and portable technology has greatly benefited patients and allows physicians to visually explain complex medical conditions to patients.

For a VR environment applied in healthcare research, prior research used VR for exposure therapy and designed seven VR scenarios for driving phobias in terms of the driving situations, such as road, mountain road, and highway driving during the day or night. The experiments collected the physiological feedback of subjects using the bio-sensors. The results show that the subjects have a higher evaluation of the immersive experience after the system is optimized [17]. In addition, the results of the meta-analysis demonstrate that VR can be used as an effective intervention to distract patients with needle-related surgery and relieve pain in children [18].

With the aging of the population in many countries, the emphasis on the healthcare of the elderly has become a new research area. Elderly people often have the possibility of falling, which can damage their body and mind. Many researchers have extended the application of VR in health care to fall prevention and remote rehabilitation of the elderly population. According to the analysis results [19], VR rehabilitation training can be used as an auxiliary system for physical therapy, and it is expected to become a means to implement remote home rehabilitation.

However, most studies still have the problem of insufficient interactivity, overemphasizing sensory stimulation, and ignoring the importance of interaction. Therefore, virtual reality exposure therapy (VRET) should apply active learning methods and increase interactive experiences [20]. Next, the analysis of patents regarding VR and counseling services are reviewed to describe the future trends of psychological therapy.

2.3. Patent Review

This research collects patent data from Innovation Q+. Table 1 shows the keywords used for the search and the International Patent Classification (IPC) and annual filter settings of the search strategy. A total of 3178 patents with a relevance level of four or more were collected and analyzed. The results showed that the leading technologies have been developed in the United States and China with few related patents before the year 2000. Although there were some applications, they were not registered and published. The number of related patent applications and publications increased after 2000 and began to accelerate in growth after 2015.

Using IPC analysis, the technical focus of VR applied to psychological service and the scope of technical development can be accurately described. The top IPC classification results showed three dominant technical fields. The largest field was the G categories related to physics, including G06: computing, G09: educating and display, and G16: information and communication technology especially adapted for specific application fields. These patents are applied to VR environment design and the display of VR headsets. The second largest field was category A, which is related to human needs. A61 stands for medical science, and A63 relates to sports and amusement. The third largest field was

category H, which is electricity. H04 refers to electric communication techniques used for signal transmission between devices.

The results show the trend of the leading IPCs from 1991 to 2015. Most of the patents belong to category G06, which is electric digital data processing. After 2015, the number of medical science related patents in category A61 increased. By 2018, the category G16 for information and communication technology became the leader. The technology trend shows the development of related patents shifting from digital data processing to applications in the medical field and especially inventions related to communication and interaction between devices. The communication technology is relevant to group counseling and for developing chatbots. Chatbots automate the means to effectively interact with people who are suffering stress recording what they say so these constructs can be related to information stored in the communication databases. By relating conversational constructs to stored treatment solutions, accurate responses can be modelled and used during psychological consultation. The figures show the results of the patent analysis in Appendix A.

Table 1. Patent search strategy.

Domain: Virtual Reality Immersive Technology and Group Counseling	
Keyword combinations	Virtual reality + Group counseling (442 outcomes) Virtual reality + Group consultation (711 outcomes) Virtual reality + Psychological service (2412 outcomes)
Number of patents	3178
IPC	G06F, G06Q, A61B, G09B, G06T, A61M
Application years	1991~2021
Patent database	Innovation Q+

2.4. Chatbots

Woebot is a chatbot designed to guide and reframe users' negative cognitive thoughts into positive ones. Through continuous interaction, users can establish bonds with Woebot in three to five days [21]. Of the experimental subjects, 85% were willing to interact with Woebot daily, and 22% of depression symptoms were reduced after 2 weeks [22]. As a result, the chatbot demonstrated an ability to be an effective tool in combating depression while establishing good relationships with users. Some studies have experimented with a chatbot's personality construction. In Minjeong Kang's research, the mainstream functions of a chatbot were matched with personalities [23] like steadiness and conscientiousness. Another study constructed an online chatbot that can identify users' emotions from their conversations, analyzing whether there were signs of depression or anxiety as a means to prevent mental illness [24]. After conversations, the results showed that users gradually reduced their negative emotions and transformed them into positive emotions using Evebot.

Chatbots can be combined with VR and the approach has been widely applied in education. According to Tsamirsis's research [25], a set of VR asynchronous distance learning software was developed. The results showed that the performance of students using this software for learning was an improvement over traditional videos used for learning. Dibitonto [26] concluded that chatbots must have their own personality and must fully understand the user's motivation for conversing with the chatbot. They developed a chatbot that provides campus information for students in a university by establishing relationships with them and being attractive. The results showed that most students like to use a quick reply when interacting with the chatbot. If the chatbot did not provide this function and asked users to provide their personal opinions freely, most users ceased the conversation. A small number of students (6%) would insult the chatbot and say unnecessary things. Therefore, it is necessary to properly design the chatbots' personality and enhance empathy. VR chatbots can be used for interviews. The VR Job Interview Simulator proposed a way for people to simulate an interview [27]. A chatbot was trained

beforehand with questions and answers and pairs of word terms that can create associations. The chatbot then generates conversations based on the user's response and deliver a humanlike experience. These applications demonstrate the basic elements needed to create a VR group counseling system using chatbots.

3. Methodology

The focus of this research is to develop a test base VR group counseling (VRGC) system that can be used to help students relieve stress at school. Figure 1 depicts VRGC research that assists students in solving stress problems, including the interaction of development, clinical experiments, analysis, and system verification processes.

