Exploring the academic stress of Chinese university students majoring in Chemistry during the online studying period of the Covid-19

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Abstract: Since the outbreak of covid-19, the location of students' classes has changed from one where students could meet face-to-face with teachers at school to one where students can only study online at home, bringing a different student experience and a different kind of learning pressure. It is worth noting that for some theoretical classes, teachers can teach and students can listen through the internet, but for some practical classes, it is difficult for teachers to teach online and students do not learn the relevant knowledge. As a result, this brings about academic pressure on students. This study aims to examine the impact of online learning on Chinese university students majoring in chemistry during the 2020 epidemic preparedness period. A mixed-methods approach was used to gain insight into the perceptions and resolution strategies of online learning stress among undergraduate chemistry students at a Chinese university during the epidemic. In the quantitative phase, this study used questionnaires to reveal the impact of gender and grade level on students' academic stress; in the qualitative phase, semi-structured interviews were used to reveal how students coped with the stress associated with online learning. The results showed that Chinese male university students majoring in chemistry had significantly higher academic stress than Chinese female university students majoring in chemistry. Statistically significant differences in perceived levels of academic stress were found between fourth-year and first-year, second-year and third-year undergraduate students. Senior year students exhibited significantly higher levels of academic stress than students in other years. It was also found that studying online during the epidemic did not only cause negative academic stress among Chinese university students majoring in chemistry, but also had the aspect of reducing academic stress. The results of this study will help to better understand the needs of chemistry undergraduates in online learning, which will help teachers and schools to develop better teaching and learning activities and thus build a better university education.

Keywords: Academic stress, Chinese university students, Chemistry, Online, The Covid-19

1 Introduction

Beginning in late 2019, the COVID-19 pandemic expanded quickly within a short period of time (Du Toit, 2020). Due to the high transmission rate of the new coronavirus, most countries have adopted measures

to prevent transmission, including locking down cities, strictly enforcing contact isolation, and strict health system precautions (World Health Organization, 2021). It is worth noting that education systems around the world have also been adversely affected by the COVID-19 outbreak, and various preventive measures have been taken in different countries. Among them, governments all over the world have closed all educational facilities to ensure the safety of students and then launched online teaching initiatives to try to stop the disease from spreading. At the same time, reduced population mobility has led higher education institutions to eliminate face-to-face delivery and move to distance learning (Ali, 2020). Universities, places with large numbers of students, must develop similar precautions to minimize the impact of COVID-19 on higher education and beyond. For example, it started by promoting hygiene-conscious messages on campus, encouraging behaviors such as frequent handwashing and not touching face and eyes, while also advising students and teachers to stay home if they felt unwell. Soon, the university canceled large-scale public-facing events such as conferences and speaking engagements, shifting its approach to stricter measures. In other words, the COVID-19 pandemic forced universities to shift their entire teaching process to online classes overnight. As can be seen, the spread of the new coronavirus poses challenges to health systems and education in many countries. Notably, the outbreak presents a bigger threat to the vast Chinese population. The majority of Chinese colleges have implemented online learning in accordance with the government's directive for "uninterrupted studying and instruction" in reaction to the virus' quick spread throughout China. In a short amount of time, a lot of professors have switched to using computers in the classroom, and students are now able to access lessons online from home. (Bao, 2020).

Notably, the sudden change from classrooms to virtual digital spaces based on internet-based tools may have implications for students (Chandra, 2020). The original purpose of human use of computers is to assist learning. Since the 1990s, when the Internet first appeared, individuals have begun to use it for educational purposes (Volery and Lord, 2000), so online teaching is nothing uncommon to us. Online instruction is more repeatable for each student than traditional classroom instruction, and because there are no time or location restrictions, students can learn whenever and wherever is most convenient for them. They can also use resource playback to regularly review and consolidate their knowledge. (Huang, 2020), to a certain extent, reduce students' learning pressure. During the pandemic, the only key difference is that online teaching is the only source of learning due to the virus (Chandra, 2020). Due to the emergence of the COVID-19 pandemic crisis, e-learning has become a compulsory subject in educational institutions such as schools, colleges and universities around the world. In addition, it is no longer the question of whether online education can make high-quality higher education work, but how universities can immediately and effectively carry out online learning activities on a large scale (Liguori, E. and Winkler, C., 2020). Nevertheless, the majority of students are still inexperienced with distance learning despite the rise in enrolment in online courses over the previous few years. Lessons from online learning during the epidemic can only come from prior online course experience (Hachey et al., 2012).

In addition to this, this unprecedented experience of "home isolation" has had a multifaceted impact on students' learning. As a global public health emergency, the virus has caused disturbing psychological stress around the world (MA and Miller, 2021). In addition to the psychological problems caused by the

epidemic, it has also brought many challenges to students. With students isolating at home during the pandemic, this inexperienced online program can be exacerbated by challenging home conditions, including lack of access to academic resources (e.g., computer and internet connectivity) and disruptions in home learning environments (Clabaugh, Duque and Fields, 2021). As a result, there is a demand on students to perform academically. In order to achieve their educational objectives, university students must overcome numerous obstacles. The motivation and performance of students may suffer if these encounters are viewed negatively (Covington, 1993; Weiner, 1979). In addition, if these experiences are prolonged and viewed as uncontrollable, they can make students feel helpless (Abramson, Garber and Seligman, 1980) and stressed (Folkman and Lazarus, 1985), putting some students' academic future at risk among. By contrast, other students who have the ability to successfully endure the harmful consequences of a negative academic experience are easily encouraged later on after minor setbacks, and such challenges can motivate students to develop for the better. In the midst of the pandemic, we should pay special attention to the academic stress associated with college students in this new environment. Academic stress is a student's reaction to having to complete too many demands and tasks (Bedewy and Gabriel, 2015; Nist Olejnik and Holschuh, 2011). It has long been believed that students are least affected by any stress or problem and that the only task a student should undertake is learning, which is considered stress-free (Reddy, Menon and Thattil, 2018). But it turns out that students always live under more pressure than their peers. Their parents and teachers are always comparing them to other children of the same age, asking them to behave better, achieve better grades, excel in extracurricular activities, participate in interest classes, etc., causing these children to be confused and constantly Under pressure. When students experience unprecedented levels of academic stress, most of them report low self-esteem, difficulty concentrating, trouble sleeping, worrying about the future, developing symptoms of anxiety and depression, and being unable to manage coursework have a very negative impact. These affected their academic performance (Bedewy and Gabriel, 2015). In addition to this, less stress does not necessarily lead to better performance by students, as in this case they perceive the task as unchallenging and may also be easily bored (Uchil, 2017). Although a certain level of stress motivates students to perform at their best, when it cannot be managed due to ineffective ways of coping with stress, it can have negative consequences for students (Reddy, Menon and Thattil, 2018). Therefore, in the context of the unprecedented epidemic, the academic pressure of students should also be taken seriously.

