COVID-19: MID- AND LONG-TERM EDUCATIONAL AND PSYCHOLOGICAL CONSEQUENCES FOR STUDENTS AND EDUCATORS

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COVID-19: MID- AND LONG-TERM EDUCATIONAL AND PSYCHOLOGICAL CONSEQUENCES FOR STUDENTS AND EDUCATORS

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EDITORIAL
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Editorial: COVID-19: Mid- and Long-Term Educational and Psychological Consequences for Students and Educators

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Editorial on the Research Topic

COVID-19: Mid- and Long-Term Educational and Psychological Consequences for Students and Educators

INTRODUCTION

COVID-19 pandemic has been a great challenge to our societies. To reduce its impact, different approaches, and politics have been used. However, public health, along with educational breaches have been evidenced in most countries in which not all citizens have the same opportunities to deal with the pandemic. Therefore, this has led to pervasive consequences, including mental health problems because of the disruption of everyday life routines.

LITERATURE AND RESEARCH

The impact of COVID-19 pandemic on the educational system happened abruptly in the spring of 2020, when most of the countries experienced a shift from face-to-face education to distance and online learning, or in the worst cases, to non-existent education. The consequences of such changes have been studied at the different stages of the education within this Research Topic (Figueroa-Quiñones et al., in university students; Rao and Rao, in highschoolers; Combette et al. in middle school scholars; or even honors research students in Kumar et al.).

In countries where the population did not have the possibility to get access to electronic devices or the internet, governments implemented alternative educational strategies, including teaching via public TV channels or even cell phone applications, such as *WhatsApp or Telegram* to set homework for children. In other cases, school platforms were used so that teachers and students were able to interact, but this was only possible in those schools where digitalization and teacher training was already initiated (do Amaral et al., 2021). These changes once again demonstrated the lack of equity in access to education, not only between countries, but also within-countries. In February 2022, some regions in the world still have partially opened schools and educational centers, affecting more than 40 million enrolled learners around the world (United Nations Educational Scientific and Cultural Organization, 2022).

The existing resources are not the same for everyone, and even the closure of schools showed the bitter face of the reality of many children, who were not only left without an education, but without their daily food rations (World Food Program, 2020). Further, some other children were forced to

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stay at home with their aggressors and abusers, as described in the opinion article by Fares-Otero and Trautmann, published in this Research Topic.

Hardly any country knew how to act ahead of what was happening in different parts of the world, leaving populations at their mercy until the healthcare system collapsed. Governments began then to impose lockdowns, restrictions on mobility, curfews, and prohibitions, along with the closure of workplaces and non-essential activities, including schools. Children and adolescents were confined to their homes with no other alternatives. Even currently (March 2022), in some countries there are still restrictions on children's access to education because of the pandemic. For instance, most children and adolescents, and their teachers, must wear masks for several hours in their classes, something which is not only uncomfortable, but also impedes a natural social interaction because they cannot see each other's facial expressions. In addition, many social activities are still restricted and consequently, all these changes in everyday lives and activities have a clear impact on mental health.

Many of the problems that we have been experiencing during the last 2 years of the pandemic have been described in this Research Topic as a result of the authors' examination of the ongoing reality in their countries. Undoubtedly, their research helps us to better understand the repercussions that the pandemic will have, not only in terms of mental health consequences, but also in terms of education, equal opportunities and/or access to health, education, work, and quality social networks, which are all essential factors for the integral development of the human being.

Two years later, we have seen that the pandemic has brought stress, anxiety, depression, and symptomatology associated with post-traumatic stress in a broad spectrum of the population. The frequency of emotional disorders has considerably increased in children, adolescents, and young people, who have seen their development and their freedom impeded. In addition, eating disorders in children and younger adolescents have multiplied, and self-injurious behaviors and suicidal ideations have also notoriously increased and are extremely common, reaching, in some countries alarming figures (Henry et al., 2021). Despite this dramatic situation, the policies of most countries in relation to mental health have not changed much.

In this Topic Research, Rao and Rao studied mental health and stress in teens at High School, reporting a positive correlation between mental health degradation and online learning, with a negative correlation between physical exercise and mental health degradation. These findings are important because in many countries, for more than one scholar-year, all classes were conducted online, and thus physical exercise was not possible due to the pandemic restrictions.

Another relevant factor is that the resources for education during the pandemic have not changed significantly in many countries either. Therefore, the attention to students remained similar, although with stressed and burned-out professionals. In different parts of the world, and in different cultures, we have observed very similar reactions from the population, witnessing a global decline in mental health in young people, which will undoubtedly have repercussions in the future. The research works included in this Topic Research address different examples of this kind.

Educational resources are low in many countries and regions. Not all the students or teachers have access to an adequate e-learning environment, or access to computers and/or internet and, above all, training in digital competencies are still not guaranteed in most places. Weißenfels et al. investigated the burnout and self-efficacy in teachers during the first pandemic school year in Germany, a country where the access to internet is common [e.g., 94% of internet use, according to the Federal Statistical Office of Germany (2022). https://www.destatis.de] and the access to the internet is considered a basic right. However, even under these favorable circumstances, in Germany, the lack of educational resources was still considered a great challenge to the education professionals, who experienced problems with their daily activities.

Finally, it is important to define protective factors which could ameliorate the negative impact that the pandemic has exerted in our daily lives. For instance, in the study conducted by Combette et al. the authors identified the student's motivation as a key factor for engagement throughout difficult times because of the pandemic, in middle school students. Further, some ideas to prevent dropout or failure in the event of a catastrophe (i.e., global or local), have been pointed out by Supriya et al. Among these, we would like to highlight the importance to build a fluid and robust channel of communication between the agents of the educational community so that, in case of need for change or flexibility of the methods, these can have a positive outcome and be adapted to the needs of all.

CONCLUSIONS

In conclusion, this Research Topic highlights the importance of Education and Mental Health after the breakage of the COVID-19 pandemic worldwide. Communication, training, resources, and motivation are all key factors in dealing with such challenging times, but behavioral-educational factors should be also considered, as these are essential if preventive and rationale intervention strategies want to be implemented among the general population (De la Fuente et al., 2021).

Future lines of research should investigate how specific policies and strategies employed in different countries might have a differential impact on the mental health and the educational systems. Further, the long-term effects associated with the COVID-19 pandemic need further consideration. We believe that a detailed examination of the short, mid, and long-term consequences caused by COVID-19 would help us to better prepare for future challenges and to ameliorate their impact.

AUTHOR CONTRIBUTIONS

MA-A, RS, and IM-M contributed to the conception, design, writing, and correction of this editorial. All authors contributed to the article and approved the submitted version.

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ORIGINAL RESEARCH
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The Mental Health of High School Students During the COVID-19 Pandemic

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The American Psychological Association (APA) reports 81% of Gen Z teens (ages 13–17) have experienced more intense stress during the COVID-19 pandemic. This study uses a survey-based approach along with robust statistical analyses to identify key stressors from a set of students in a high school in Midwest United States. Our survey includes a broad range of stressors (15 explanatory variables) specific to high schoolers, controls (4 factors for pre-existing conditions), and mental health estimators (7 dependent variables) to identify changes in mental wellbeing during the pandemic. The results (n = 107) show good consistency in our estimators (Cronbach's α = 0.78) and statistically significant (t = 0.636, $p \ll 0.001$) degradation in the mental health. Correlation (r = 0.2, p = 0.034) and regression analysis showed that online learning ($\beta 1$ = -0.96, p = 0.004) has the most influence on degradation in mental health, with some race-based differences. Exercise time helps reduce mental health degradation ($\beta 3$ = -0.153, p = 0.037). Many other factors such as gender, homework time, school time, pre-existing mental health issues, and therapy did not have a significant influence on mental health degradation. Analysis of freeform feedback identified the following three recurring themes: increased stress due homework (13.2%), social isolation or lack of social interactions (8.5%), and lack of support for mental wellbeing (12.3%).

Keywords: mental health, online education, COVID-19, high school students, survey-based

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INTRODUCTION AND LITERATURE REVIEW

The COVID-19 pandemic has had a significant worldwide impact on the lives of more than 1.6 billion students at its peak (UNESCO 2021) and their schooling. Similar to many other countries, the United States also pursued a policy to lockdown schools, starting in mid-March 2020, to mitigate the pandemic. The lockdown caused the schools to rapidly adopt and pursue remote learning using video conferencing methods. The teachers, students, and their families have experienced several different challenges, including increased stress and anxiety that has led to degradation of mental health. The issues have been further compounded by stringent social distancing measures necessitated due to the lack of vaccines and high mortality rates (over two million deaths worldwide).

The issue of degrading mental health due to pandemics has been reported in the past (Hawryluck et al., 2004; McAlonan et al., 2007; Lau et al., 2010; Xiang et al., 2014). The circumstances surrounding the COVID-19 pandemic have increased the stress and anxiety in people (APA 2020; Tandon 2020; Wang et al., 2020), including high school students. Liang et al. (2020) report a much higher fraction of youth with psychological issues during the COVID-19 pandemic when compared to prior pandemics. The American Psychological Association (APA)

reports [American Psychological Association (APA), 2020] that nearly 81% of Gen Z teens Gen Z teens (ages 13–17) experience more intense stress due to COVID-19, associated with schooling. However, APA's report does not delve into the specific details of the stressors arising from the pandemic-related changes in schooling. The issues related to schooling and their impacts have been reported in many countries (Dolean and Lervag, 2021).

China was the first country to be impacted by the COVID-19 pandemic. Hence, several studies analyzing the impact of the pandemic on the mental health of students have been reported. Hou et al. (2020) discuss the issue of mental health problems and suicidality among senior high school students in China during the COVID-19 pandemic. Their study involved 859 high school students (61.4% male and 79.4% below 16 years of age). Their results showed that depression, anxiety, PTSD, and suicidal ideation, and suicidal attempts were 71, 54.5, 85.5, 31.3, and 7.5% respectively. However, their study did not specifically focus on specific stressors, though they surmise that educational pressure, pronged school closure, and social stigma of COVID infection might be stressors. Nevertheless, they report that higher exercise frequency, a control in our study, correlated with fewer symptoms of depression and anxiety. Another cross-sectional study of 532 Chinese high school students by Zhang et al. (2020) used three types of questionnaires from prior studies and showed that nearly 20% of the students' mental health was impacted. Their analysis showed that resilience and positive coping were protective factors against depression, anxiety and stress symptoms. Another cross-sectional study (Liang et al., 2020) of 584 youth (age 14–35) in China showed that 40.4% were prone to psychological problems and 14.4% had PTSD symptoms. In the context of COVID-19, their study suggested that mental health was related to educational level, employment, and using negative coping styles.