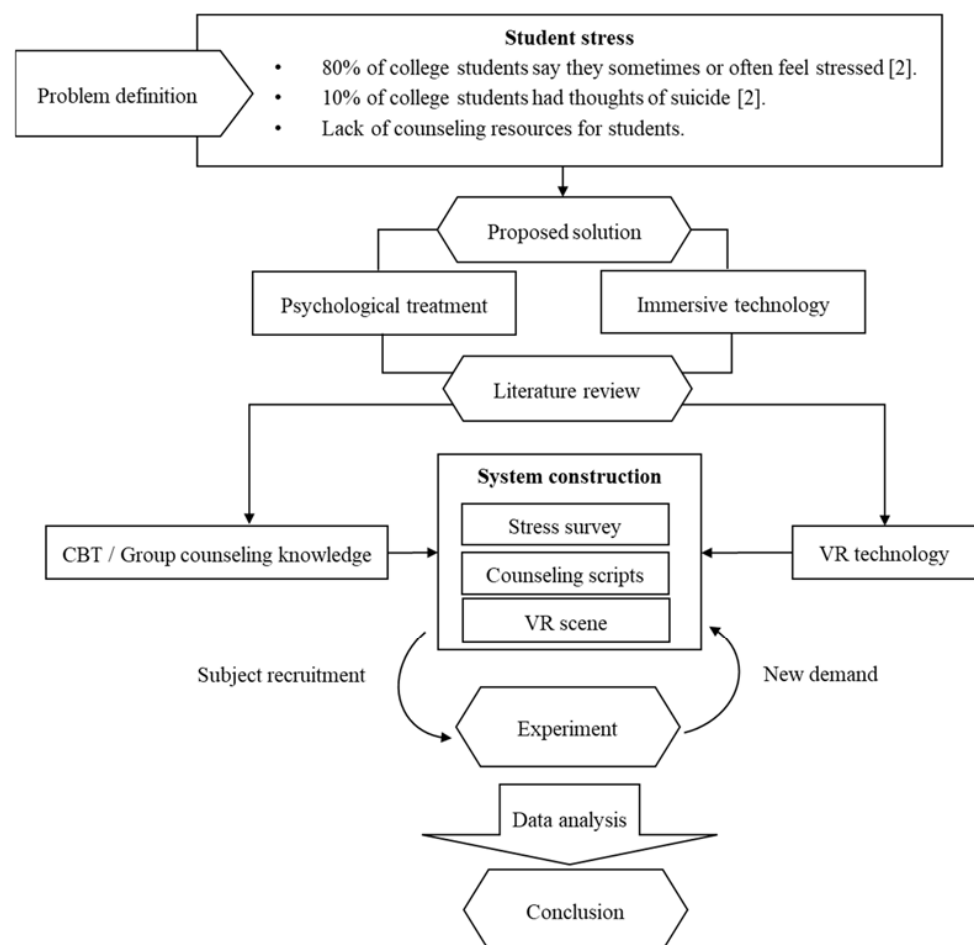


Figure 1. VRGC research flow.

First, the problem was defined, and two solutions were introduced: psychotherapy and immersion technology. The background literature and patent collection provided the basic knowledge base, and hypotheses for expected results were written. The literature review includes aspects of VR, group counseling, and psychological scales. Then the test base counseling system was developed. The system included three parts: a stress survey to measure the stress of subjects, counseling scripts to interact with users, and the VR environment. The subjects were recruited in the classroom to participate in the experiment and follow-up data analysis was performed. To develop a deeper understanding of the stress and needs of students, an additional off-line survey was added to this research to collect the responses of college students. Individuals who measured high in stress were invited to use the VR system. This research has completed the preliminary system design and has recruited subjects to fill out the questionnaire and completed the analysis of the questionnaire. Inviting subjects to participate in various VRGC clinical trial experiments

will be carried out in follow-up research. The test platform will be redesigned and refined to enhance validity and reliability through medical clinical trials.

This study uses the results of the questionnaire (see Appendix A) to measure the subjects' mental state of stress related to school. The questionnaire consists of two parts. The first part includes two questions using a 10-point Likert scale to measure the degree of stress and the ability to cope with stress, and a series of questions with 5-point Likert scale to measure the impact of stress on life [28]. The second part is PCL-5, which is used to measure the severity of the subjects' stress [29] and shows strong internal consistency and discriminant validity [30]. Respondents rate each of 20 items that have bothered them in the past month with a 5-point Likert scale. A cut-point score of 32 (range = 0 to 80) was made by the National Center for PTSD in the United States [29]. According to the previous relevant psychological research, the agency suggested that the cut-point is 31 to 33 points, so this research adopts an average of 32. The stress level on the first scale was used for preliminary screening, and the median split was applied to screen out subjects with greater stress levels [31]. Then the cut-point score of 32 was used for the second scale to further filter the subjects.

The system framework is shown in Figure 2. First, a survey module is created. This module includes problems such as the degree of stress, the source of stress, and the severity of stress which are used to measure the psychological state of subjects. The counseling module is divided into two parts, consisting of a chatbot or real counselor (chatroom). The system will suggest that subjects choose a chatbot or a real counselor based on the questionnaire results and the subjects' related information. All of the modules require subjects to be connected to the server with a VR device. The system records the subject's questionnaire scores and the content of the conversation and converts these data into information to be stored in the database.