As can be seen, this was an extremely challenging time for both students and teachers, especially since many were unaware of the weaknesses of online learning until they adopt an online learning environment (Pilkington and Hanif, 2021). While some courses may transition to distance learning with minimal disruption, such as theory courses, distance learning also hinders one component of many scientific disciplines: the laboratory (Kelley, 2020). Especially for chemistry and related disciplines, this part of the curriculum hinders teaching progress due to lack of access to laboratories (Pilkington and Hanif, 2021). For chemistry courses, much of the interest in the field is believed to originate from student experimentation to teacher demonstrations, while critical thinking, practical knowledge, observational skills, and strong operational skills are developed through laboratory experience (Kelley, 2020). However,

this process was interrupted by covid-19. During the epidemic, chemistry students may not be able to carry out their studies well because they cannot enter the laboratory, and then have related academic pressures. Therefore, this study aims to explore what are the academic stress factors that induce online learning of Chinese college students majoring in chemistry during the 2020 Covid-19 epidemic prevention and control period and how Chinese college students majoring in chemistry cope with academic stress.

1.1 Rationale for the study

Higher education in various countries is facing disruptions due to the emergence of the new crown epidemic. Chinese universities had no choice but to move their courses online. Online teaching is nothing new to students and the only difference from regular online teaching is that it has become the only source of education due to the coronavirus epidemic. The coronavirus epidemic has been accompanied by strict isolation measures, a disturbing social life and isolated learning that has left students feeling stressed. One of the main components of student stress is academic stress. Academic stress comes from a variety of factors experienced by students, such as family-related stress, class competition, curriculum-related stress and financial burdens. For some students, stress may also arise because they are moving from place to place to accommodate academic requirements. In addition, chemistry is part of higher education and unlike some humanities and social sciences chemistry is a laboratory science and during the epidemic students do not have access to laboratories to conduct experiments. These changes can be stressful for students academically, both positively and negatively, and this is part of their experience. Therefore, exploring the impact of online teaching during the epidemic on the academic stress of Chinese university students majoring in chemistry can help students address the issue of academic stress and put themselves in the students' shoes.

1.2 Objectives of the study

The purpose of this study is to consider the impact of gender and grade on the academic pressure of chemistry majors in Chinese universities during the period of epidemic prevention and control. To further determine how Chinese chemistry majors face these academic pressures.

1.3 Research questions

Quantitative phase: The impact of gender and grade on the academic stress of Chinese undergraduate chemistry students during the epidemic preparedness period

Qualitative phase: How Chinese undergraduates majoring in chemistry deal with these problems about academic stress during the epidemic prevention and control period.

1.4 Hypotheses

The following null hypotheses were formulated to guide the quantitative study:

1. In 2020, there was no significant difference in the perceived level of academic stress among Chinese undergraduates majoring in chemistry between males and females.

2. There is no significant difference in perceived academic stress levels among chemistry undergraduates in different grades.

2 Literature Review

2.1 Definitions of terms

2.1.1 academic stress, Chemistry courses in Chinese higher education, online studying

Academic stress is an unpleasant situation that occurs due to the many demands placed on a student or learner, including taking exams, maintaining a healthy and academic life, competing with peers, meeting the academic expectations of teachers and parents, and one's own academic expectations (Aihie and Ohanaka, 2019), meaning that academic stress is the body’ s response to academic-related demands that exceed students’ ability to adapt (Wilks, 2008). Stress can have a positive or negative impact on students' academic performance. Lesser levels of stress may lead to positive outcomes, such as the phenomenon of self-motivation, while higher levels of stress can lead to psychological disorders such as anxiety. High levels of stress are associated with poor academic performance (Sohail, 2013). It is estimated that a significant proportion of students experience some level of academic stress during their academic careers (Johnson, 1979). In this research, I will focus on the academic pressure of college students majoring in chemistry in higher education in China, especially in the context of online learning during the epidemic, because in addition to theoretical courses in chemistry, chemistry experiments may constitute a major component of online teaching. The biggest challenge (Huang, 2020), followed by a series of academic pressures.

Traditional chemistry courses typically include lectures, tutorials, and laboratory components (Lo et al., 2021). In addition, compared with science education research in Western countries, China's chemistry education research stands out for the close connection between curriculum policy, textbook development, classroom teaching, and teacher education. It also distinguishes itself by emphasizing the connection between theory and practice (Liu, Liang and Liu, 2012).

For online studying, learning is defined here as the voluntary act of learning through the Internet (Thomas and Rohwer, 1986), and online learning systems are used to distribute learning knowledge and manage learning sessions through the Internet (Keis et al., 2017). Online learning systems include designing and delivering learning content and facilitating communication between students and teachers (Thanji and Vasantha, 2016). It also includes features such as chat rooms, polls, and quizzes that allow teachers and students to communicate online. These provide convenient ways to achieve learning objectives (Mukhtar et al., 2020).