Asanov et al. (2021) discuss results from a cross-sectional survey of over 1,500 high school students (age 14–18) in Ecuador. Their survey has been conducted via phone interviews with the participants, focusing on topics related to access to remote learning technologies and their impacts. They used the MHI-5 index proposed by Veit and Ware (1983) that uses a five-point Likert-like scale to assess their mental health along with a cutoff score of 17 (max score of 25), with higher scores indicating better mental health. Their survey found 16% of participants had scores that indicate major depression. Similarly, a longitudinal study involving 442 last year high school in Greece by Giannopoulou et al. (2021) showed an 15.3% increase in depression, 17% increase in severe depression, 25.7% increase in anxiety, and 16.7% increase in severe anxiety after just one month of lockdowns. They use Generalized Anxiety Disorder Scale (GAD-7), which is a 7-item questionnaire with each item using a 4-point Likert-type scale to assess anxiety. They used a modified version of the Patient Health Questionnaire-9, that also uses a 4-point Likert-like scale, to assess depression.

Similar to the works of Asanov et al. (2021) and Giannopoulou et al. (2021), our study also used a 5-point Likert-like scale to assess the mental health of high school students. Although our survey is not longitudinal, it includes self-reported mental health scores before and during the pandemic, giving it some longitudinal characteristics. Since the survey was conducted during the pandemic, the self-reported mental health scores prior to the pandemic are subject to recall bias, similar to the analysis reported by Giannopoulou et al. (2021). Moreover, similar to Giannopoulou et al. (2021) we have also used Cronbach's alpha to establish good internal consistency of the survey results, which mitigates some of recall bias and increases confidence in our results and analysis.

Motivation for This Study

The aforementioned investigations on COVID-19 pandemic and its impact on mental health have focused on more general aspects of mental health. They identify some of the socioeconomic stressors and their impact on anxiety and depression. They don't delve into the specific stressors arising from the pandemic-related changes in schooling. In contrast, this study emphasizes several key stressors and controls along with their influence on mental health of high school students. Such a detailed analysis is exigent to identify and mitigate the impact of the stressors in order to improve the mental wellbeing of high school students. Our objective is to focus on the common stressors experienced by high school students. Hence, several stressors and controls were identified via a focus group of students and teachers. In addition, we include several controls to account for existing mental health issues. Our main research question is – has the mental health of high school students changed during the COVID-19 pandemic and what factors have contributed to the change in mental health? Moreover, we also aimed to elicit potential approaches to mitigate degradation in mental health from the participants.

METHODS

This study uses a well-established scientific method for conducting a descriptive and exploratory research using a survey-based approach (Bhattacherjee 2019). An overview of the method is summarized in **Figure 1**. The first phase of the investigation focused on eliciting the three main categories of variables, namely ① stressors (independent variables) that influence mental health, ② controls to account for any pre-existing mental health conditions, and ③ mental health estimators. This phase of the research first involved literature survey of peer reviewed articles to identify key variables to be surveyed. The APA surveys (APA 2020) did not provide many parameters but suggested time invested on key activities such as school work, leisure, sports, and sleep. We also reviewed several instruments proposed in the literature for mental health assessments including MIH-5 (Viet and Ware, 1983), GAD-7 (Spitzer et al., 2006), PHQ-9 (Johnson et al., 2002).

At the time of this study, there was a paucity of technical articles pertaining to COVID-19 pandemic and its impact on mental health. Hence, we decided to pursue a focus group approach to obtain community input to elicit parameters and appropriately structure questions. The focus group consisted of a few high school students and two teachers. The focus group also motivated us to keep the questionnaire as short as possible and

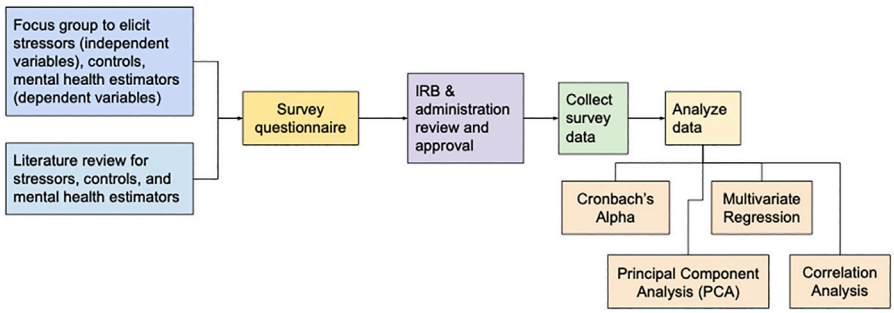

FIGURE 1 | Overview of the methods used in this study.

TABLE 1 | Category and summary of parameters included in our instrument. Full questionnaire is included in the supplementary materials.

Category	Abbreviated question	Question type
Stressors (independent or explanatory variables)	In-person vs. online schooling	Binary (Yes/No)
	Switched learning modality	Binary (Yes/No)
	Feeling about back to online	Likert-like (5-point scale)
	Number of college classes	Continuous
	After school tutoring	Binary (Yes/No)
	Gender	Nominal
	LGBTQ?	Binary (Yes/No)
	Race	Nominal
	School time	Continuous
	Homework time	Continuous
	Sleep time	Continuous
	Physical Training (PT) time	Continuous
	Number of sports	Continuous
	Clubs	Likert-like (interval)
	Death in family	Binary (Yes/No)
Controls (for pre-existing conditions)	Previous mental health issues?	Binary (Yes/No)
	Had therapy?	Binary (Yes/No)
	Currently in therapy?	Binary (Yes/No)
	Start or continue therapy?	Binary (Yes/No)
Mental health estimators (dependent variables)	Mental health before COVID-19	Likert (5-point ordinal scale)
	Current mental health	Likert (5-point ordinal scale)
	Increased anxiety	Likert (5-point ordinal scale)
	Increased stress	Likert (5-point ordinal scale)
	Issues with daily tasks?	Likert (5-point ordinal scale)
	Increased impact on relationships?	Likert (5-point ordinal scale)
	Frequency of breakdowns	Nominal (interval)
Freeform suggestions	Suggest community measures	Freeform question
	Other feedback	Freeform question

structure questions to be quickly understandable by students. Based on the focus group feedback, we have structured our mental health estimators along the lines of MIH-5, though our questions are different and included six questions, based on focus group feedback.

Overview of Our Instrument

The results from the literature survey and focus group analysis led to 29 questions pertaining to stressors, controls, and mental health estimators as summarized in **Table 1**. The complete survey administered to the participants is included in the supplements. Our survey started with a consent question (not shown in **Table 1**). The questions covered 15 stressors (i.e., independent variables) that influence mental health and were identified via literature survey (APA, 2020; Zhang et al., 2020; Asanov et al., 2021). In addition, the questions included stressors related to online vs. in-person learning that were identified via our focus group discussions. Our instrument included four controls to account for any pre-existing mental health issues that could be unrelated to COVID-19, but could be exacerbated due to the pandemic. The survey then included questions on mental health estimators to assess the mental wellbeing before and during the pandemic (Liang et al., 2020). The survey was administered during the pandemic and hence, the

question on mental health prior to the pandemic is subject to recall bias, similar to other investigations (Giannopoulou et al., 2021). Lastly, the survey included freeform questions for participants to share their opinions on how their mental health could be improved.

IRB and School Administration Approvals

The survey was designed to be administered to students in a high school in Mason, Ohio (Mid-West, United States). The survey questionnaire and protocol were approved by the school's Institutional Review Board (IRB). After IRB approval was obtained, consent was also sought from the school's administration. The school's administration restricted us to administer the survey to a subset of high school students. The administration did not provide an explanation for their decision to restrict the survey to only a subset of students.

Study Participants

As part of the IRB approval, the school's administration restricted us to administer the survey to a subset of students who were enrolled in the biomedical science program in the high school. As a result, the sample size ($n = 107$) of our data is somewhat limited. Nevertheless, the dataset has sufficient statistical power as discussed in the results section.

Survey Administration and Data Collection

The survey was designed as a web-based (fully anonymized) survey using Google Forms (Google Inc, 2021) to ease distribution and completion. The survey link was shared with the students with the help of teachers in the biomedical science program in the high school. We also requested the teachers to periodically remind the students to complete the voluntary survey. The fully anonymized web-based survey was made available to participants for 30 days (Dec 1 to Dec 30, 2020). Participation was voluntary and no incentives (money, prize, extra credit, etc.) were provided to the participants. The fully anonymized data was obtained from Google Forms at the end of the survey time and stored safely in a password protected CSV file for further analysis.

Data Analysis and Intermediate Variable

The survey results were obtained from Google Forms as a Comma Separated Values (CSV) file. The data was analyzed using R statistical software (Core Team, 2020) and Microsoft Excel. As summarized in **Figure 1**, first we established internal consistency of the mental health estimators (dependent variables) using Cronbach's alpha. Once we established good internal consistency, we tried to reduce the number of independent variables using Principal Component Analysis (PCA) (Jolliffe and Cadima, 2016).

To ease further analysis, we have also encoded the categorical questions to numeric values based on the Likert-like scales used for each question. In addition, to streamline analyses, we have added a dependent intermediate variable indicating change in mental health (Mt.Health.Change), which is computed as shown in the equation below.

$$\text{Mt. Health.Change} = \text{Curr} - \text{Mt. Health} - \text{BC} - \text{Mt. Health}$$

RESULTS

In accordance with the high school administration's conditions, the fully anonymous survey was made available to high school students (age 15–17) enrolled in the biomedical sciences program. The survey was made available for 30 days (from Dec 1–Dec 30, 2020). The voluntary survey was completed by 107 students whose demographics are summarized in **Figure 2**. The respondents were mostly Asian students (69 of 107 ~ = 64%) and most of the students were female (75 of 107 ~ = 70%). At the time of the survey, 80 of 107 participants (about 74.8%) were taking classes in-person while 27 participants (about 25.2%) were taking classes online. Out of the 107 participants, 102 participants were learning in their modality of choice (i.e., in-person or online) and had not recently switched learning modality. Four participants were considering switching learning modalities and only one participant had switched from online to in-person schooling.

Our survey questionnaire requested time (in hours) spent on several key activities related to schooling each day, including: time spent in school (online or in-person), average time spent on homework, approximate time spent in exercising or sports, and average sleeping time. We solicited this data because time pressure was reported as a key stressor during our focus group discussions. In our study we aimed to delve into specific categories of time use to identify the most influential time-related stressor, if any. The summary statistics for the time usage is shown in **Figure 3**. Only 14 out of the 107 students (i.e., ~13%) were not involved in a student club or an honors society.