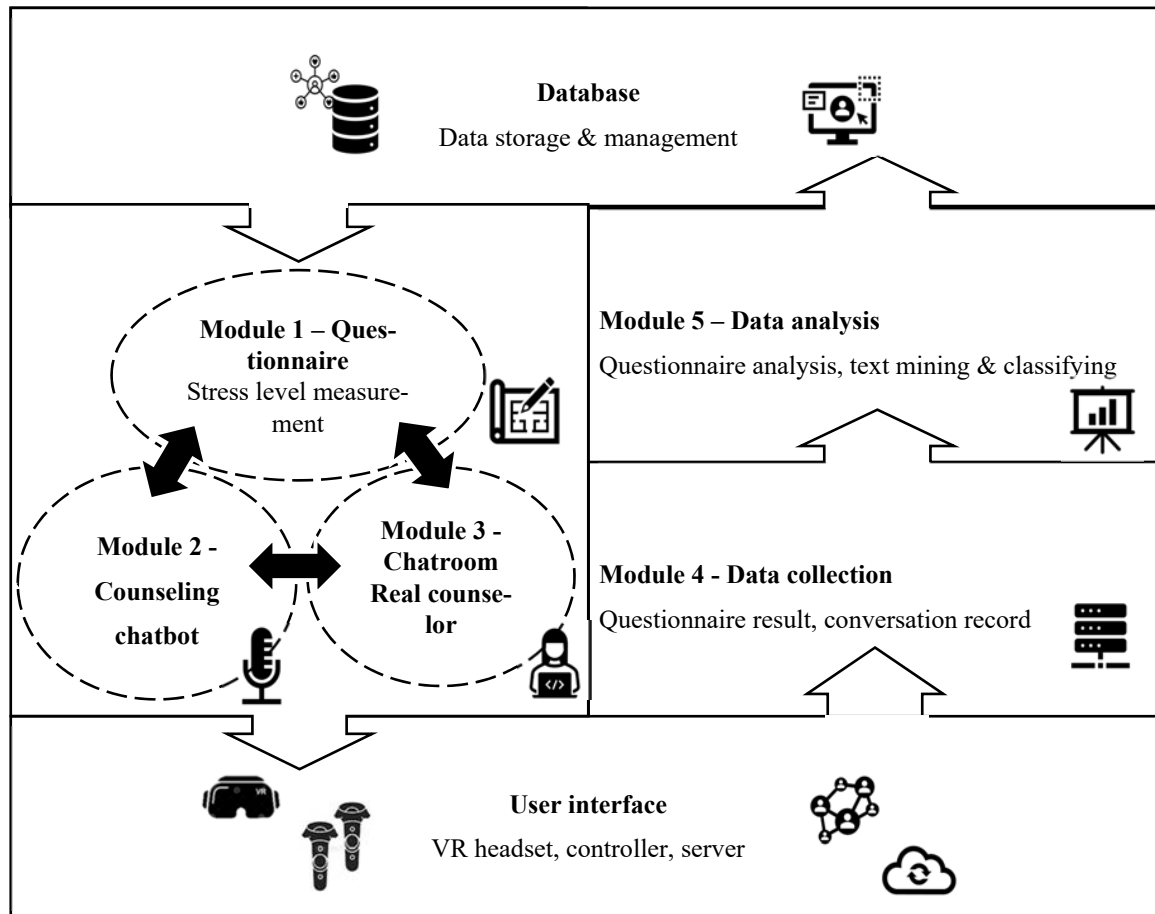


Figure 2. System framework.

The therapists contribute their knowledge to the chatbot and create an avatar to connect to the group therapy environment (chatroom). Subjects can wear VR headsets and directly use the chatbot, or they can create their own avatars to join the chatroom. All the VR scenes are managed by servers provided by Photon. For record tracking of subjects, the server connects to the database. This database is responsible for storing information such as questionnaire scores and conversations. The information will be used for data mining and to analyze the effectiveness and efficacy of the system.

3.1. Module 1 Questionnaire: A Survey for Measuring Stress Level

The two-part questionnaire as mentioned previously was embedded in the Unity software. This module has an automatic scoring mechanism. First, it determines the subject's stress level and provides relevant suggestions based on the subject's score in the first part of the survey. Suggestions for coping with different sources of stress are shown in Table 2. Suggestions are collected from the American Institute of Stress (AIS) [32], the American Psychological Association (APA) [33], BeWell Stanford [34], and Michigan State University Extension [35]. The scores of the subjects in the second part were summed and the 32-point cut-off value was used to recommend subjects. If the score in the second part is higher than or equal to 32 points, the participant is recommended to go to the chatroom. If the score is less than 32, the subject is recommended to use the chatbot.

Table 2. Suggestions for users with different sources of stress.

Source of Stress	Suggestions
Studies	Focus on getting your education instead of getting certain grades. Get enough sleep. Work on time management skills.
Financial	Always keep in mind why you want to pursue a degree in the first place, and remind yourself that it can lead to better job opportunities after you graduate. Experts and employers still believe that college is worth the investment.
Family	Take time to do something that is meaningful, relaxing and fun to you and your family. Consider the emotional needs of your family members. Focus on your health and the health of others in your family.
Friends	Make an effort to only befriend people whose company you enjoy. Spend time with people with whom you have a good relationship.
Work	Establish some work-life boundaries for yourself. That might mean making a rule not to check email from home in the evening or not answering the phone during dinner.
Health	If a particular illness is going around your campus or community, try your best to avoid contact with anyone who is contagious and wash your hands frequently. Everyone gets sick on occasion. Accept that you might get ill even though you try not to. If you do catch something, take care of yourself and rest as much as possible before resuming your normal activities.
Activity	Pursue a new hobby.

3.2. Module 2 Counseling Chatbot: A Knowledge-Based Chatbot

The chatbot operation for module 2 is shown in Figure 3. The user can ask questions by speaking or typing, and the speech will be converted into text. Preprocessing is performed using Python software to simplify the question before putting it into the model. Simplified questions are categorized according to issue and sentiment to limit the search scope for frequently asked questions (FAQs). Using the cosine similarity, the most similar frequently asked questions can be selected, and the corresponding answer can be extracted. The answer will be presented to the user in the form of screen display and voice recitation.

If there is no similar frequently asked question, the question will be stored, and the professional therapist will provide the answer to the question and enter it into the database to improve the system.

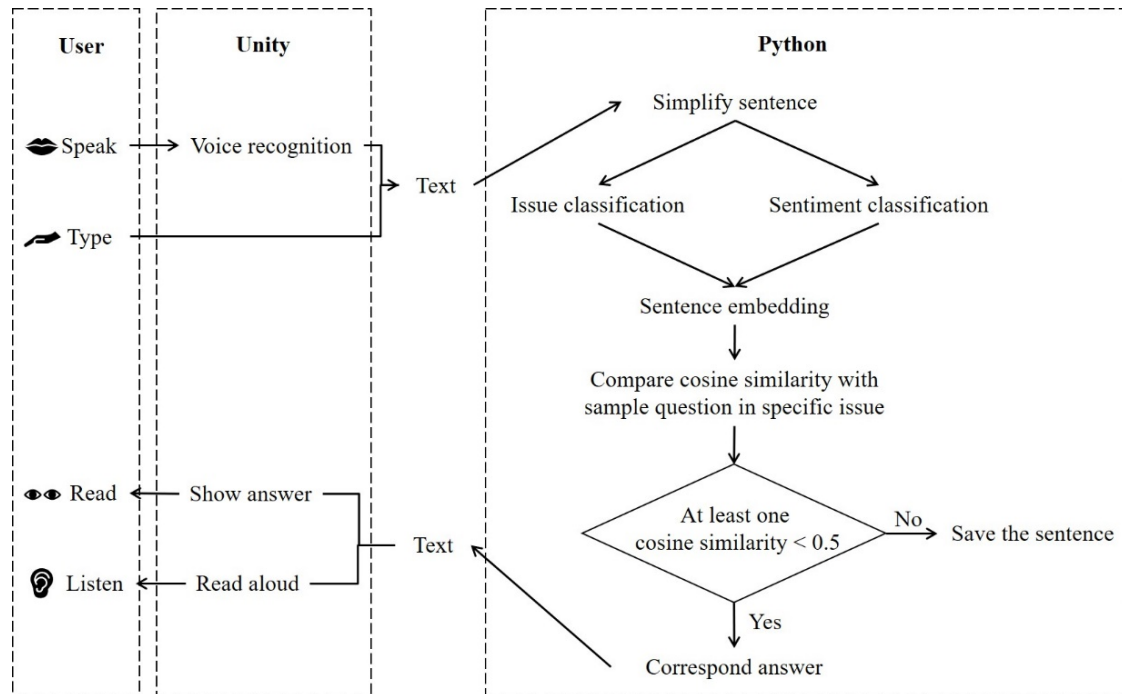


Figure 3. VRGC chatbot methodology.