2.2 The studies about the importance of academic stress

The COVID-19 pandemic presents a variety of unprecedented challenges, including a significant impact on the mental health of young people. Although there is evidence of a high prevalence of mental health disorders among university students, little is known about the specific impact of the COVID-19 pandemic on students' mental health and how they cope with this stress (Prowse et al., 2021). To address this gap, several researchers have examined the impact of the COVID-19 pandemic on the stress and mental health of university students and the extent to which they implement various coping strategies (Prowse et al., 2021; Li et al., 2021; Chen, Sun and Feng, 2020), finding that the main cause of stress among university students is academic stress (Bedewy and Gabriel, 2015), and the majority of articles currently examining the impact of online learning on university student stress during the epidemic have taken a quantitative approach (Li et al., 2021; Chen, Sun and Feng, 2020; Prowse et al., 2021).Comparing these three articles, it can be found that the stress of college students during the COVID-19 period has had a certain impact on their mental health. It also shows that academic stress is one of the sources of stress for students. The results of the reports are different. Li et al. (2021) and Chen, Sun and Feng (2020) believed that when the epidemic comes, men were under great pressure, but more notably, Li et al. (2021) believed that the COVID-19 disease was more aggressive to older male students in masters and doctoral programs living in Wuhan during the pandemic, because when the COVID-19 disease first emerged (National Health Commission of the People's Republic of China, 2020) , and most students have left their hometowns when it has not yet spread widely. This schedule has spared most of the students returning to their hometowns outside Wuhan from the vicious attack of COVID-19, so the pressure on masters and PhDs who have not completed their experiments at this time is even greater. On the other hand, Chen, Sun and Feng (2020) believed that young men were stressed. In addition, Prowse et al. (2021) argued that women were more stressed, and the data trends observed in this study are consistent with predictions from other studies related to young people's mental health, suggesting that their data may be representative of other college student groups, but the results of this study differed from the other two, because the current sample contains more female participants than males, and also gender queer and transwoman, so the sample was of mixed ethnic/racial backgrounds. For this reason, this approach will make research more general.

For Li et al. (2021), Chen, Sun and Feng (2020) and Prowse et al. (2021), the studies have certain limitations. Firstly, the research investigations were all conducted in one location, but due to cultural differences, different patterns may exist elsewhere, thus requiring cross-cultural comparative studies. Secondly, all three articles used quantitative methods, maximising the advantages of quantitative research and allowing more reliable data to be obtained. However, qualitative research could also be conducted to better understand the impact of academic stress on young people's mental health. The reason for these results could also be due to the fact that majors differ in the amount of tasks each major has, with some science majors requiring experiments while arts majors do not need tedious experiments to do, and therefore each individual has different academic tasks that cause different levels of academic stress.

It is evident that the epidemic brought many stressors to university students, and if stress is not treated correctly, students' mental health will suffer and the community should pay attention to students' stress, especially academic stress. There are many types of stress among university students, and although all three studies were designed to address the aspect of academic stress, they did not focus on the impact of online learning during the epidemic on students' academic stress, which is one of the main sources of stress among university students (Gonmei and Devendiran, 2017). We therefore need to go deeper and explore what sources of academic stress induce online learning among university students during the epidemic. Furthermore, all three experiments only utilized quantitative methods and did not take a qualitative approach, resulting in the researchers not being able to address the mental health issues associated with stress from the participants' perspectives and experiences, which should be investigated in a multidimensional manner to address the underlying issues. Therefore, for the study of stress among university students during the epidemic, we should focus on academic stress and use a mixed-method approach to investigate the perceptions of the sources of academic stress among university students, so that we can better address the mental health problems caused by stress from subjective data as well as objective data.

2.3 The studies about the relationship between academic stress levels of university students and gender

Another factor that has been found to influence students' levels of expressed stress is the gender of the student, according to previous research. However, reports of gender differences in the level of expressed academic stress are inconsistent. Some researchers have found that females report higher levels of academic stress than males (Calvarcse, 2015), but others report higher levels of academic stress in males (Mishra, 2018). In other studies (Gonmei and Devendiran, 2017), gender was found to have no significant effect on expression levels on academic stress.

Yikealo, Yemane and Karvinen (2018) used both quantitative and qualitative methods to distribute a questionnaire to students in the Faculty of Education and in addition to the questionnaire, 30 students were selected for focus group discussions. Uncontrollable stress was found to reduce people's social, environmental, and academic resilience. This study was interested in the main academic and environmental factors that contribute to increased stress among university students. In addition, investigating the stress management strategies used by university students was one of the main components of the study. The findings revealed that the majority of students in the School of Education experienced moderate levels of academic and environmental stress. Gender differences and academic performance of university students were also found not to differ significantly. The study is expected to make a significant contribution to assessing stress levels and identifying the most stressful academic and environmental factors.

While Mishra (2018) used a quantitative approach to distribute questionnaires to fifty education students, the findings of this study were that male students had higher levels of academic stress and that the causes of stress were rooted in the current educational and social system. It can be seen that Mishra

(2018) compared to the findings of Yikealo, Yemane and Karvinen (2018), although the participants were all education majors, the results of the study did differ. The reason for this difference could be that the participants in Mishra's (2018) survey were soon-to-be teacher trainees who were in the transition phase between student and teacher. They were worried about their future and their jobs. The scarcity of jobs and fierce competition for them caused them to feel anxious and depressed. Male students are more stressed academically than their female counterparts. Female students are less stressed and perform better than their male counterparts because they are more focused on their studies. They are less likely to be distracted by other social and recreational activities. They see exams and future goals as challenges and work hard to meet them. This is why they score higher in exams than their male counterparts. While male students are more casual and take their studies less seriously, they are easily distracted from the ongoing social and extra-curricular activities on campus and in society. So they start studying just before exams, and when the final deadline arrives, they panic to finish. Thus, the bad habit of procrastination can cause them too much stress. Ebrahim (2016) also used a quantitative approach by distributing questionnaires to the respondents and the study demonstrated that women were significantly more stressed than men. Furthermore, the results of this study indicated that higher education is stressful and that students have higher stress levels than the general population. Notably, the study also found that the subjective health of university students was related to the experience of stress and that good activity habits could reduce stress levels. Therefore, every physical activity should be practised in multiple areas of life, including university, family and leisure.