Analysis of Cronbach's Alpha

Prior to statistical analysis, the internal consistency, validity and reliability of mental health estimators (dependent variables) in the survey data was verified and using the well-established Cronbach's alpha (Taber, 2018). Cronbach's alpha requires that the data must all be on a consistent scale. Hence, for our alpha calculations, we have used the mental health change (**Eq. 1**) intermediate variable along with the estimators "Increased anxiety", "Increased stress", "Issues with daily tasks?", and "Impact on relationships?" from **Table 1**. For the mental health estimators, the Cronbach's alpha was $\alpha = 0.78$, which in social sciences is considered a good value (Taber, 2018). Other investigations related to COVID-19 that used other instruments have reported comparable scores for Cronbach's alpha: 0.79 for GAD-7 (Liang et al., 2020), 0.81 for GAD-7 (Giannopoulou et al., 2021), and 0.79 for GHQ-12 (Liang et al., 2020) to mention a few (Tavakol and Dennick, 2011). The results from our Cronbach's alpha establish consistency, validity, and reliability of the responses. In other words, the $\alpha = 0.78$, shows that the mental health assessment instrument was well designed, is unidimensional (i.e., focusing on mental health), and the responses are meaningful (i.e., students were not randomly or nonchalantly filling-in the survey, but were responding conscientiously).

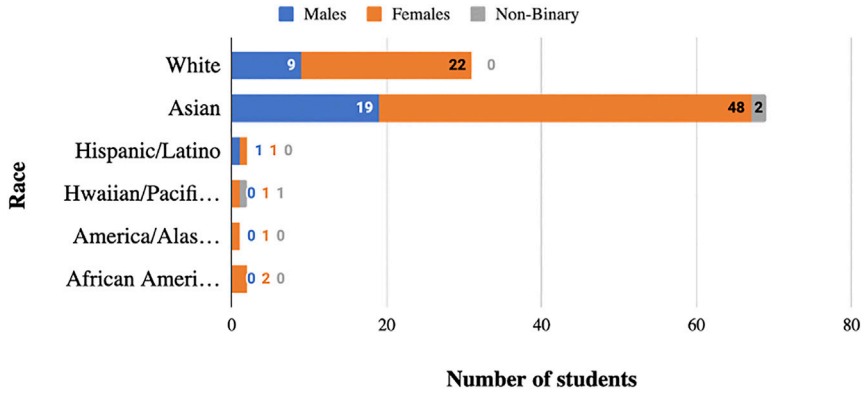

FIGURE 2 | Demographic summary of participants (N = 107) that completed our survey.

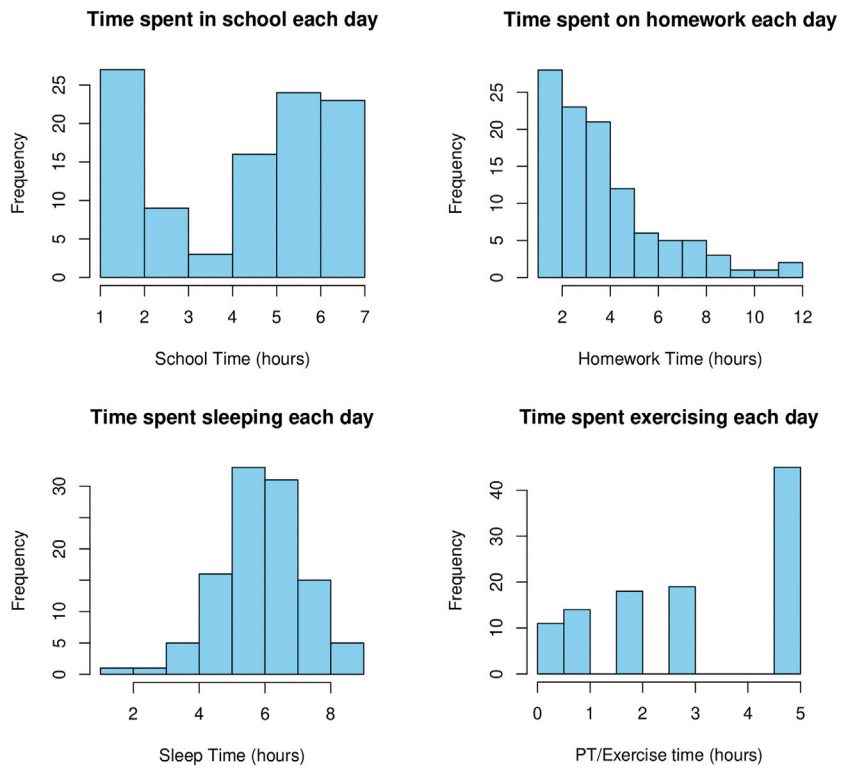

FIGURE 3 | Time distribution reported by participants for key daily activities.

T-Test for Degradation in Mental Health

An overall key question in this survey was to determine if students experienced any degradation in their mental health. In our survey, 24 out of 31 (77.4%) of White students and 37 out of 69 (53.6%) Asian students, two of 2 (100%) Hispanic/Latino, and one of 2 (50%) Black participants reported some degradation in mental health. **Figure 4** shows a comparison of the distributions of mental health status reported by the participants before and during the COVID-19 pandemic. The boxplots in **Figure 4B** show a comparison of the mental health ratings. We conducted a paired two-sample *t*-test comparing the mental health of participants before and during the pandemic (see **Table 1**). We also verified that the change in mental health was normally distributed (a prerequisite for the t-test) using the Shapiro-Wilk normality test (W = 0.944, *p*-value = 0.00025). The *t*-test showed a statistically significant mental health degradation of 0.636 ($p \ll 0.001$). Of the 64 participants who reported degradation in mental health during the pandemic, 45 (70%) of them were enrolled in online schooling. The proportions of males and females reporting mental health degradation was 18

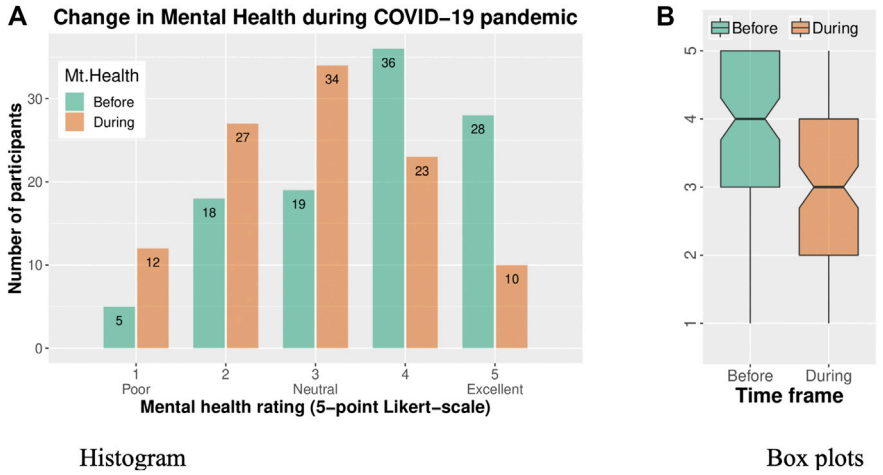

FIGURE 4 | Mental health ratings reported on a 5-point Likert-scale by the survey respondents before and during the COVID-19 pandemic. Paired *t*-test showed a statistically significant degradation (the changes were normally distributed -- Shapiro-Wilk test W = 0.944, *p*-value = 0.00025) in mental health ratings with t = 0.636 ($p \ll 0.001$). **(A)** Histogram of Mental Health ratings before and during the pandemic. **(B)** Box plots comparing the ratings before and during the pandemic.

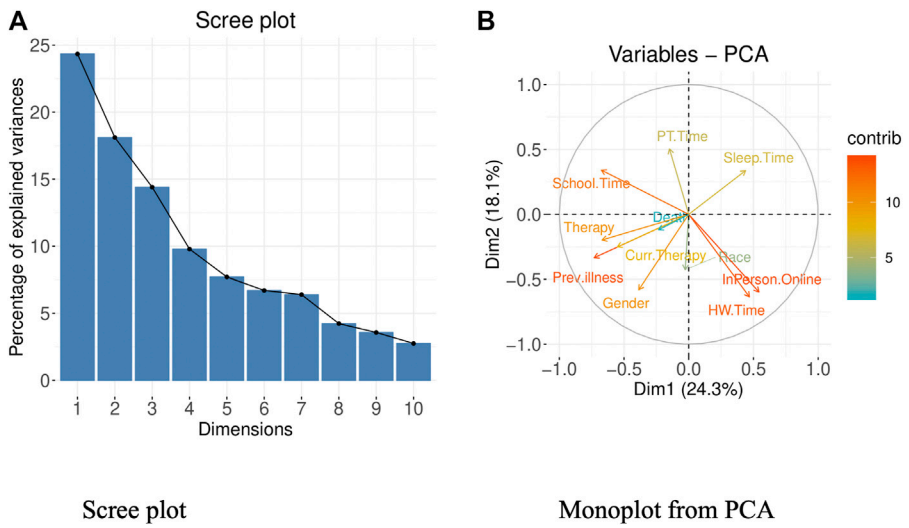

FIGURE 5 | Results from Principal Component Analysis (PCA). **(A)** Scree Plot from PCA. **(B)** Monoplot from PCA.

(28%) and 45 (70%) respectively. Amongst the 64 participants, 24 were White and 37 were Asian. Therapy was followed by nine and six participants who reported degradation and no degradation respectively.

Principal Component Analysis

Having established a good value of Cronbach's alpha for mental health estimators, we focused on analysis of stressors (independent variables) and controls (pre-existing conditions). This part of the analysis aimed to identify influential parameters and reduce the number of parameters to be addressed in further analyses. Accordingly, we have used the widely used Principal Component Analysis (PCA) (Jolliffe and Cadima, 2016), to explore the feasibility of dimensionality reduction – i.e., check if some of the controls and stressors are redundant and can be discounted in further analyses. The key results from PCA are summarized in **Figure 5**. The Scree plot in **Figure 5A** shows that all of the parameters need to be included in order to account for 95% of the variance in the data. The monoplot also shows that all of the parameters have substantial contribution to the first two dimensions in PCA. In other words, the PCA results showed that our survey has very desirable features in that all of the stressors (independent variables) and controls are relatively uncorrelated and provide statistically significant information regarding each participant.