Figure 4 illustrates the method of matching FAQs in this study. Users' questions were classified twice according to different aspects. The method narrows the search scope to find a matching sample question. First, the question was analyzed to find the cause of the problem, including a total of seven issues, which are studies, family, friends, finance, work, health, and activity. Then it analyzes the sentiment of the user based on the user's words, finds a related question, and answers it using the corresponding sample question set.

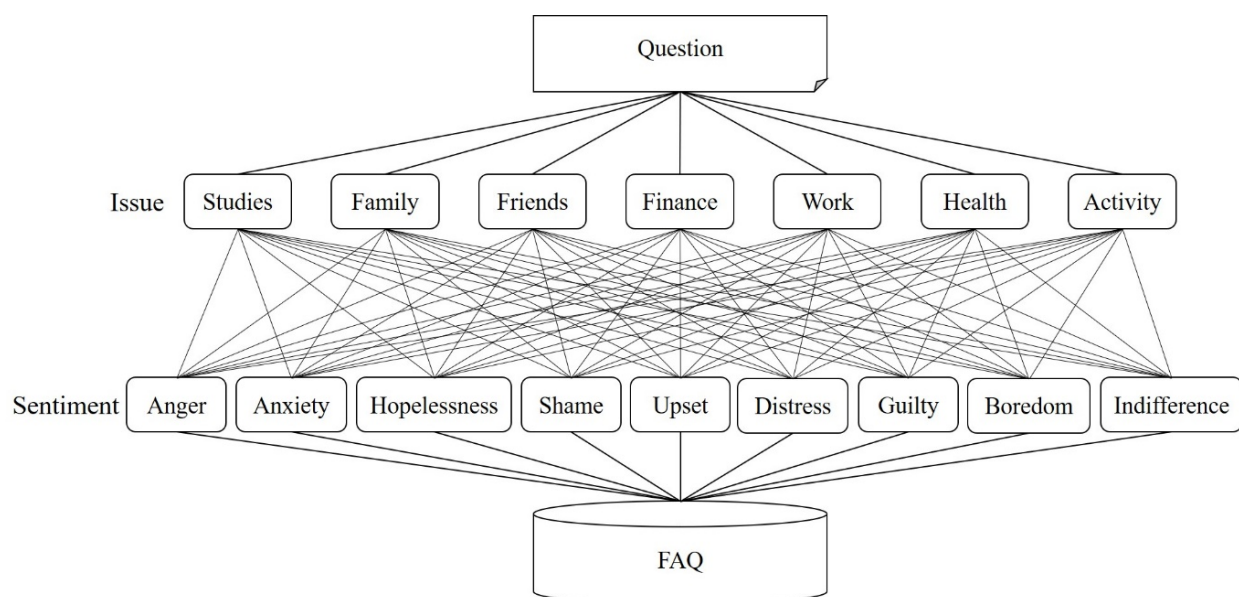


Figure 4. Matching user's question to FAQs by issue classification and sentiment classification.

FAQs are derived from the transcripts of different therapists' and psychologists' therapy sessions and also include data from various worldwide organizations for better coverage of the targeted treatment. The chatbot is an auxiliary tool for therapists to reduce their workload. Basic questions can be answered through this chatbot, and the real therapy session can be conducted in the second part of the system, which is group therapy using the VR interface. Beginning in May 2021, many people were suffering emotionally from the outbreak of COVID-19, so FAQs also include information related to pandemic stress.

Google speech to text and Google text to speech are used to enable the interaction of speaking and listening to the VRGC system, and they are implemented by loading the necessary dynamic-link library files in the plugin folders of the system. Several voice command keywords are used for better navigating different functions of chatbot. For example, "start" is used to initiate identifying Google speech to text and the recognition results will be shown in the InputField of the chatbot. "Search" is used after user's questions and chatbot can use the query to search for an answer by conducting a cosine similarity test.

To enable voice command keywords and the corresponding functions, we designed a global variable named EnVar, and it is used to represent the different status of the chatbot. After detecting specific voice command keywords, the module will change the value of EnVar. If the value of EnVar is equal to a designated number, the main chatbot module will then execute corresponding functions according to different designated number. By doing so, we are able to integrate various C# codes and use voice command keyword to execute wanted functions.

3.3. Module 3 VR-Enabled Chatroom: A Group Therapy VR Interface with a Real Counselor

The chatbot cannot replace humans, and especially not person-to-person interaction. People can expand their knowledge very effectively by sharing their experiences with others. People who share similar backgrounds can easily access and are more willing to listen to others' opinions about their emotions if phrased in friendly terms. This reflects the underlying structure of group therapy. People are not alone, and anyone can have daunting and life challenging problems. The therapist will conduct the therapy session and oversee the process of interaction to maintain a balance of collegiality. The same environment can be synthesized in a virtual environment and modified to enhance communication. People can be disguised as avatars to eliminate the fear of showing up and greeting people in reality. The virtual environment can be created in a classroom where casual encounters among the target suffering from stress maintain anonymity when discussing and seeking advice about ways to manage school stress.

The test system uses the Photon engine as the tool for enabling communication between multiple members. The Photon engine is an online server solution that can be implemented in Unity. The formation of each avatar, the verbal interactions, the corresponding avatar movements are transmitted to the server of Photon engine to achieve real-time activities. Group therapy can be programmed using the same concept. The therapist and the students will all be directed to the same designated virtual room. The therapist and the students will be represented by avatars designed earlier in Unity. The therapist can then lead a group therapy session and are able to communicate at their will in real time. If the students prefer using text messages, the Photon engine supports sending and receiving text messages. This greatly benefits students who are reluctant to speak or those who are eager to respond to the therapist but do not have a chance to talk. With the use of Photon engine, group therapy sessions can be conducted in the forms of oral and written communication.

4. Case Demonstration

This section shows the implementation of the system described Section 4.1 as a result of the offline survey. Section 4.2 demonstrates the online VR group counseling system including the e-survey, the chatbot and the VR-enabled chatroom.