There are certain advantages and disadvantages for Yikealo, Yemane and Karvinen (2018), Mishra (2018) and Ebrahim (2016). Yikealo, Yemane and Karvinen (2018), this study adopts a mixed method to maximize the realization of the research purpose and obtain two different perspectives. The quantitative research perspective is taken from closed data, while the qualitative research perspective is taken from open individuals data, to obtain a more comprehensive perspective, and obtain more data than quantitative or qualitative research alone. Moreover, this study only focuses on students of the same major, which can focus more on one variable and make the data more accurate. In addition, one of the limitations of this study is that the sample size is limited, that is, the number of participants is small, and only one school in one area is selected, and the data are not generalizable. There is also a lack of time and sufficient financial support to expand research needs. Likewise, the studies by Mishra (2018) and Ebrahim (2016) had a small and limited number of students surveyed, who were not completely randomly selected, may not be representative of the general population, and therefore may not be of a general nature. Furthermore, Ebrahim's (2016) study was based solely on self-reported data, which affects the overall quality of data analysis.

From the above studies, it is also possible that academic stress is a different result for gender differences in students of the same major, because it is possible that the studies have different focuses, and although they both investigate the effect of gender differences on academic stress in university students, the different factors investigated, as well as the investigation of different geographical areas, each with different customs and habits, also contribute to the different results. In addition, Ebrahim (2016)

investigated different majors than the other two studies and the results of the study were different from the other two studies. It is evident that for different majors, each major is set up differently and the sources of academic stress to students are different. Therefore, reports of gender differences in expressing levels of academic stress are inconsistent (Aihie and Ohanaka, 2019). In conclusion, stress greatly affects all students, and it negatively affects the academic performance and well-being of almost all students, regardless of their gender. Many studies have reported significant gender differences. The current situation therefore deserves attention and we cannot ignore it. This issue must be taken seriously and addressed accordingly for students at different stages of their majors so that the stress of students can be reduced (Mishra, 2018).

3. Methods

3.1.1mixed methods research design models

The first stage of the explanatory sequential model, which will be used in this study, focuses on collecting data through a questionnaire and analyzing it using quantitative methods. The second stage is the collection and analysis of qualitative data to explain or extend the quantitative results of the first stage. The qualitative phase is designed to follow the results of the quantitative phase. That is, quantitative followed by qualitative in a sequential manner, ultimately to demonstrate the reliability of the quantitative findings.

3.1.2 interviews

Semi-structured interviews will be used in this study. In this type of interview, the researcher has the flexibility to adapt the questions to the actual situation of the interview. There are no specific requirements on the way participants answer, the form in which the researcher records the interview, the time and place of the interview, etc. All are left to the flexibility of the researcher depending on the actual situation.

It can be seen that, according to the needs of the research, I choose the mode of explanatory sequential design and semi-structured interviews. This study used a mixed method, including quantitative and qualitative research. In the quantitative research process, a questionnaire will be used to study the influence of gender and grade on the academic stress of Chinese undergraduates majoring in chemistry. Quantitative methods are used in the first stage because quantitative research is more standardized and precise, and logical reasoning is more rigorous, so it is more objective and scientific. Quantitative data that measures student cognition, academic stress and its sources. During the qualitative research process, a semi-structured interview method will be used. The qualitative approach was adopted in the second stage because the advantages of qualitative research lie in its simplicity and proximity to the respondents. Qualitative data are available on how Chinese university chemistry students deal with academic stress. Specifically, the quantitative phase saves time, money, and manpower through the use of questionnaires. The results of the questionnaire survey are easy to quantify, which is convenient for statistical processing and analysis of the perception of academic pressure of Chinese college students

majoring in chemistry during the epidemic. In the qualitative stage, semi-structured interviews were used to gain a deep understanding of the views and coping strategies of Chinese college students majoring in chemistry on academic stress, and direct and reliable information and data could be obtained. It is worth noting that if this research only adopts quantitative methods, then quantitative research will simplify the behaviors and concepts of the research subjects, ignore individual differences, and fail to reveal the complex relationship between phenomena and their causes; or if this research Only qualitative methods are used, and the research of qualitative methods is time-consuming and labor-intensive, and it is impossible to study large samples, and it is difficult to obtain general conclusions. Therefore, the mixed method used in this study can give full play to the advantages of the two types of research and obtain two different perspectives. The quantitative research perspective is taken from closed data, while the qualitative research perspective is taken from open personal data, overcoming the limitations of its single research method. Congenital insufficiency.

3.2 Validity and Reliability

Based on empirical evidence and a recent literature review, this study drew on previous experience and obtained the agreement of the researchers who developed the scale to use an 18-item scale to measure perceptions of academic stress and its sources (Bedewy and Gabriel, 2015). This scale was administered to (n = 12) students by experts (n = 12) who were involved in the content validation process of the instrument and each expert reviewed and provided comments on the relevance of the scale to be developed before testing it with students. The developed instrument had an internal consistency reliability of 0.7 (Cronbach's alpha), evidence of content validity, and factor analysis yielded four relevant and theoretically meaningful factors. Chinese university students have some basic knowledge of English, so completing the scale, which measures academic stress and its sources, took 10 minutes.

3.3 Credibility of interview

The interview component of the study was pilot tested by four students. During the interviews concerns and feedback were sought from the students: clarity of questions, identification and reporting of any ambiguous items, and items that were difficult to interpret. Make a list of questions beforehand, write out on paper what you want to know before conducting the interview, put it together as a list of items to ask, and work out the questioning ideas in your own mind beforehand. The list of questions can be used to prevent missing certain questions, but never follow the list exactly, as this will prevent the logical coherence of the person's expression, and also to carefully Listen carefully to what is being said and take each conversation seriously. The questions are in Chinese and the time required to complete the interview is 20 minutes.