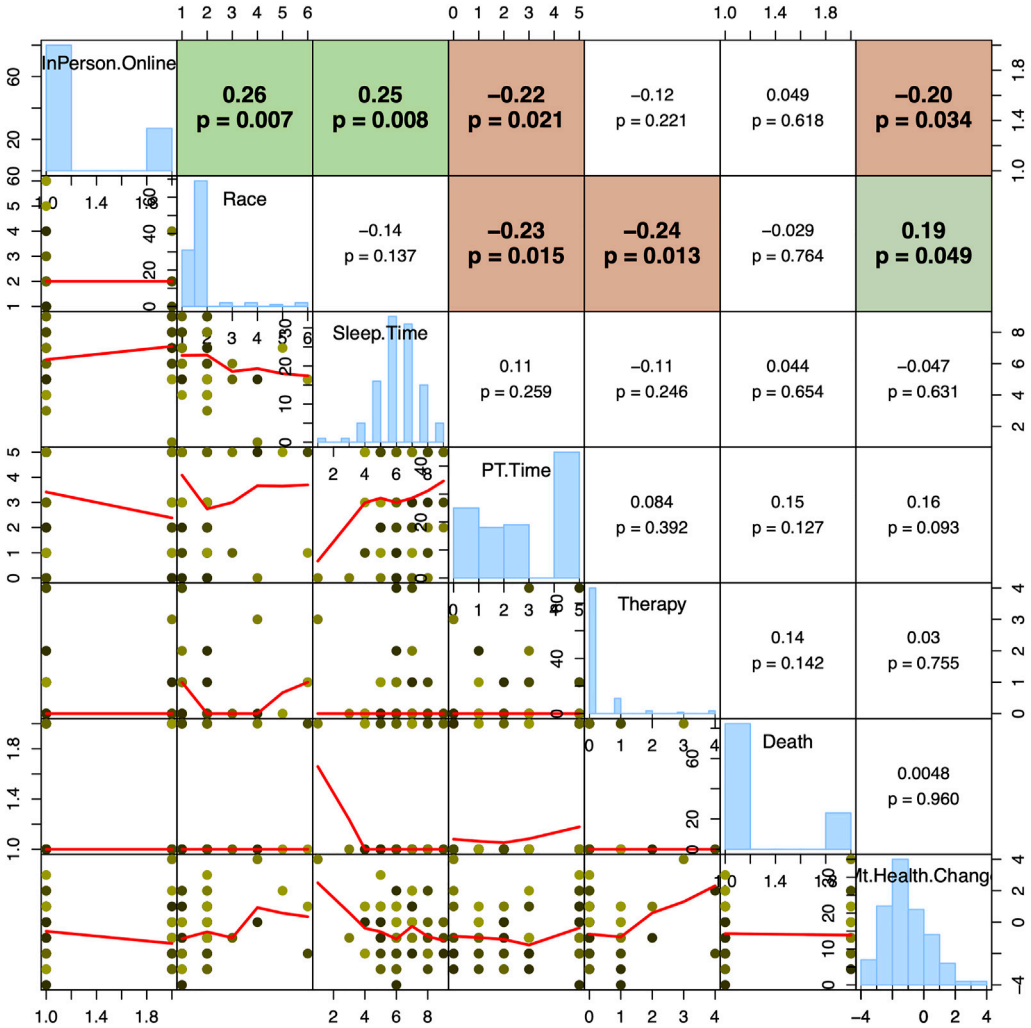

FIGURE 6 | Key subset of results from correlation analysis. The values in the upper-right triangle show the Spearman correlation between pairs of values. For example, 0.19 (p = 0.049) shows the correlation between Race (the row) and Mt.Health.Change (column). The red lines in the scatter plots show the Lowess curve to highlight correlation patterns within sub-ranges of data. The full correlogram with all stressors (independent variables), controls (pre-existing conditions), and mental health estimators (dependent variables) is included in the supplementary materials.

Correlation Analysis

Since PCA showed that all of the stressors (independent variables) and controls (pre-existing conditions) cannot be reduced, we pursued extensive correlation analysis to estimate their influence on mental health estimators (dependent variables). The analysis was conducted using R statistical software. **Figure 6** shows a subset of results from correlation analysis with stressors (independent variables) and controls (pre-existing conditions) that showed statistically significant correlation with "Mt.Health.Change" intermediate variable (**Eq. 1**). The full correlogram with all stressors (independent variables), controls (pre-existing conditions), and mental health estimators (dependent variables) is included in the supplements. The upper right triangle of the correlogram shows the Spearman correlation values. Interestingly, for this data set, the Pearson correlation coefficients were exactly the same as Spearman coefficients, indicating that there is both a monotonic and linear relationships between the parameters.

The key intermediate variable used for analysis was "MT.Health.Change", which shows change in mental health. The correlation analysis showed that the controls (i.e., pre-existing mental health issues) had no correlation (p > 0.1) to change in mental health. Among the various stressors, only "In-person vs. Online" learning modality and race showed statistically significant correlation r = -0.20 (p = 0.034) and r = 0.19 (p = 0.049) to mental health degradation. That is, students learning online reported a statistically significant degradation in mental health. A large fraction (77.4%) of White participants reported some mental health degradation, and hence some correlation with race was observed. Sleeping time (Sleep.Time) and exercise Time (PT.Time) stressors showed no statistically significant correlation to change in mental health. However, these two

```
Call:
lm(formula = Mt.Health.Change ~ factor(InPerson.Online) + factor(Race) +
    PT.Time, data = surveyData)

Residuals:
    Min      1Q  Median      3Q     Max
-3.2019 -0.7270 -0.1939  0.7981  3.1200

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                         -1.56284    0.36106  -4.329 3.62e-05 ***
factor(InPerson.Online)2:Online     -0.90644    0.30865  -2.937  0.00413 **
factor(Race)2:Asian                  0.89037    0.29933   2.975  0.00369 **
factor(Race)3:Hispanic/Latino        0.10398    0.92295   0.113  0.91053
factor(Race)4:Hawaiian/Pac.Islander  0.79807    1.28471   0.621  0.53591
factor(Race)5:American/Alaskan Native 2.79807   1.28471   2.178  0.03181 *
factor(Race)6:Black                  0.60398    0.92295   0.654  0.51439
PT.Time                              0.15295    0.07229   2.116  0.03688 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.262 on 98 degrees of freedom
Multiple R-squared:  0.1833,     Adjusted R-squared:  0.125
F-statistic: 3.142 on 7 and 98 DF,  p-value: 0.004886
```

FIGURE 7 | Regression results from best fitting generalized regression model. The best fitting regression model was determined using R statistical software which identifies parameters that minimize AIC.

stressors had a good negative correlation to increase in anxiety and stress -- that is, participants who spent more time sleeping or exercising reported lower stress and anxiety changes. These observations regarding the benefits of sleep and exercise are consistent with findings reported by other investigators (Liang et al., 2020; Giannopoulou et al., 2021).

Multivariate Regression Analysis

The correlation analysis showed that pandemic-time degradation in mental health (i.e., the Mt.Health.Change intermediate variable) is correlated only to learning modality (In-person vs. online) and the race of students. Other stressors did not show any influence on changes in mental health during the pandemic. We have cross validated this inference by identifying the best-fitting generalized regression model that explains the observations in mental health changes during the COVID-19 pandemic. For this analysis we have removed one outlier participant who was taking most of classes via the College Credit Plus (CCP) program. The best fitting regression model (Johnson and Wichern, 2015) was determined using R statistical software which identifies parameters that minimize the Akaike Information Criterion (AIC) (Rabbi et al., 2020). The model automatically identified included a School.Time parameter that was not significant ($p >> 0.05$). When we removed it from the regression model, the Switched parameter was no longer significant ($p >> 0.05$). Hence, these two parameters have been removed from our final regression model as they were not statistically significant. The results from multivariate regression analysis using the best fitting model are shown in **Figure 7**.

Consistent with the correlation analysis, changes in mental health is best explained by online learning and race. Online learner's mental health degraded by about −0.9 (on a 5-point Likert scale) ($p = 0.004$) while Asian participants reported lower degradation of 0.89 ($p = 0.003$) when compared to other races. Exercise time (PT.Time) had only mild protective influence of 0.15 ($p = 0.037$) on the mental health of participants. This is corroborated by the correlation analysis (**Figure 6**) where PT.Time and Therapy was only correlated to stress and anxiety levels, but not on changes in mental health. Controlling for gender did not have any impact (p-value >> 0.05) showing that mental health issues were equally experienced by all of the genders in our survey.

Our regression analysis identified three explanatory parameters, namely learning modality (in-person vs. online), race, and PT.Time. The first two parameters were also highlighted by correlation analysis. In order to assess the influence of PT.Time, we compared the explanatory power with and without PT.Time. We also chose this minimal subset to avoid overfitting our regression model to the survey data. **Figure 8** shows a comparison of the predictions of the full regression model vs. the simpler model. Note that, in both the models, we are attempting only to predict degradation (i.e., Mt.Health.Change <0), if any, and not the magnitude of degradation.

The confusion matrix shows that overall, this simple model with the two explanatory variables (see **Table 1** for full list) can predict potential mental health issues with an accuracy 62.6% ($p = 0.003$). On the other hand, inclusion of PT.Time in the regression model improves the accuracy to 72.0% ($p << 0.001$) by primarily decreasing the number of false positives (FP) from 40 to 25.

Biases and Limitations of Our Study

The biomedical science program is an elective program in the high school. Hence, the proportion of students in this program is different and hence the demographics of the survey was different than that of the high school. The percentage of male vs. female respondents was ~27 and ~70% respectively, while the overall high school's proportions are 51 and 49% (US News, 2021).