4.1. Offline Survey Result

For this prototype test, students from a university filled out a questionnaire in class. Respondents were between 20 and 39 years old, including 68 females and 49 males. A total of 134 questionnaires were collected, 117 of which were valid. The stress level survey using the 10-point Likert scale (range = 0 to 9) showed that the students' stress level score averaged 5.40 points and the standard deviation was 1.60. Among the cohort, 26% of students had a stress level greater than 7 points, 22 females and 9 males, respectively. The 5-point Likert scale (range = 0 to 4) was used in the survey of students' stress and life. Among the sources of student stress, the average score for stress caused by schoolwork was the highest (2.73 points), and about 16% of students give 4 points for stress caused by schoolwork. In terms of stress affecting their lives, 58% of students stated that stress made them unable to rest or relax, and 47% stated that stress changed their sleeping habits. In terms of physical condition, 37% of students felt too fatigued to be effective, 36% of students felt stomach pain, and 35% of students experienced increased or decreased appetite due to stress. In terms of social interaction, 31% of students withdrew or even isolated themselves from others because of stress. In the 10-point Likert scale (range = 0 to 9) survey of coping with stress, the students' ability to cope with stress had an average of 5.28 points and a standard deviation of 1.88. Among them, 7% of the students have coped with stress levels of less than 2 points, including three females and five males. According to the results of the student stress analysis, students are experiencing a lot of stress with social disturbances which could endanger their health.

Table 3 lists the 20 PCL-5 questions and the average score and standard deviation of each question. A score for each item higher than 3 out of 5 points means that there is a certain degree of severity, so the number of participants with a score higher than 3 points was counted. Next, scores of 20 questions were summed to provide a total severity score (range = 0 to 80). A cut-point score of 32 was used based upon current psychometric research references. A total of 35 students in the PCL-5 survey had ratings higher than 32 points, including 19 female and 16 male students.

Table 3. Result of PCL-5.

In the Past Month, How Much Were You Bothered by:	Avg.	S.D.	Number of Participants ≥ 3 Points
1. Repeated, disturbing, and unwanted memories of a stressful experience?	1.29	1.13	18
2. Repeated, disturbing dreams of a stressful experience?	0.97	1.09	12
3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?	1.18	1.09	16
4. Feeling very upset when something reminded you of the stressful experience?	1.79	1.09	30
5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?	1.00	1.11	16
6. Avoiding memories, thoughts, or feelings related to the stressful experience?	1.58	1.12	25
7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?	1.54	1.17	23

Table 3. Cont.

In the Past Month, How Much Were You Bothered by:	Avg.	S.D.	Number of Participants ≥ 3 Points
8. Trouble remembering important parts of the stressful experience?	0.61	0.85	6
9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?	1.38	1.29	27
10. Blaming yourself or someone else for the stressful experience or what happened after it?	1.30	1.14	22
11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?	1.52	1.16	22
12. Loss of interest in activities that you used to enjoy?	1.04	1.10	13
13. Feeling distant or cut off from other people?	1.15	1.17	18
14. Trouble experiencing positive feelings (for example, being unable to feel happiness or feeling love for people close to you)?	1.12	1.18	18
15. Irritable behavior, angry outbursts, or acting aggressively?	0.96	1.12	15
16. Taking too many risks or doing things that could cause you harm?	0.57	1.12	4
17. Being super-alert or watchful or on guard?	0.86	1.07	11
18. Feeling jumpy or easily startled?	0.85	1.08	12
19. Having difficulty concentrating?	1.38	1.10	16
20. Trouble falling or staying asleep?	1.48	1.26	27

For the subjects tested, a total of 134 questionnaires were collected, of which 17 were incompletely answered and were removed. Among the 117 valid questionnaires, the median stress level was 6, and 67 subjects were in the higher stress level score group. Among the group with higher stress level, 27 subjects with more than 32 points of PCL-5 total score were listed as candidates for VRGC experiments in the future research. The subject selection flow is shown in Figure 5.

4.2. Online VR Group Counseling System Demonstration

This section introduces the implementation of the three modules in the VR interface. The modules include the questionnaire, the counseling chatbot, and the VR-enabled chat-room. The test system will be studied and redesigned through clinical trials to deliver the best group therapy experience and make it easy to navigate for therapists and users.

To distinguish different users and the therapist, it is necessary to have separate accounts to log into the system. Information from a user is logged when using this system to give a thorough analysis and make the best suggestions to the user. If the subject has not registered their account, they can click the register button. The subject inputs username, email, and password to register. After establishing an account, users input their email and password and login. If everything is correct, then the user will be directed to the start scene and is able to enter the system. Since there are three separate modules in the system,

a simple start page is used to navigate between modules after logging into an account. When user clicks the top button (Questionnaire), the Questionnaire module is activated. When the left button Chatbot is clicked, users are directed to the knowledge-based chatbot module. When the right button Chatroom is clicked, users enter group therapy with the VR interface module.

Figures 6 and 7 show the user interface of the e-survey. The user can choose options that best fit their feelings for each question. After the user has finished the questionnaire, the user receives a total score as well as preliminary suggestions based on their questionnaire results, and the system logs the current condition of the user.

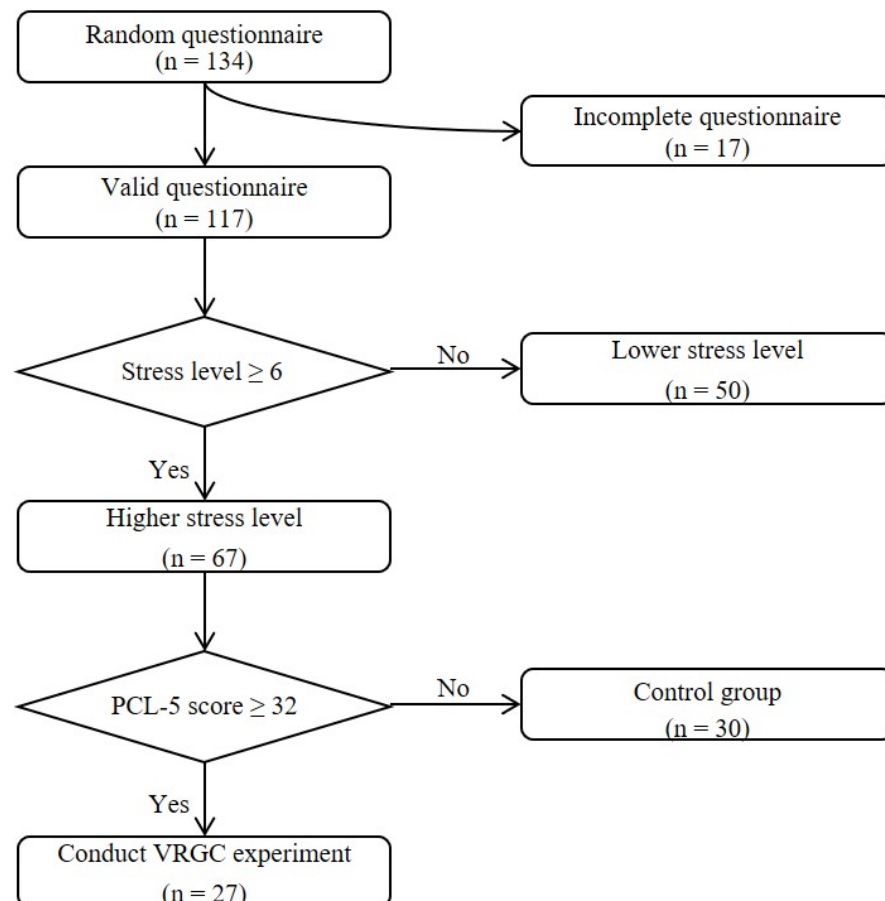


Figure 5. Subject selection flow.