3.4 Design of the study

This study adopted a mixed method approach, including both quantitative and qualitative research. In the quantitative phase, data related to gender and grade level on academic stress among Chinese university students majoring in chemistry during the epidemic could be obtained, facilitating statistical processing and analysis of academic stress related to Chinese university students majoring in chemistry.

The qualitative phase uses semi-structured interviews to gain insight into the perceptions and coping strategies of Chinese university students majoring in chemistry regarding academic stress, allowing for direct and reliable information and data to be obtained.

3.5 Sample of the study

All procedures are approved by the University of Southampton Institutional Review Board. The quantitative phase took 10 minutes to complete the survey and the qualitative phase took no more than 30 minutes to complete. All participants voluntarily agreed to participate after being informed of the purpose of the study. The questionnaire was anonymous to ensure confidentiality and reliability of the data. The quantitative study entailed an online questionnaire survey of 256 randomly selected undergraduate chemistry students from a university in China between 1 and 7 September 2022. To minimise personal contact during the outbreak, the link to the questionnaire was distributed via WeChat. Prior to completing the survey, participants were asked to read an informed consent form and indicate their agreement to participate in the study. Only after they had given their consent were they allowed to answer the questionnaire. Participants had to be aged ⩾18 years and be Chinese university students majoring in chemistry. Exclusion criteria were: age <18 years, which was the cut-off age for requiring parental consent; deletion of similar patterns of responses; or failure to complete the entire questionnaire. You can fill in your email address at the end of the questionnaire to facilitate the qualitative phase. A sample of eight university students (N=8; 5 females and 3 males) will be selected from the quantitative phase of the qualitative study. Participants will be contacted via email or WeChat and asked to participate in the study for a personal telephone interview. Telephone interviews will be conducted with those who agree to participate. Prior to the interview, a consent form was sent to the participants and they then gave informed consent. To reduce personal contact during the outbreak, interviews were conducted by telephone.

3.6 Instrument of the Study

A questionnaire was used for the quantitative phase and the Academic Stress Scale (PAS) (Bedewy and Gabriel, 2015) is an 18-item, 5-point Likert-type scale that measures students' perceived, academic stress and its sources. The scale is applicable to both undergraduate and postgraduate students. Responses range from (1 = strongly disagree to 5 = strongly agree). The overall internal consistency reliability was 0.7, with higher scores indicating higher levels of stress for students (Bedewy and Gabriel, 2015). The questionnaire was divided into two sections. Part A sought demographic information about respondents' age, gender and email address, while Part B was an 18-item perception of the Academic Stress Scale. A semi-structured interview method was used in the qualitative phase. The questions were viewed from the participants' perspectives in order to deepen the understanding of the respondents and to draw meaningful insights into the multidimensional phenomenon.

3.7 Procedure

During the quantitative phase, the researchers distributed the Academic Stress Scale to Chinese university students majoring in chemistry via the social media software WeChat. The researcher

explained the purpose of the study to the respondents and assured them of the confidentiality of their responses. Eight students were then selected to participate in the qualitative phase of the study during the quantitative phase. In the qualitative phase, the research instrument was a semi-structured in-depth questionnaire. The interviewer encouraged the participants to recall their experiences in 2020. The interviews were based on the questionnaire in the quantitative phase. The interviews were conducted with questions ranging from shallow to in-depth and participants agreed to record the interviews. Each interview lasted 30 minutes.

3.8 Data analysis

In the quantitative phase, data were analysed using SPSS version 26. The data collected were collated and analysed using descriptive (mean and standard deviation) and inferential statistics (t-test for independent samples and ANOVA). The alpha level was set at 0.05. The independent variables of the study were two, one being gender and the other being grade. The dependent variable of the study was the perceived level of academic stress among the Chinese university students majoring in chemistry who participated in the study.

Content analysis during the qualitative phase consisted of the following stages: 1) the primary researcher first read each interview transcript line by line, jotting down notes to capture and identify the categories that emerged from the data; 2) the researcher reviewed the main topics to prevent omissions; 3) the researcher identified connections between contextual and content-related themes and sub-themes. They compared all completed interviews to consolidate meaning and derive a theoretical structure; 4) core themes or major categories that emerged from the data were conceptually reordered and placed back in context.

4.Findings

4.1.1 Quantitative phase results

Table 1: Descriptive levels of perceived academic stress among male and female undergraduate students

1male
2Female

Sex	N	Mean	Std Deviation
1	112	63.51	7.553
2	144	55.08	6.968

The results on Table 1 show that the average score of men's perceived academic stress was 63.51 (SD=7.553), and the average score of women was 55.08 (SD=6.968).

Hypothesis 1: There is no significant difference in the perceived level of academic stress between male and female Chinese undergraduate chemistry students in 2020.

Table 2: Independent samples t-test on the difference in the level of perceived academic stress between male and female undergraduate students.

	Levene's Test for Equality of variances		t-test for equality of means				
	F	Sig	t	df	Sig. (2-tailed)	Mean diff	Std Error diff
Equal variances Assumed	.583	.446	9.251	254	.000	8.426	.911
Equal variances Not assumed			9.158	228.781	.000	8.426	.920

*significant at 0.05 level

The mean scores for males and females were compared using an independent samples t-test. The results shown in Table 2 indicate that the difference in means of 8.426 was significant at the 0.05 significance level. Therefore, it is inferred that male undergraduate students have significantly higher levels of academic stress than their female counterparts.

Hypothesis 2: There is no significant difference in the level of perceived academic stress between undergraduate chemistry students between years.