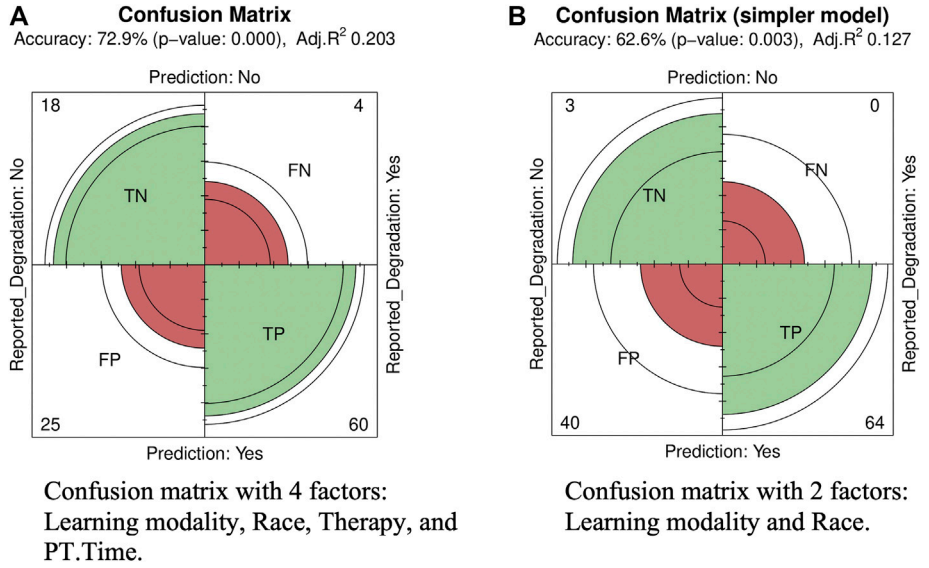

FIGURE 8 | Confusion matrix to compare the effectiveness of a regression model using just two explanatory variables, namely: learning-modality (In-person vs. online) and Race. **(A)** Confusion matrix with 4 factors: Learning modality, Race, Therapy, and PT. Time. **(B)** Confusion matrix with just 2 factors: Learning modality and Race.

Similarly, the proportion of Asian (including S. E. Asian) students who responded to our survey are much higher at ~64% whereas the overall high school's proportions is 20% Asians. This skew introduces a bias in our study. The survey did not track students who had access to the survey but chose not to participate -- prior investigations report a "pre-existing interest" bias, where participants with interest in mental health issues are more inclined to respond, which can introduce bias in the data. However, Giannopoulou et al. (2020) report that such "pre-existing interest" bias applies to most mental health surveys of COVID-19, which have mostly used web-based convenience samples (Pierce et al., 2020). The survey then included questions on mental health estimators to assess the mental wellbeing before and during the pandemic. The survey was administered during the pandemic and hence, the question on mental health prior to the pandemic is subject to recall bias, similar to other investigations (Giannopoulou et al., 2021). Although our study included freeform comments, we did not specifically ask participants to list aspects that cause mental health issues. Hence, our study does not draw inferences on additional factors such as family situation, social isolation, etc. (APA 2020; Tandon 2020; Wang et al., 2020) that may degrade mental health. Lastly, the mental health estimators used in this study, despite its good internal consistency, is not a well-established instrument and hence may have an impact on the results from this study.

DISCUSSIONS AND CONCLUSIONS

The ongoing COVID-19 pandemic has not only caused considerable socioeconomic impacts but has also caused mental health degradation worldwide. The American Psychological Association (APA) reports that nearly 81% of Gen Z teens Gen Z teens (ages 13–17) experience more intense stress due to COVID-19, associated with schooling. Several recent investigations have confirmed the technological challenges and psychological impacts due to the COVID-19 pandemic on school students in different countries. However, similar to the APA's report, the recent studies have not focused on eliciting key stressors that cause mental health degradation in school students.

This study pursued a data-driven, scientific, and ethical approach to assess the impact of COVID-19 pandemic on the mental health of high schoolers. There are a few distinguishing aspects of this study. First, it used a focus-group based approach to elicit key stressors that impact the population under study. We found this approach to be very useful particularly due to the paucity of articles that focus on the impact of the pandemic on the high school population. Similar to recent publications to assess stress and anxiety changes, our study also used 5-questions on a 5-point Likert-like scale to elicit the mental health of the participants. The results from Cronbach's alpha ($\alpha = 0.78$) analysis showed good internal consistency of our instrument. Our alpha value ($\alpha = 0.78$) is considered a good value (Taber, 2018) and is consistent with the values reported by recent investigations conducted using different assessment instruments. PCA was used to establish that the controls and stressors (explanatory/independent variables) contain important information about this survey population, adding further credence to the survey used in this study.

Our fully anonymous survey was made available via a Google Form to students enrolled in the Biomedical science program in William Mason Highschool (Ohio,

United States). The school administration restricted the survey to this subset of students. No incentives of any kind were provided to the participants. Yet, a majority of the students in the program completed the survey over a period of 30 days. This outcome suggests that students are open to sharing information about their wellbeing.

A comparison of mental health ratings showed a statistically significant mental health degradation t = 0.636 ($p \ll 0.001$) before and during the pandemic as summarized in **Figure 5**. Correlation analysis (**Figure 6**) and regression analysis (**Figure 7**) showed that the most influential factor was Online schooling (estimate = −0.90), followed by race (estimate = 0.89), and exercise time (0.15). In our study, Asian students reported a much lower rate of mental health degradation. This could possibly be due to bias in our survey population because 64% of the respondents were of Asian descent. However, despite 70% of the respondents being female, no differences were found when controlling for gender, suggesting that both males and females experienced comparable mental health issues. Other factors such as pre-existing mental health issues and therapy did not influence mental health degradation.

The survey gathered time spent by the participants on several daily activities, namely: school time, homework time, exercise time, and sleeping time. We used an unpaired *t*-test to compare these four times reported by participants who did and did not experience mental health degradation. None of the times in the four categories showed any statistical difference. Prior to the unpaired *t*-test, we verified that all of the times in the four categories were normally distributed, verified using the Shapiro-Wilk normality test. In addition, except for homework time, they all had similar variances, verified using F-test.

Nevertheless, exercise time (PT.Time) was found to have explanatory power, in addition to learning-modality and race, in multivariate regression analyses. Consequently, we analyzed its contribution by comparing it with a regression model without it just two explanatory variables, namely learning-modality (In-person vs. online) and race. The simpler model was able to predict potential degradation in mental health with an accuracy of 62.3% ($p = 0.014$) vs. 73.6% with PT.Time included (see **Figure 8**). When compared to the full regression model, the false positive rate for the simpler model is higher. The key difference between the two models is attributed to the known benefits of exercise time (PT.Time). This finding is consistent with results reported by recent investigations (Liang et al., 2020). Adding PT.Time to the model essentially reduced the number of false positives from 40 to 25. That is, the simpler model tends to be more cautious and predict potential mental health degradation, which in this context, may be an acceptable risk. On the other hand, the number of false negatives from the simpler model is zero, showing that the chances we would miss a potential mental health problem is rather low, which is a positive aspect of the simpler model. The overall good prediction rates suggests that the two explanatory variables, namely learning-modality, and race are strong indicators of mental health changes in our survey data, with PT.Time helping to mitigate impact of stressors on mental health.

Multiple statistical analyses clearly showed degradation in mental health of students pursuing online schooling. Several recent articles suggest that this degradation can be attributed to a feeling of social isolation, loss of social structure in the form of friends or clubs (85% of students reported being in a club or student organizations), and family issues (Zhang et al., 2020). Although, our questionnaire did not specifically solicit factors impacting mental health, 45.8% of the participants provided freeform comments. Reviewing the freeform feedback identified three recurring themes in the feedback. First, 14 participants (13.2%) indicated that stress caused by homework as being an influential factor and suggested coordination between instructors to spread the workload. Second, nine participants (8.5%) reported social isolation or lack of social interactions as being a factor. Third, 13 participants (12.3%) suggest increasing community support and social interactions through flexible times or during short breaks during school time could improve mental wellbeing.

The regression analysis showed that exercise has a positive impact on mental wellbeing. Hence, online schooling can explore opportunities to engage students by providing breaks for physical activity. Electronic approaches for gaming such as Wii exercise could be used for exercising and their results can be used to provide bonus points for students to encourage regular exercising. Exercises can be combined with the aforementioned actionable approaches proposed by participants to further alleviate some of the stressors experienced by high schoolers.

Combining with the data published by the APA (2020), this study further helps our community to move from correlation to causality, which is a critical step in addressing the rising amount of mental health issues in younger generations in the United States. Although our results are subject to some bias in race, there is no gender bias. Hence, our results are also applicable in other communities and possibly in other regions as well. This study provides survey instruments and valuable inferences to many communities to help improve mental health of their children. By conducting further research, the scientific community would be able to learn more about what impacts mental health and how to help those in need.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: http://pc2lab.cec.miamioh.edu/documents/RawMentalHealthSurvey.xlsx.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board, William Mason High School, Mason, OHIO, United States. Written informed consent

from the participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MR conceived the research, designed the study, developed survey, collected data, helped with data analysis, helped with creating charts and figures, and writing the article. DR helped with data analysis, drawing inferences, assisted with creating charts and figures, and writing the article.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.719539/full#supplementary-material

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Experiences of Honours Research Students and Supervisors During the COVID-19 Pandemic: A Pilot Study Framed by Self-Determination Theory

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This study evaluated the impact of the COVID-19 pandemic in a sample of Honours students (n = 21) and Honours supervisors (n = 41) at a major Australian university. Data were collected from voluntary, online, anonymous surveys, which included ratings of the pandemic's impact on their 1) experience of Honours research activities, and 2) sense of relatedness, competence, autonomy, and wellbeing. Self-determination theory (SDT), which posits that the psychological needs of relatedness, competence, and autonomy lead to a sense of wellbeing, provided a theoretical framework for understanding student and supervisor experience during the pandemic. Both students and supervisors indicated significant impact of the pandemic on the students' research projects, and the degree of perceived impact did not differ between students and supervisors. There was no relationship between the severity of impact and student or supervisor wellbeing. Student wellbeing was low, but the hypotheses that student SDT needs would not be met were only partly supported. Overall, the extent to which Honours students' SDT needs were met predicted wellbeing; the outcome was similar for supervisors. Our hypothesis that SDT needs and wellbeing would be higher for supervisors than for students was supported. The theoretical and practical implications of these findings are discussed, including recommendations for Honours programs as we move through the current pandemic.

Keywords: COVID-19, wellbeing, honours, self-determination theory, research supervision, student experience

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INTRODUCTION

The aim of this research was to investigate the impact of the COVID-19 pandemic on the experiences of Honours degree students and research supervisors. Prevalent in Commonwealth countries, the one-year Honours degree in Australia is the primary pathway to doctoral studies and subsequent careers in research and academia. It also serves to better prepare graduates for a diverse range of careers where critical thinking and research skills are highly valued (Zeegers and Barron, 2009; Kiley et al., 2011; Backer and Benckendorff, 2018).

The Australian Qualifications Framework (2013) states that Honours graduates should display "a coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines and knowledge of research principles and methods" (p.16). Whilst the amount of prescribed coursework varies (Kiley et al., 2009; Martin et al., 2013; Backer and Benckendorff,

2018), the primary goal of the 4th-year undergraduate Honours year is research training. The research component is an intensive period, beginning with the development of a research question and culminating in the submission of the research thesis. The expected assessable output is usually a minimum of a draft journal manuscript, and often includes a substantial literature review (Kiley et al., 2009).