The screenshot shows a questionnaire interface with a dark background. At the top, a blue header box contains the text: "In the past month, how much were you bothered by:". Below this, a white text box asks: "How do 'Study issue' cause stress in your life:". Underneath the question, there are five horizontal buttons with the following labels: "Never", "Seldom", "Sometimes", "Often", and "Always". The "Seldom" button is highlighted in a bright blue color, while the others are in a lighter blue/grey color.

Figure 6. Questionnaire of the system.

Figures 8 and 9 present the chatbot interface. Users can select the language of the chatbot by clicking on the Chinese or English button. They can also leave the chatbot and enter the chatroom or e-survey using the auxiliary button on the right side. After the user selects their preference language, the chatbot will be activated. The user can type in their question into the InputField section and then press enter to receive a visual and verbal answer in the answer section. The user can also say start and then begin asking any question to the chatbot. The recognition results will show up in the InputField section. After finishing the question, the user must say search at the end of question. The answer will show up in the Answer section, and the user can also hear the answer.

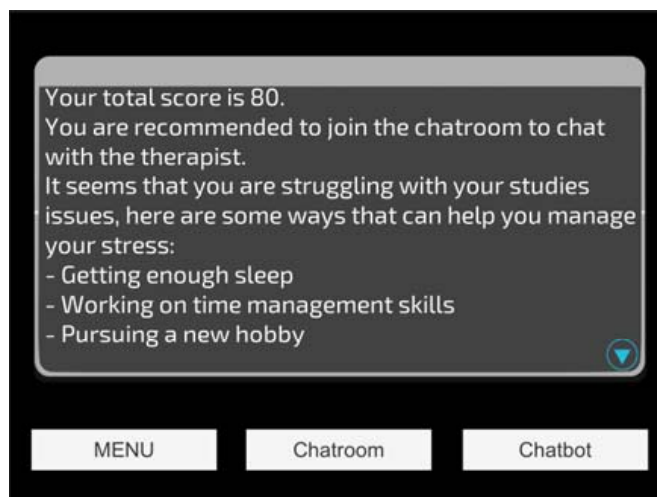


Figure 7. Questionnaire results of the system.



Figure 8. Interface of knowledge-based chatbot.

The VR-enabled chatroom scenes are shown in Figures 10 and 11. As soon as the first user logs in to the group therapy in the VR interface module, an avatar will show up in a specific random location. The username will also show up in the panel. Whenever the user wants to speak, they have to click the speak button first, and then the other people can hear their voice. Users can type in the InputField section to communicate with others. The chat log will also include the username so that other people can know who is chatting. When the user presses the speak button, the system will initiate the voice recognition function. The transcript will also be shown on the panel so that the system and the therapist can keep a record. The chat log will be used for future analysis.

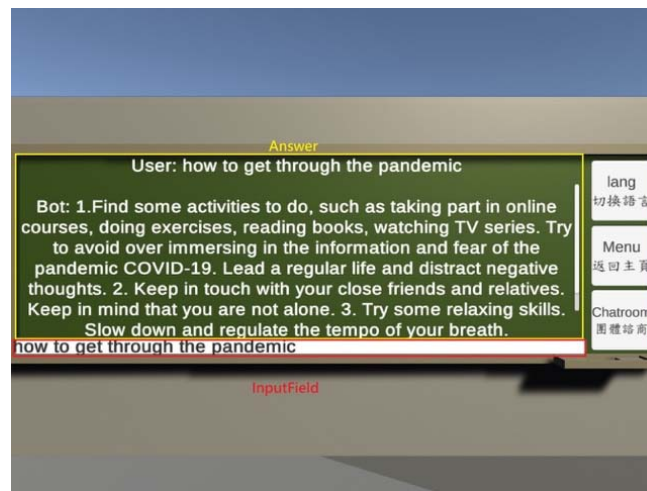


Figure 9. Question and answer of knowledge-based chatbot.

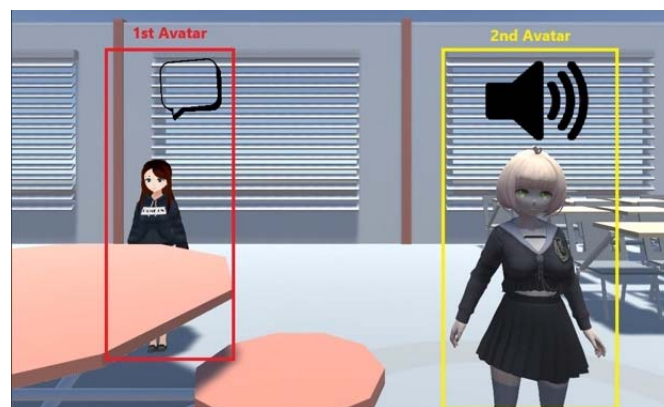


Figure 10. Two avatars chatting in VR-enabled chatroom.



Figure 11. Panel with users' dialog.

5. Conclusions

In this research, a testing platform was developed using a VR chatbot for group counseling to better manage and provide greater access to students suffering from stress. According to our survey results, student stress is a significant problem, and up to 26% of students' daily lives were greatly affected by stress. In practice at the university, traditional counseling services cannot afford the increasing needs of coping with this problem. In addition, our patent review shows that the combination of VR and psychological services is a future direction in the development of better technological applications. Students spend

more time online, especially during the COVID-19 pandemic. Therefore, an online platform for group counseling services integrated with a VR chatbot has multiple advantages for students regarding professionalism, convenience, reality, and ease of interaction. To emphasize these advantages in this counseling system, this research uses the photon server to initially set up a psychological counseling system in a simulated classroom. There is a chatbot counselor in front of the classroom, which covers many counseling-related FAQs drawn from data including knowledge from various therapists worldwide, and using issue and sentiment classification from professional counseling. Students can log in to this platform using their own devices. This provides the advantage of convenience of using the counseling service at any time if needed. Using the platform, they can get professional advice through Q&A with the chatbot. In the chatroom space, they can also communicate with other members about their problems or mood transitions, and receive group learning and group support. The counseling chatbot will be integrated into the chatroom, allowing users to observe each other's interaction with the counseling chatbot, learn from each other, and make progress together. This can motivate students to use the counseling service whenever they need and interact with others if they chose.