Table 3: Descriptive statistics showing the mean and standard deviation of perceived academic stress levels of undergraduate students at different levels of study

	N	Mean	Std Deviation
1	57	52.81	5.749
2	63	56.59	8.143
3	63	58.08	7.499
4	73	65.90	5.561
Total	256	58.77	8.343

The descriptive statistics shown on Table 3 indicate that fourth-year Chinese undergraduate students majoring in chemistry had the highest mean score for perceived academic stress (M = 65.90, SD = 5.561), followed by second-year undergraduates (M = 56.59, SD = 8.143), third-year undergraduates (M = 58.08, SD = 7.499) and first-year undergraduates (M = 52.81, SD = 5.749). A one-way ANOVA was conducted to determine if the differences between the three groups were statistically significant at the 0.05 significance level and the results are shown in Table 4 below.

Table 4: Summary of non-parametric tests on differences in academic stress levels of undergraduates at different stages of study

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of MD is the same across categories of grade.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

The results on Table 4 show the p-value = 0.000. The p-value is less than the alpha level of 0.05. The results therefore reject the original hypothesis. To determine the direction of the significant difference, a Independent-Samples Kruskal-Wallis Test was conducted and the results are shown in Table 5 below.

Table 5: Pairwise comparison of academic stress levels of undergraduates at different stages of study

Pairwise Comparisons of grade

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
1-2	-36.717	13.508	-2.718	.007	.039
1-3	-42.503	13.508	-3.147	.002	.010
1-4	-117.310	13.061	-8.982	.000	.000
2-3	-5.786	13.165	-.439	.660	1.000
2-4	-80.593	12.707	-6.343	.000	.000
3-4	-74.807	12.707	-5.887	.000	.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.

Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

The results in Table 5 above indicate that there is a statistically significant difference in the perceived level of academic stress among seniors versus freshmen, sophomores, and junior undergraduates. There is a significant difference in academic stress between freshmen and sophomores. There are also significant differences between freshmen and juniors. There is no significant difference in academic

pressure between junior and sophomore students

4.1.2 Qualitative phase results

In this section, we analyze the reported results and identify three main themes from the participants' narratives: 1) gradual adjustment to a new learning environment; 2) advantages and disadvantages of online teaching by teachers; and 3) academic integrity. Participants reported that these issues were prominent during the epidemic, away from campus, and during online learning at home. We will analyze how best to address academic stress among Chinese university students majoring in chemistry by observing the participants' state of mind in the face of the academic stress caused by the onset of the epidemic.

4.2.1. Gradual adaptation to a new learning environment

All eight participants in the qualitative phase described how their lives were affected by the new coronavirus. This change was unprecedented. At the beginning of the epidemic, when the virus was first discovered, participants felt that the virus was so far away from people's daily lives that they did not pay much attention to the epidemic. However, as the epidemic continued to spread, the scope of the people affected gradually expanded and spread to other countries, and the respondents' sense of shock and serious concern increased (Levkovich and Shinan-Altman, 2021). People received information from a variety of media sources. Some of these sources were reliable, such as the Chinese government. Other less reliable sources spoke of Wuhan, China as the origin of the virus (Sarkar, Mandal and Paul, 2021), but it was later confirmed that the virus did not start in China. In addition, the guidelines provided by the Ministry of Health were not clear to everyone, leading to confusion, information confusion and internal unrest (Levkovich and Shinan-Altman, 2021).

Zhang said, "A few months ago, I had just started university and was enjoying the good old days of starting university, then the winter break started and I was back home with my family looking forward to Chinese New Year. When Covid-19 was first reported, it didn't get much attention, but as the number of people in the viral crisis grew and I saw more and more requests for help and casualties, it became apparent to me that the mood of people around me began to change, becoming panicked and helpless. As the start of the school year approached, the school sent out a notice saying that the return to school would be suspended and teaching activities would be fully online. At first everyone was feeling new and even a tinge of excitement because they didn't have to go to school. It was a new time that we had never experienced before, and teachers and students began to familiarise themselves with the instruments and equipment. Although there were many jokes in the process because we were not familiar with the online equipment, we gradually adapted to the new learning environment. On top of that, I felt a great need to follow the news and find out what was happening in the world to dispel my uncertainty" (female freshman student in 2020, just six months into the course).

Six participants reported that their feelings ranged from indifference, to panic, to being organised for online learning. They began to adapt to the advantages as well as the disadvantages that online learning

brings. They therefore needed to download various learning software and become proficient in its functions. At the same time, the instability of the network is also a factor, as some students live in remote rural areas where communication facilities are not well developed, which greatly affects their academic progress.

Li said: "I thought the epidemic would pass quickly, I never thought it would reach such a large scale that all the universities in China were closed and teachers needed to turn on online teaching, so I needed to download some learning software to keep up with the teaching, because my family is in a rural area and sometimes the signal for online classes is not very good, which causes the classes to be intermittent, which affects my progress in learning" (female second-year student in 2020).

Seven participants described being shocked by the arrival of the outbreak. The subject of chemistry itself is an experiment-based science, so doing experiments is an important part of the chemistry course. However, the epidemic caused the school to close and students could not return to do their experiments, and the course schedule was changed.

Chen: "We have quite a lot of classes that require labs in our junior year of school, and the epidemic caused us to be unable to access the labs. The teachers cancelled some of the labs and made up for them offline after the school year started. Although, the pressure regarding online courses decreased during the epidemic, the pressure became high for everyone when we returned to school." (Male student in his third year of university in 2020).

Most participants reported that after initial shock, they found themselves gradually adapting to life in the presence of COVID-19. The difficulty in adapting stemmed from having to stay in their own homes and limiting their activities. These participants described how difficult this was, citing the fact that they felt their freedom had been taken away from them. However, the situation also provided them with an opportunity to reacquaint themselves with and draw closer to their families.

Dai: "When I was first at home, the family atmosphere was quite harmonious. But after staying at home for a long time, there was a lot of friction with my parents. I have my own schedule, but my parents think I should be doing other things during this time. This kind of demand makes me feel distressed" (female second-year student in 2020).