Each Honours candidature constitutes independent, inquiry-based learning but the individual student experience is influenced by multiple factors. For example, the degree of independence during research project design and implementation varies. Science projects (the focus of this paper) usually involve less student autonomy than do Arts and Social Sciences projects, given the constraints on laboratory resources (Kiley, et al., 2009). Even within the sciences, the nature of the research may vary from online surveys to rigorously controlled experimental manipulations that may involve complex measurement techniques. The supervision experience for the Honours student may also vary across disciplines. For example, there may be a supervisory arrangement of at least two active supervisors whereas in other instances there may only be one supervisor. Similarly, the physical research setting itself may be solitary or social with other research students and personnel.

Prepandemic, studies have suggested that students typically experience lack of confidence, and increased stress, and time management challenges (Cruwys et al., 2015). Compared to the preceding Bachelor's degree, the Honours degree program typically involves transition from course-work based study to a self-directed research project, a mentor-mentee relationships, and can be a relatively isolating experience (Johnston and Broda, 1996). Student-supervisor interactions impact the Honours student experience and subsequent motivation for postgraduate research (Kiley and Austin, 2000). The research environment, supervisor availability, and a sense of belonging to a community within an institution are important factors promoting support and encouragement, and countering any feelings of isolation (Lovitts, 2005). Despite the challenges, at least one study indicated that students rate the Honours experience highly, especially in terms of the research skills gained and the high levels of support by fellow Honours students (Martin et al., 2013).

The Honours supervisor role confers resource, thesis writing, and research running and management support. Supervising Honours students may be perceived as more difficult than supervising doctoral candidates due to the short timeframe (9 months) during which supervisors are expected to provide intensive and time-consuming research training and supervision. These factors and a dearth of Honours supervisor training (compared to doctoral supervisor training), have the potential to lead to additional stress for the supervisor.

The beginning of the COVID-19 pandemic significantly impacted everyday life (e.g., Dawel et al., 2020), including higher education (e.g., Jung et al., 2021). Both students and staff have been affected, mostly adversely (e.g., through disruption to studies/work due to university campus closure, sudden transition to online educational delivery or reduction or termination of employment) as reflected by reported psychological distress, although occasionally positive aspects have been reported (e.g., advantages to studying/working remotely; e.g., Chirikov et al., 2020; Ye et al., 2020). In one of the few academic-focused studies, academics indicated that their research programs had been adversely affected by university campus and laboratory closures (Abbott et al., 2020). One of the few studies on research students indicated that both collaborative research training and professional relationship building has been negatively impacted (Wang and DeLaquil, 2020). Researchers have yet to study the impact of the pandemic on Honours students and Honours supervisors, and this paper seeks to address that gap.

The Present Study

At the authors' university, staff and students were requested to work from home to the greatest extent possible. When campus attendance was necessary and permitted, all government restrictions needed to be adhered to, for example, physical distancing and limiting in-person meetings to no more than 2 people. This reduced opportunities for supervisors to train their students on research techniques. Honours projects involving laboratory training, teamwork in close proximity or clinical client contact were impracticable to support. This transition necessarily occurred very rapidly in mid-March 2020, 1 month after the beginning of Honours candidature. Given that the physical restrictions applied to both students and supervisors, it was expected that both samples would give similarly high ratings of the impact of the pandemic on the research project and experience. We predicted that severity of impact would be significantly associated with wellbeing for students, but not for supervisors, because Honours research is paramount to the student experience. Moreover, given that student's would expect significant face-to-face interaction during course-work, as in their undergraduate years, it was predicted that most students would prefer to go back to in-person coursework.

We propose that Self-Determination Theory (SDT; Ryan and Deci, 2000) provides a useful theoretical framework for understanding the psychological impact of the COVID-19 pandemic on Honours experience and wellbeing of students and supervisors. SDT has received extensive empirical support in a variety of contexts, including higher education contexts (e.g., Niemiec and Ryan, 2009. Baik et al., 2017a; Baik et al., 2017b). A central aspect of SDT is that there are core psychological needs, the satisfaction of which leads to increased psychological wellbeing (e.g., Sheldon and Elliot, 1999; Ryan et al., 2008). These needs are: *relatedness*, the feeling of being understood and cared for by others; *competence*, the feeling of being effective (able to get valued things done); and *autonomy*, the feeling of being "in control" of one's own behaviours (i.e., one is not being constrained by external forces in one's choice of behaviour; Ng et al., 2012). For the remainder of this article, we will refer to these as "SDT needs."

The pandemic and related government restrictions were likely to have had several consequences for Honours students, including decreased face-to-face interaction with supervisors, fellow students, and other research staff (Wang and DeLaquil, 2020). The rapid uptake of video-conferencing technologies may not have fully compensated for this, leaving Honours students with

low feelings of relatedness. We were interested in measuring three aspects of "Honours Relatedness": relatedness with fellow students (given the findings of Martin et al., 2013), relatedness with staff members (given the increased importance of interactions with supervisors during Honours), and relatedness with the university (given the key importance to the student experience of the concept of "belonging"; Van Gijn-Grosvenor and Huisman, 2020). We predicted low levels of relatedness on all three aspects, given the impact of the pandemic on face-to-face interaction and the need to work from home. We predicted low feelings of competence because of: 1) the disconnection from face-to-face guidance by supervisors and other senior members within the research group (Wang and DeLaquil, 2020); and 2) required learning of different knowledge and skills, which may have left some students feeling less than competent to plan and manage changes to the research project. We predicted low feelings of autonomy if the nature of the research project, or of coursework assessments, needed to be changed due to COVID-19. It was expected that Honours SDT need satisfaction would predict student's wellbeing, and that such wellbeing would be low.

It was expected that Honours supervisors would also be experiencing decreased face-to-face interactions with both colleagues and students, thus experiencing a low sense of relatedness. We were interested in measuring two aspects of relatedness: relatedness with work colleagues and students, and relatedness with the university. We predicted that academic staff could be experiencing a decreased sense of competence given potential disruption of their normal work activities. We predicted that the restrictions imposed by governments and university leadership would also bring about a feeling of low autonomy regarding their student's Honours projects. It was expected that SDT need satisfaction would predict supervisor wellbeing and that such wellbeing would be low. However, given that the Honours experience is usually perceived as highly demanding for the student—more so than for the supervisor—it was expected that overall, supervisors would exhibit higher SDT need satisfaction and wellbeing than would students.

Both students and supervisors were asked open-ended questions regarding their experiences of the 2020 Honours year, and basic exploratory thematic analyses were undertaken to better inform recommendations for post-2020 Honours degree procedures. Additional exploratory analyses were undertaken of participant's responses to 1) a statement regarding equity during the Honours experience, and 2) a general wellbeing scale.

METHODS

Participants

Ethics approval was obtained from the UNSW Human Research Ethics Committee (approval number: HREAP 3403), and participants gave their informed, written consent to take part in this study.

Students

Participants were School of Medical Sciences and School of Psychology Honours students at the University of New South Wales (UNSW, Sydney), who commenced full-time on-campus study in mid-February 2020. Out of a maximum number of 147 students (19 Neuroscience Honours, 43 School of Medical Sciences Honours, 85 Psychology Honours), a total of 21 responses were recorded; a response rate of 14.19%. Two responses were subsequently excluded from analyses for not listing degree details, so there was a total of 19 responses included in the final analyses. Participants were predominantly male (Male = 42.11%, Female = 31.58%, Not specified = 26.32%), and had a mean age of 24.64 (SD = 6.27; $N = 14$). The majority of students were domestic/local (Local = 73.68%, International = 5.26%, Not specified = 21.05%) who spoke English as their first language (English = 63.16%, Cantonese = 10.53%, Hebrew = 5.26%, Not specified = 21.05%). Students were from the following programs: Bachelor of Science (36.84%), Bachelor of Psychological Science (26.32%), Bachelor of Psychology (21.05%), Bachelor of Advanced Science (15.79%). Students had the following specialisations: Psychology (63.16%), Medical Science (15.79%), Pathology (10.53%), Pharmacology (5.26), Neuroscience (5.26%). All students reported that they were at the end of their candidature.

Supervisors

Participants were research academics with a Faculty appointment and currently supervising Honours students at the University of New South Wales (UNSW, Sydney). Out of a possible 168 supervisors (37 Neuroscience, 88 School of Medical Sciences, 43 Psychology), a total of 43 supervisor responses were recorded, a response rate of 25.60%. Two responses were subsequently excluded from analyses for not listing degree supervision details, so that 41 responses were included in the final analyses. Supervisors were predominantly female (Female = 41.46%, Male = 39.02%, Not specified = 19.51%), and had a mean age of 46.12 (SD = 13.31, n = 33). At the time of survey participation, supervisors were supervising students from the following degrees: Bachelor of Science (26.83%), Bachelor of Psychological Science (21.95%), Bachelor of Psychology (21.95%), Bachelor of Advanced Science (9.76%), not specified (19.51%). Students supervised were from the following specialisations: Psychology (49%), Medical Science (17%), Pharmacology (2%), Neuroscience (32%). Supervisors had supervised students for a mean of 12.94 years (SD = 10.33, range = 1–40). The mean number of students being supervised by an individual supervisor, at the time of the survey, was 1.91 (SD = 0.90, range = 1–4).

Survey Participation Procedure

Students were invited to participate in the voluntary, anonymous online survey via an announcement posted on their Honours course page in the learning management system platform Moodle. Supervisors were invited by receiving an email from a shared administrative mailbox for the Honours degree. All invitees were reminded to participate in the survey 1 week after the initial invitation. All participants were provided with a Participant Information Statement, Consent form, and web link to access and complete the survey using the Qualtrics platform.

Participants were asked to identify with an Honours degree and specialisation (as a student or supervisor) before completing

9 quantitative and 6 qualitative (open-ended) questions about the impact of COVID-19 on their Honours research project(s) and experience. The detailed wording of the impact questions can be found in the **Supplementary Material**. They also rated their agreement with key Honours-relevant SDT relatedness, competence, autonomy, and wellbeing statements, and this is detailed below. Participants reported key demographic information, and completed the 15-item general wellbeing scale which was used to determine their Wellbeing Profile (WB-Pro15; Marsh et al., 2020). The details and results of the WB-Pro are reported in the **Supplementary Material**.