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Informed Consent Statement: Not applicable.

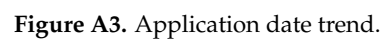
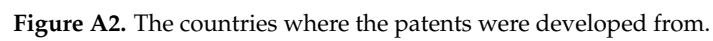
Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Visualized Patent Analysis Result



Figure A1. Related patent application agencies breakdown.



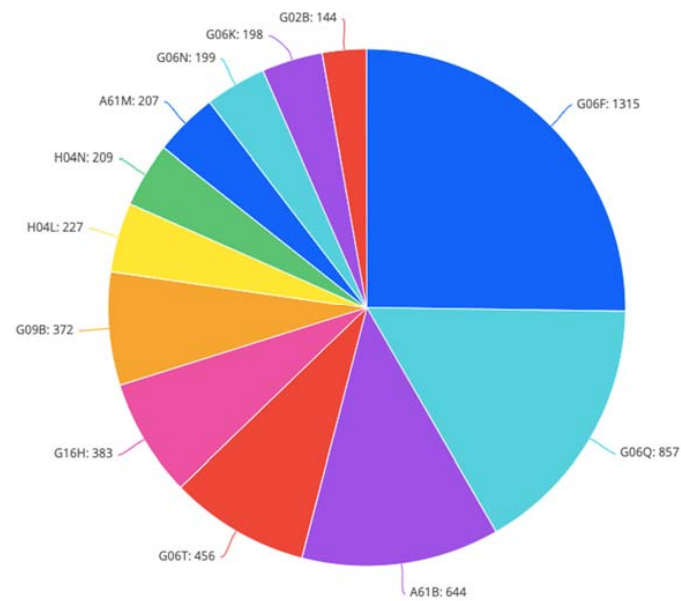


Figure A5. Top IPC classification results.

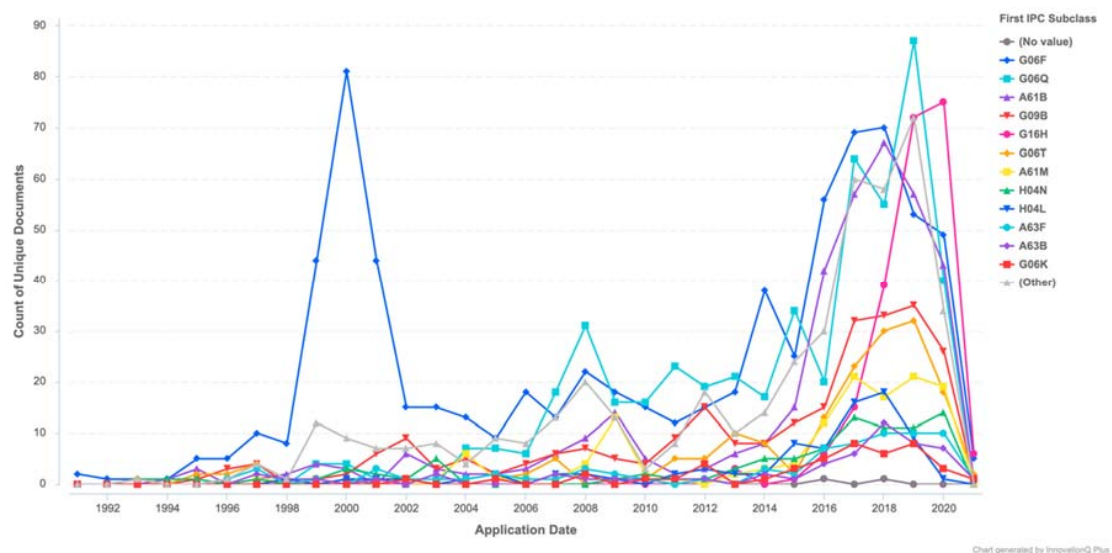


Figure A6. Trend of top IPC over the years.

Appendix A. Survey for School Stress—VR Group Therapy Application

- Phone number: _____
- E-mail address: _____
- Are you willing to participate in a virtual reality group therapy experiment for school stress?
☐ Yes ☐ No

=====

Part I

1. The name of your institution: _____
2. The name of your program of study: _____
3. Your current class level is:
☐ Freshman (Undergrad) ☐ Sophomore (Undergrad) ☐ Junior (Undergrad)
☐ Senior (Undergrad) ☐ Graduate student ☐ Other: _____
4. Your gender is:

☐ Female ☐ Male

5. Your age is: _____
6. How stressed do you feel on a daily basis during the academic year? Please circle your stress level:(Low) 0 1 2 3 4 5
6 7 8 9 (High)
7. What are the usual causes of stress in your life? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Studies issues	0	1	2	3	4
Financial issues	0	1	2	3	4
Family issues	0	1	2	3	4
Friend issues	0	1	2	3	4
Issues with the significant other (partner)	0	1	2	3	4
Work (job-related) issues	0	1	2	3	4
Health Related Issues	0	1	2	3	4
Sports/Athletics activities issues	0	1	2	3	4
My involvement in clubs and organizations	0	1	2	3	4
Other: _____	0	1	2	3	4

8. How do you usually experience stress (in the situations selected from the list above)? Please, describe using a few words to describe the physical sensations and the feelings you encounter when you are feeling stressed.