4.2.2 Advantages and disadvantages of online teaching for teachers

All study participants described the advantages and disadvantages of online classes for teachers. seven mentioned that the teachers taught through online devices and the students talked to their classmates and teachers through their mobile devices. The internet became the only means of communication between them, which increased their uncertainty. They described how the teacher's lack of proficiency with the device during the online teaching process led to deviations in the quality of the teaching and what could happen unexpectedly during the teaching process, adding to the uncertainty of teaching

online while leaving students feeling at a loss. However, online lessons are repeatable and students can watch them repeatedly after the lesson.

Zeng said: "In class, because my major involves the need to write chemical equations, teachers are not skilled in the operation of online equipment and use PowerPoint presentations directly, resulting in this result not being so comprehensible. In previous offline classes, teachers could teach people step by step on the blackboard to come up with the result of this equation, but online teachers cannot so The result of the chemical equation could not be written out so intuitively. So this has had some impact on my learning. But thankfully, the online class was recorded by the teacher and I could watch it again and again offline" (male second year student, 2020).

Five participants felt anxious about communicating with their teachers, as the students could only communicate with them via mobile devices due to the epidemic, but the lack of face-to-face communication resulted in students not being able to communicate with their teachers in depth. These concerns led to feelings of uncertainty about online learning, anxiety and a lack of control over the current situation.

Liu said, "During class, I would have some knowledge that I didn't understand and needed to ask the teacher for advice. But because everyone communicates online, it leads to a lot of problems, for example, if the internet is down, you can't communicate with the teacher very well; sometimes the results of a chemistry experiment need to be demonstrated, and this is difficult to answer online. These cause a hindrance to my studies." (Female student in her third year of study in 2020).

4.2.3 Academic integrity in relation to online examinations

All eight participants described the school's arrangements for online exams during the epidemic, which involved the academic integrity of the exams. five mentioned that the exams were held online without the supervision of teachers around them, who could only observe students taking the exams through cameras, and that students had to rely on self-awareness to comply with the exams.

Lu said, "Our exam was online and the teacher asked us to turn on the webcam during the exam because the computer's webcam is not 360 degrees free. After the exam, I heard from another student that he had searched the answers on another device and got a high score and that the teacher hadn't noticed him doing so. This made me feel very unfair. Our school is guaranteed by grades and some students care about the high marks, but I think this behaviour is wrong and unfair." (Male third-year student in 2020).

Four participants expressed concern about the online examinations because the online teaching equipment was not very well equipped and the quality of the online teaching was slightly less than that of the offline teaching, but the content of the examinations was assessed according to offline standards.

Lin said, "The exams at our school are taken online and some teachers ask us to turn on a double camera,

which means one camera in front and one in the back. I feel that this has improved the authenticity of the exams. But some teachers in our school, who were not that familiar with the use of the equipment, just distributed the question papers and asked us to finish writing them within the time limit, without even turning on the camera, so that the students could pass the answers among themselves. Many times in our class, after the teacher had called the roll, some students left the computer screen, and they were not very clear about what the teacher was doing in class. When it was time for the exams, the top students in the class started to be approached and asked for the key points of the exams. The exams for the lab classes were moved to the offline start of the school year, and many students were also improvising to catch up on their knowledge. It can be found that students are not very efficient in the online learning process" (female 2020 second-year student)

Some participants described how their schools did not hold online exams, but rather followed regular offline exams, with some schools notifying students to return to school in June and July for exams when most schools begin to resume regular schooling in September in the fall of 2020.

Li said, "I feel that the arrangement of the school is very unreasonable, why can't we wait until we are in a safe period before we return to school? Instead, we were told to return to school in June and July. We had offline exams after we returned to school and wore masks throughout the exams, which meant I couldn't breathe well enough to focus on my exams. The campus was closed and students were confined to their dorm rooms, resulting in us being very unfree and mentally tortured. Why can't the school postpone the start of school backwards, like most schools do? We are also closed when we return to school and we are isolated in our dormitories and suffer mentally and physically. It is better to be isolated at home and postpone the start of school like most schools. I don't know what the point of schools starting earlier is?" (female 2020 second-year student)

5.Discussion

The results of the quantitative study showed that male students majoring in chemistry in Chinese universities had significantly higher academic stress than female students majoring in chemistry in Chinese universities. This result is inconsistent with the results of Ebrahim (2016) and Calvarese (2015), who found that female students have higher academic stress than male students. Furthermore, the results of Gonmei and Devendiran (2017) and Yikealo, Yemane and Karvinen (2018) showed that gender did not have any effect on students' academic stress. However, the results of this study showed that male university students were more academically stressed than females. This could be because patriarchal societies are more male seeking (Aihie and Ohanaka, 2019), or it could be because the study group in this study was university students majoring in chemistry, while the results of other studies differed depending on the study group. Another reason is that males are more casual in their studies than females, which leads to procrastination, which can lead to more work and going through assignments near the end of the task, which in turn can lead to tension and stress (Mishra, 2018). The results indicate that there is a statistically significant difference in the perceived level of academic stress

among seniors versus freshmen, sophomores, and junior undergraduates. There is a significant difference in academic stress between freshmen and sophomores. There are also significant differences between freshmen and juniors. There is no significant difference in academic pressure between junior and sophomore students. The findings do not support Khan, Altaf and Kausar (2013) who found higher levels of academic stress in lower grades than in higher grades. Notably, the qualitative phase of the study also found that students in their final year of university felt significantly more academic stress than those in their first three years of university. This result could be due to the fact that in 2020, being juniors, their lab classes were shifted to their senior year courses due to the epidemic. This reason leads to an increased workload for them, including pressures such as a final year thesis in their final year of university. This may also be due to concerns and anxieties about the final results and future employment. Students in their final year are about to graduate and failure in their courses may result in them not graduating successfully. This finding is in line with Elias, Ping and Abdullah (2011) and others who found that final year undergraduates felt more stressed than students in other years.