Measures of Honours Relatedness, Competence, Autonomy, and Wellbeing

All participants rated their extent of agreement with several statements associated with SDT needs, using a 9-point scale, with the range: 1 (completely disagree), 2 (strongly disagree), 3 (disagree), 4 (somewhat disagree), 5 (neither agree nor disagree), 6 (somewhat agree), 7 (agree), 8 (strongly agree), and 9 (completely agree).

For students, the relatedness-to-students statement was "I was able to form positive professional relationships with other students in this program," the relatedness-to-staff statement was "I was able to form positive professional relationships with the staff (e.g., Honours convenors, Honours committee members, teachers) in this program," the relatedness-to-university statement was "This program built my feeling of belonging to university communities," the competence statement was "This program built my feeling that I have the capacity to undertake what is required to reach my goals for my Honours year," the autonomy statement was "This program allowed me to have some choice and to pursue my specific interests in the subject matter," and the wellbeing statement was "This program built my feeling of wellbeing as a university student." In addition, the equity statement was "Students are equitably supported to achieve their academic goals in this program."

For supervisors, the relatedness-to-students/staff statement was "I was able to form positive professional relationships with students and staff (e.g., Honours convenors, Honours committee members, teachers) in this program," the relatedness-to-university statement was "This program built my feeling of belonging to university academic communities," the competence statement was "This program built my feeling that I have the capacity to undertake Honours supervision," the autonomy statement was "This program allowed my Honours students flexibility in revising their research plan in response to COVID-19," and the wellbeing statement was "This program built my feeling of wellbeing as an Honours supervisor." In addition, the equity statement was "Honours supervisors are equitably supported to achieve their research supervision goals in this program."

Because we were interested in whether participants, overall, "agree" or "disagree" (or are neutral) toward the questions, we also collapsed the response distribution into 3 bins, where scores of 1-4 constituted "agree," a score of 5 constituted "neither agree nor disagree," and scores of 6-9 constituted "disagree."

Coding of Participant Responses to Open-Ended Questions

For the qualitative analysis of this research, we incorporated themes derived from common quotes from participant's open-ended written responses represented in aggregate by the survey data. To explain patterns in participant responses, we used the systematic process of content analysis modelled by Lune and Berg (2016). For "Impact of COVID-19 on research" questions, participant's responses in each analytic category were read and themes were identified. Then each response was re-read and coded to indicate the presence or absence of each theme (0 = absent, 1 = present). A single participant response could contain multiple themes. For each of the themes, we report the number or proportion of all participant response samples that made relevant statements. All items were rated by a primary coder (ES, in consultation with NK) and a second independent coder blind to the study hypotheses. The majority of Intraclass Correlation Coefficients (ICC) were >0.70, indicating that interrater reliability was good (see **Supplementary Material**: Interrater Reliability, for more specific statistics). ICCs were calculated using SPSS 27, all other analyses were conducted using Statistica (TIBCO Statistica version 13.3.0).

STUDENT RESULTS AND DISCUSSION

Impact of COVID-19 on Original Research Project, Assessments, and Honours Experience

All students (N = 19) reported that COVID-19 had impacted their original research project in some capacity. The reported impacts were: Minimum impact (6.67%), Moderate impact (20.00%), Significant impact (40.00%), Total impact (33.33%). When asked to elaborate on changes to their research projects due to COVID-19 circumstances (n = 16), students mentioned the need to amend projects (n = 12), the need to take time off (n = 3), work remotely/online (n = 12), concerns about the quality of their theses (n = 2) and issues with resource availability (n = 1). When outlining contingency plans if the university shut down, the majority of students reported changes to the type of data being collected; students also reported on different aspects of their planned and actual research projects, and of impact on course work and living conditions (see **Supplementary Material**: Additional Responses).

When asked if they would prefer to go back to face-to face coursework (n = 15), the majority of students reported yes (n = 12), and the remaining students reported that this question was not applicable to them (n = 3). This result supports the hypothesis that the majority of students would prefer to go back to face-to-face coursework.

When asked about the best part of their Honours year, students (n = 15) mentioned gaining new skills and/or

TABLE 1 | Means and response distributions for student agreement with honours SDT needs and wellbeing statements.

Item	Mean (SD)	Response distribution n (%)		
		Agree	Neither agree nor disagree	Disagree
Relatedness-to-students	5.00 (2.17)	9 (60.00%)	0 (0.00%)	6 (40.00%)
Relatedness-to-staff	5.80 (1.82)	9 (60.00%)	3 (20.00%)	3 (20.00%)
Relatedness-to-university	4.67 (2.16)	5 (33.33%)	3 (20.00%)	7 (46.67%)
Autonomy	6.07 (1.67)	11 (73.33%)	1 (6.67%)	3 (20.00%)
Competence	5.60 (2.20)	9 (60.00%)	2 (13.33%)	4 (26.66%)
Wellbeing	4.20 (1.90)	5 (33.33%)	3 (20.00%)	7 (46.67%)
Equity	5.27 (1.95)	9 (60.00%)	3 (20.00%)	3 (20.00%)

Note. N = 15; 9-point scale, with higher number = greater agreement.

knowledge (n = 5), being in the lab or interacting with lab members (n = 4), feeling accomplished after finishing (n = 3), the period before COVID-19 (n = 2), receiving feedback/learning from their supervisor (n = 2), and specific Honours level coursework subjects (n = 2). When asked about the worst part of their Honours year, students (n = 15) mentioned separation from support networks (e.g., family, friends, Honours cohort, lab members; n = 8), project changes (n = 4), issues communicating with supervisors (n = 2), uncertainty (n = 2), COVID-related delays (n = 2), and struggles with motivation (n = 2). Additional survey responses are reported in the **Supplementary Material**.

Honours Psychological Needs and Wellbeing

See **Table 1** for a breakdown of means and response distributions for items regarding Honours needs (relatedness, competence, autonomy), wellbeing, and equity. The highest number of students "agreed" with the statement for autonomy, competence, relatedness-students, relatedness-staff, and equity. Thus, our hypotheses that student ratings on these variables would be low, were not supported. The highest number of students disagreed with the statements for relatedness-to-university and for wellbeing. Thus, our hypotheses that relatedness-to-university and wellbeing would be low were supported. Contrary to our expectations, ratings of the severity of the impact of COVID-19 on student's research projects was not significantly associated with Honours-related wellbeing (Spearman's Rank r = −0.10). The highest number of students agreed with the statement that they had been equitably treated in the program, with quality of the supervisor-student relationship being the most common "agree" comment (see **Supplementary Material**: Additional Responses).

Regression Analysis

To test the hypothesis that student's SDT needs would predict their wellbeing, we conducted simultaneous multiple regression. The overall model was significant R^2 = 0.67, F (5,9) = 3.66, p = 0.044, indicating that the hypothesis was generally supported. However, neither relatedness-students (b* = −0.01, t (9) = −0.02, p = 0.987), relatedness-staff (b* = −0.07, t (9) = −0.24, p = 0.819), relatedness-university (b* = 0.05, t (9) = 0.17, p = 0.872), autonomy (b* = 0.20, t (9) = 0.68, p = 0.511), nor competence (b* = 0.75, t (9) = 2.08, p = 0.068), significantly predicted role-related wellbeing.

SUPERVISOR RESULTS AND DISCUSSION

Impact of COVID-19 on Original Research Project

Supervisor's (n = 41) reported impact of COVID-19 on their student's original research project was: Minimum impact (14.63%), Moderate impact (41.46%), Significant impact (29.27%), Total impact (14.63%).

When asked to "elaborate on changes to research projects," the small subset that reported minimum impact (n = 6) elaborated that face-to-face testing of human subject volunteers switched to online testing (n = 3), the lab remained open (n = 1), lab closed but managed to test off campus (n = 1) or did not comment (n = 1). The remaining supervisors (n = 35) stated that the "lab closed" (n = 15), the planned experiments were halted/delayed/rescoped (n = 26) or their Honours students were prevented/banned from conducting research on campus (n = 5). When asked to outline their contingency plan (n = 36), the main themes of supervisor responses were: Working remotely (n = 10), running online studies (n = 9), analysing other/existing datasets (n = 8), conducting literature reviews and/or meta-analyses (n = 4), and having no plan or adapting as they went (n = 4). When asked to share the specific problems their Honours students encountered in 2020 (n = 38), supervisors mentioned student's lack of interaction/connectedness with students and staff (n = 10), mental health concerns (stress, anxiety, loneliness, isolation; n = 10), difficulties surrounding remote supervision (n = 7), practical issues collecting data (n = 6), less time to conduct research and gain experience in the lab (n = 16) and lack of motivation (n = 2).

Supervisors (n = 25) reported little change in the type of research subjects used for their students projects pre-pandemic compared to during the pandemic (see **Supplementary Material**: Additional Responses).

When asked about the best part of their Honours supervisor experience, supervisors (n = 32) mentioned seeing their students grow and master new skills (n = 9), their student's resilience (n = 9), and meeting and working with their students (n = 8). When asked about the worst part of their Honours supervisor experience, supervisors (n = 30) reported increased time

TABLE 2 | Means and response distributions for supervisor agreement with honours SDT needs and wellbeing statements.

Item	Mean (SD)	Response distribution n (%)		
		Agree	Neither agree nor disagree	Disagree
Relatedness-to-Students and Staff	7.79 (0.91)	34 (100.00)	0 (0.00)	0 (0.00)
Relatedness—to - university	6.35 (1.43)	25 (73.53)	7 (20.59)	2 (5.88)
Autonomy	7.50 (1.42)	29 (85.29)	3 (8.82)	2 (5.88)
Competence	7.09 (1.44)	28 (82.35)	5 (14.71)	1 (2.94)
Wellbeing	6.32 (1.43)	24 (70.59)	6 (17.65)	4 (11.77)
Equity	6.21 (1.45)	23 (67.65)	9 (26.47)	2 (5.88)

Note. N = 34.9-point scale, with higher number = greater agreement.

commitment (n = 6), lack of face-to-face interaction including having provided guidance on how to perform data analysis online (n = 8), concerns for wellbeing of both staff and students including stress and burnout (n = 8), increased use of technology and associated technological issues (n = 4), and student's negative perception of the academic profession due to stress and strain during COVID-19 (n = 1).

When asked to provide suggestions about how Honours could be improved in the future, supervisors (n = 25) reported the need for better communication—both between the university and faculties/supervisors, and between supervisors and students (n = 7); need for greater flexibility around data collection (n = 3); and the need for a more consistent response across Faculties from the University (n = 2). Individual responses (i.e., n = 1) included eliminating coursework, flexibility for individual research clusters to manage their own response to the pandemic, broader range of thesis methodologies such as systematic reviews and meta-analyses and granting students initial access to a broader range of IT programs and digital support.