9. What are the usual BEHAVIORAL effects of stress you've noticed with yourself? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Change in activity levels	0	1	2	3	4
Decreased efficiency and effectiveness	0	1	2	3	4
Difficulty communicating	0	1	2	3	4
Increased sense of humor/gallows humor	0	1	2	3	4
Irritability, outbursts of anger, frequent arguments	0	1	2	3	4
Inability to rest, relax or let down	0	1	2	3	4
Change in eating habits	0	1	2	3	4
Change in sleep patterns	0	1	2	3	4
Change in activity performance	0	1	2	3	4
Periods of crying	0	1	2	3	4
Increased use of tobacco, alcohol, drugs, sugar or caffeine	0	1	2	3	4
Hyper-vigilance about safety or the surrounding environment	0	1	2	3	4
Avoidance of activities or places that trigger memories	0	1	2	3	4
Accident prone	0	1	2	3	4
Other: _____	0	1	2	3	4

10. What are the usual PSYCHOLOGICAL or EMOTIONAL effects of stress you've noticed at yourself? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Feeling heroic, euphoric or invulnerable	0	1	2	3	4
Denial	0	1	2	3	4
Anxiety or fear	0	1	2	3	4
Worry about safety of self or others	0	1	2	3	4
Irritability or anger	0	1	2	3	4
Restlessness	0	1	2	3	4
Sadness, moodiness, grief or depression	0	1	2	3	4
Vivid or distressing dreams	0	1	2	3	4
Guilt or "survivor guilt"	0	1	2	3	4
Feeling overwhelmed, helpless or hopeless	0	1	2	3	4
Feeling isolated, lost, lonely or abandoned	0	1	2	3	4
Apathy	0	1	2	3	4
Over-identification with survivors	0	1	2	3	4
Feeling misunderstood or unappreciated	0	1	2	3	4
Other: _____	0	1	2	3	4

11. What are the usual PHYSICAL effects of stress you've noticed at yourself? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Increased heart rate and respirations	0	1	2	3	4
Increased blood pressure	0	1	2	3	4
Upset stomach, nausea, diarrhea	0	1	2	3	4
Increased or decreased appetite which may be accompanied by weight loss or gain	0	1	2	3	4
Sweating or chills	0	1	2	3	4
Tremors or muscle twitching	0	1	2	3	4
Muffled hearing	0	1	2	3	4
Tunnel vision	0	1	2	3	4
Feeling uncoordinated	0	1	2	3	4
Headaches	0	1	2	3	4
Sore or aching muscles	0	1	2	3	4
Light sensitive vision	0	1	2	3	4
Lower back pain	0	1	2	3	4
Feeling a "lump in the throat"	0	1	2	3	4
Easily startled	0	1	2	3	4
Fatigue that does not improve with sleep	0	1	2	3	4
Menstrual cycle changes	0	1	2	3	4
Change in sexual desire or response	0	1	2	3	4
Decreased resistance to colds, flu, infections	0	1	2	3	4

	Never	Seldom	Sometimes	Often	Always
Flare up of allergies, asthma, or arthritis	0	1	2	3	4
Hair loss	0	1	2	3	4
Other: _____	0	1	2	3	4

12. What are the usual COGNITIVE effects of stress you've noticed at yourself? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Memory problems/forgetfulness	0	1	2	3	4
Disorientation	0	1	2	3	4
Confusion	0	1	2	3	4
Slowness in thinking, analyzing, or comprehending	0	1	2	3	4
Difficulty calculating, setting priorities or making decisions	0	1	2	3	4
Difficulty concentrating	0	1	2	3	4
Limited attention span	0	1	2	3	4
Loss of objectivity	0	1	2	3	4
Inability to stop thinking about the disaster or an incident	0	1	2	3	4
Other: _____	0	1	2	3	4

13. What are the usual SOCIAL effects of stress you've noticed at yourself? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Withdrawing or isolating from people	0	1	2	3	4
Difficulty listening	0	1	2	3	4
Difficulty sharing ideas	0	1	2	3	4
Difficulty engaging in mutual problem solving	0	1	2	3	4
Blaming	0	1	2	3	4
Criticizing	0	1	2	3	4
Intolerance of group process	0	1	2	3	4
Difficulty in giving or accepting support or help	0	1	2	3	4
Impatient with or disrespectful to others	0	1	2	3	4
Other: _____	0	1	2	3	4

14. What are your personal methods to relieve stress? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Eating	0	1	2	3	4
Sleeping	0	1	2	3	4
Drinking	0	1	2	3	4
Drugs	0	1	2	3	4
Sports/Exercise	0	1	2	3	4

	Never	Seldom	Sometimes	Often	Always
Talking with someone	0	1	2	3	4
Shopping	0	1	2	3	4
Computer Games	0	1	2	3	4
Social Media	0	1	2	3	4
Other: _____	0	1	2	3	4

15. How able do you feel to handle stress when you are experiencing it? Please circle your coping skills level:
(Low) 0 1 2 3 4 5 6 7 8 9 (High)

16. What are the most pressing stress factors in your current academic context (related to this program of study)? (Please circle the level you feel)

	Never	Seldom	Sometimes	Often	Always
Study workload	0	1	2	3	4
Grades	0	1	2	3	4
Financial pressure (e.g., tuition, living costs)	0	1	2	3	4
Work (and Study)—Life balance	0	1	2	3	4
Relationship with (some) faculty members	0	1	2	3	4
Relationship with other students	0	1	2	3	4
Campus social life	0	1	2	3	4
Other: _____	0	1	2	3	4

17. What is something that our university could do to help lower your stress?

In the Past Month, How Much Were You Bothered by: (Please Circle the Level You Felt)	Not at All	A Little Bit	Moderately	Quite a Bit	Extremely
1. Repeated, disturbing, and unwanted memories of the stressful experience?	0	1	2	3	4
2. Repeated, disturbing dreams of the stressful experience?	0	1	2	3	4
3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?	0	1	2	3	4
4. Feeling very upset when something reminded you of the stressful experience?	0	1	2	3	4
5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?	0	1	2	3	4
6. Avoiding memories, thoughts, or feelings related to the stressful experience?	0	1	2	3	4
7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?	0	1	2	3	4
8. Trouble remembering important parts of the stressful experience?	0	1	2	3	4

In the Past Month, How Much Were You Bothered by: (Please Circle the Level You Felt)	Not at All	A Little Bit	Moderately	Quite a Bit	Extremely
9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?	0	1	2	3	4
10. Blaming yourself or someone else for the stressful experience or what happened after it?	0	1	2	3	4
11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?	0	1	2	3	4
12. Loss of interest in activities that you used to enjoy?	0	1	2	3	4
13. Feeling distant or cut off from other people?	0	1	2	3	4
14. Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?	0	1	2	3	4
15. Irritable behavior, angry outbursts, or acting aggressively?	0	1	2	3	4
16. Taking too many risks or doing things that could cause you harm?	0	1	2	3	4
17. Being super alert or watchful or on guard?	0	1	2	3	4
18. Feeling jumpy or easily startled?	0	1	2	3	4
19. Having difficulty concentrating?	0	1	2	3	4
20. Trouble falling or staying asleep?	0	1	2	3	4

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