In addition, qualitative findings on participants' perceptions of academic stress during the epidemic provide insights that complement and clarify the meaning of the quantitative findings. To briefly review: three themes emerged from the content analysis of participants' responses to the open-ended questions, which reflect the perceptions of Chinese university students majoring in chemistry regarding the stress of studying online. Specifically, online learning during the epidemic not only created negative academic stress for Chinese university students majoring in chemistry, but also had the aspect of reducing academic stress. The qualitative study revealed the prevalence of academic stress among chemistry undergraduates during the outbreak and their need to readjust to a new learning environment. The participants' negative academic stress was found to come mainly from the online teaching process, where some older teachers were not able to use online teaching tools well, resulting in students not being able to understand the knowledge well, and from senior students facing job hunting and writing their thesis. In addition, many participants said that they felt less academic pressure during the online learning process than during offline studies because they did not take lab classes during the epidemic. Another important qualitative finding - after the epidemic subsided, students felt high academic pressure upon returning to school. Because almost all institutions were closed during the epidemic, chemistry majors could not access laboratories to conduct experiments, and when universities started their offline studies, they needed to make up for the laboratory classes they had not taken during the epidemic. The pressure is particularly high for juniors and seniors, who are faced with the task of studying for graduate school, studying for graduate school, and doing internships to find jobs. In addition to these tasks, senior students have the task of writing their thesis, and writing their thesis requires a lot of experimental data, so they also need to go into the laboratory to complete the data for their thesis, causing the pressure on senior graduates to be higher than those in other years, which explains why the pressure on senior graduates is found to be higher than that on freshmen, sophomores and juniors in the quantitative.

Limitations and recommendations: This study highlights the impact of online learning on academic

stress among Chinese university students majoring in chemistry during the 2020 epidemic. However, this study still has some limitations and more research is needed to understand what types of online learning can reduce academic stress and anxiety. The data for this study was collected from only one Chinese university and the sample size was too small, which may limit its applicability. The study relied primarily on questionnaires and interviews about the Perceived Academic Stress Scale to assess academic stress among Chinese university students majoring in chemistry, and did not make a clinical diagnosis that would allow for a deeper understanding of student stress. In addition, the qualitative research questions used semi-structured interviews aimed to understand the study participants' feelings, behaviours and ways of coping with academic stress online during the 2020 epidemic. However, they limited the possibility of obtaining more realistic information from participants, and it portrayed that the review of university students majoring in chemistry about academic stress from studying online at home during COVID-19 in 2020 would have been subject to memory bias and the results could have been affected. As the virus continues to spread, research should continue to explore the psychological and emotional responses of this group of university students over time, given the rising morbidity and mortality rates worldwide. Notably, the use of mixed methods limits the ability to generalise our results to a broader population (Levkovich and Shinan-Altman, 2021).

Problems identified during the research process can be addressed in the following ways. Teachers socialise via a virtual platform and provide regular briefings about course assessments. Teachers use motivational remarks to help students stay focused and strive for excellence (Riaz et al., 2021). In terms of rewards, students are rewarded for any positive behaviour (El-Seoud, El-Khouly and Taj-Eddin, 2016). This initiative by the teacher stimulated students to continue to achieve and perform at the highest level. The next step was to reduce their stress. There are no strict deadlines set for attendance, participation or submission, which helps students engage better with online courses (Allam et al., 2020). Teachers can also use more online learning methods, such as group discussions, to enhance communication between students, and can also set up instant messaging systems so that teachers can help students in a timely manner. In this way, academic stress and anxiety can be reduced (Riaz et al., 2021).

In addition, universities should provide counselling and behavioural techniques to help students manage academic anxiety. Most important for online learning to work well is the need for government departments to remove the availability of barrier devices that limit students' access to the Internet, which is necessary to register for online learning courses. In future research, organised clinical interviews could also be used to diagnose academic stress in university students. Therefore, in view of this occurrence, universities could bring forward their offline theory classes if they are once again fully online, thus reducing the academic stress of chemistry undergraduates when they return to school. Alternatively, for some simple experiments, small programs could be developed that students could operate online to get a more intuitive feel for the experimental process. In addition, the researchers recommend that higher education institutions acknowledge students' experiences and adopt more relaxed policies during these difficult times in order to promote the learning experience and safeguard students' academic achievement and, more importantly, their physical and mental well-being. Schools also need

to train teachers in the skills of online teaching and for some older teachers, some teaching assistants could be recruited to assist them in their teaching. However, it is important for teachers to understand the negative impact of online learning on students' academic performance during the epidemic. Teachers' teaching skills should be adapted to the needs of their students. Schools can provide planning support for changes in online teaching and learning, access to academic resources and changes related to COVID-19 can both predict changes in academic stress. Those responsible for designing university courses should proactively address stress in the student body and help individuals to access specific coping strategies (Vaez and Laflamme, 2008). Helping students develop realistic expectations of learning and incorporating their previous school experiences. Stress management programmes can be offered by education professionals, as self-help, or as part of a university course. Universities should provide health training courses in stress reduction (Stormont and Young-Walker 2017). Courses on academic career guidance planning could be offered to new university students, as well as career guidance and transition for final year students.

It is worth noting that universities should also launch health awareness campaigns to address the coping mechanisms and healthy habits needed to deal with existing challenges. Students are the ones facing academic losses. All this can lead to disturbances in their mental state. Students should also use coping strategies such as yoga, exercise and pastime therapy, such as spending time with their families on watching television. Academic, environmental, social and health issues all play an important role in the development of stress, however, academic factors are the most important stressors (Yasmin, Khalil and Mazhar, 2020); during the qualitative phase, we observed that students isolated in halls of residence were prone to stress; therefore, regular reviews of halls of residence by the school based on student feedback, as well as complaints from students should be addressed in a timely manner. Although some students are frequently reluctant to use support services, the majority of students support the inclusion of stress management education in the curriculum (Deasy et al., 2016). Concrete and targeted measures are therefore needed to significantly reduce the stress burden on students.

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The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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