When invited to make comments that may help to understand how COVID-19 impacted their capacity to supervise, supervisors (n = 24) reported (n = 1 in each case): Simultaneous increase in personal and professional demands (e.g., parenting responsibilities, editorial work); academics were not alone in facing challenges; inability to predict changes in Honours marking criteria limited their ability to advise students; ongoing budgetary concerns including salary and research funding; regular meetings are essential to determine where support is needed; humans need human interaction, online meetings are challenging to run; supervising in 2020 was more stressful; contingency plans should be encouraged for supervisors taking on Honours students. Additional survey responses are reported in the **Supplementary Material**.

Supervisor ratings of the severity of the impact of COVID-19 on student's research projects was not significantly associated with Honours-related wellbeing.

Honours-Related Psychological Needs and Wellbeing

See **Table 2** for a breakdown of supervisor response distributions and means for items regarding supervisor SDT needs, wellbeing, and equity. The highest number of participants agreed with all statements suggesting that our hypotheses predicting supervisor SDT need satisfaction and wellbeing would be low, were not supported. As expected, supervisor ratings of the severity of the impact of COVID-19 on student's research projects was not significantly associated with wellbeing (Spearmans Rank r = −0.10).

Equity

The highest number of supervisors "agreed" that Honours students were equitably supported to achieve their research supervision goals in the program. When supervisors were asked if *students* were equitably supported to achieve their academic goals, of the supervisors that responded to this question (n = 35), 77.14% responded "yes," 5.71% responded "no," and 17.14% responded "not sure." When asked to explain their answer to this question, supervisors that responded "yes" (n = 27) reported: Students were well supported by staff, lab members, and the University (n = 7); while students missed some opportunities, they gained others (n = 4); and that sufficient compensatory adjustments were made, including adjustments to thesis marking (n = 8). Supervisors who responded "no" (n = 2) reported: Differences in individual circumstances (both student and supervisor; n = 1); research progress at time of shutdown (n = 1); and lack of face-to-face experience (reliance on Zoom; n = 1). Supervisors that responded "not sure" (n = 6) reported: Not knowing other's circumstances (n = 1); thesis marking adjustments (n = 1); and that inherent differences in research topic, supervisor's expertise etc. mean that all students likely don't receive the same level of support (n = 2), although this was consistent with previous years (n = 1).

Regression Analysis

To test whether supervisor's needs would predict their wellbeing, we conducted simultaneous multiple regression. The overall model was significant R^2 = 0.49, F (4,29) = 7.03, p < 0.001, indicating that the hypothesis was generally supported. Competence was a significant positive predictor of wellbeing (b* = 0.51, t (29) = 2.85, p = 0.008). However, neither relatedness-staff/students (b* = 0.09, t (29) = 0.63, p = 0.513, autonomy (b* = −0.01, t (29) = −0.07, p = 0.948), nor relatedness-university (b* = 0.22, t (29) = 1.27, p = 0.215) significantly predicted wellbeing.

BETWEEN-GROUP ANALYSES

Impact on Research Project

As expected, a chi-square test of independence found no significant association between role (student, supervisor) and self-reported impact of COVID-19 on their original research projects, X^2 (3, N = 60) = 5.03, p = 0.170.

Honours-Related Psychological Needs and Wellbeing

As expected, independent samples t-tests found relatedness-to-staff/students was significantly greater for supervisors (M = 7.79, SD = 0.91) compared to students (M = 5.60, SD = 1.77; note that relatedness ratings were averaged for this comparison), t (47) = −5.75, p < 0.001). Relatedness-to-university communities was significantly greater for supervisors (M = 6.35, SD = 1.43) compared to students (M = 4.67, SD = 2.16), t (47) = −3.23, p = 0.002. Competence was significantly greater for supervisors (M = 7.09, SD = 1.44) compared to students (M = 5.60, SD = 2.20), t (47) = −2.82, p = 0.007. Autonomy was significantly greater for supervisors (M = 7.5, SD = 1.42) compared to students (M = 6.07, SD = 1.67), t (47) = −3.09, p = 0.003, and wellbeing was significantly greater for supervisors (M = 6.33, SD = 1.90) compared to students (M = 4.20, SD = 1.43), t (47) = -4.33, p < 0.001.

GENERAL DISCUSSION

Impact and Wellbeing

The specific measure of impact on Honours student's research projects indicated that there was significant impact. As expected, there was no difference between student's and supervisor's impact ratings. The most common impacts reported by students were needing to amend projects and to work online, and by supervisors was that planned experiments were halted/delayed/re-scoped. Unexpectedly, this impact measure was not associated with student wellbeing, even though such wellbeing was, as expected, low, and lower than supervisor wellbeing. It may be that by the time students answered this survey—toward the end of their candidature–they had come to terms with the pandemic-induced changes, regardless of the extent of impact on their research program. As expected, the association between impact and wellbeing for supervisors was not significant. It should be noted that the reliability and validity of the measures used to test these hypotheses have not been established, and thus conclusions are tentative, and further research is needed. For example, the "Impact" question assumes negative impact; respondents may not have interpreted the valence of the impact in that assumed way.

The qualitative data for students (see **Supplementary Material**: Additional Responses) highlight other aspects of the impact of the pandemic on their research project. For example, many students reported that the worst part of the Honours year was separation from support networks due to the remote nature of the year. Whilst fear of failure, time management, and increased workload intensity are typical concerns of Honours students (i.e., pre-pandemic; Allan, 2011), student concerns reported here reflect the novel pandemic context. These concerns were likely more difficult for Honours students to cope with and seek support for, due to the rapidly evolving nature of the pandemic and lack of appropriate support resources. Supervisors reported themes of burnout and increased time commitment (i.e. increased workload) as the worst part about the year. These themes were not apparent in student responses, further suggesting that students' lived reality of Honours was not more intense or challenging compared to their preCOVID-19 expectations. Professional support networks are usually important for experience and wellbeing of Honours students. However, during the pandemic, the student-supervisor relationship was crucially important. Overall, the need for independent learning was challenging for students due to separation from support networks, project disruptions, and lack of prior research experience.

Complementary qualitative data for supervisors highlighted other aspects of the impact of the pandemic on their research. Novel issues included the increasing need to balance practical and administrative demands with the increased needs of their students, and the transition from face-to-face research project planning and coordination to the challenge of overseeing the research project remotely. While managing such issues is not necessarily novel for Honours supervisors, the sudden and significant increase in demand for supervisors' time and attention likely led to increased feelings of distress and burnout. Finally, although the pandemic altered mechanisms for providing supervisory support, these were perceived as equitable by most supervisors surveyed.

Need Satisfaction and Wellbeing: Theoretical Implications

According to SDT (Ryan and Deci, 2000), it was expected that students' Honours-related psychological need satisfaction would be low. This was the case for relatedness-to-university (average "disagree" rating), but not for the other SDT needs. As expected, student wellbeing was low and lower than that for supervisors. These findings, plus the fact that overall, the needs significantly predicted wellbeing, suggest support for SDT as applied in this context. However, the finding that the needs were not individually associated with wellbeing suggests that more work needs to be done (e.g., the creation of a scale with multiple items for each SDT need).

For supervisors, it was expected that Honours needs and wellbeing would be low, however, this was not the case—ratings were most frequently within the "agree" range. Because these ratings occurred at the end of the Honours year, this finding may be reflective of supervisor's relief in supporting their students to completion. As with the student data, although there is some support for SDT being usefully applied to this specific educational context, more work needs to be done (e.g., improving measurement validity and reliability).

The relatedness-university statement was not endorsed by students and was the least endorsed SDT need for supervisors. Note that most Honours students in this cohort would have undertaken their Bachelor degree at the same institution, and most supervisors would have been employed by the institution for many years. Thus, the stress of the pandemic experience may have contributed to these ratings.

Equity

The majority of students and supervisors agreed that students were equitably supported (for detailed summaries, see **Supplementary Material**). Students noted that equitable support was contingent on the quality of the student-supervisor relationship. Access to resources (including facilities and staff), and agency in assessment changes were also important. Similarly, supervisors noted that although there are likely differences in student experiences, on average these differences remained consistent despite the pandemic. Regarding the pandemic context, supervisors noted that students were well supported, and appropriate adjustments were made.

Wellbeing Profile

Our participants completed the WB-Pro (Marsh et al., 2020) as part of the general survey. Please see the **Supplementary Material** for details of the WB-Pro responses and how they relate to both 1) the Honours SDT needs and wellbeing variables and 2) the original report regarding age differences (Marsh et al., 2020). Findings relevant to understanding the Honours student and supervisor experience are briefly reported here.

Student average WB-Pro ratings appear to be lower than Marsh et al. (2020) sample (as reported by James Donald, personal communication, 15th March, 2021), while supervisor average WB-Pro ratings appear to be similar. Responses to the Honours wellbeing items correlated with the both student and supervisor average WB-Pro Average ratings. These WB-Pro Average ratings were higher for supervisors than for students.

Consistent with Marsh et al. (2020), we observed age differences for some dimensional factors (e.g., supervisors had higher competence ratings than students; supervisors were on average 20 years older). However, compared to Marsh et al. (2020), both students and supervisors in our sample appeared to provide lower ratings of optimism, and higher ratings of positive relationships. Amongst supervisors, the decreased lack of predictability regarding the future (e.g., job security) may have reduced optimism, whilst at the same time, there may have been an increased emphasis on positive relationships because isolation experiences highlighted the value of such relationships.

Limitations

Our conclusions are restricted by the following limitations. Firstly, the cross-sectional design administered close to research submission limits our ability to make strong causal inferences about the impact of the pandemic. Future studies could examine the longitudinal impact of the pandemic on research experience and wellbeing. Nevertheless, a potential strength of the paper is that the cross-sectional surveys were conducted toward the end of the candidature for most participants, rather than retrospectively. The data are of high validity since both students and supervisors were most acutely affected during the survey participation window.

Secondly, our measures could be improved, and validity better tested by considering standard student course satisfaction ratings and student academic grade data. Thirdly, selection bias should be considered, given the small sample size. The survey link was sent to all students and supervisors in participating Honours programs, allowing for selection of a random sample. However, it is possible our sample is non-random. For example, perhaps resilient students and supervisors were more motivated to participate. Alternatively, students and supervisors whose experience was more adversely impacted may have been more motivated to participate.

Whilst we surveyed students about their experiences transitioning from on-campus to conducting research from home, and how they coped with the absence of face-to-face academic support systems, these questions were not asked of supervisors. This is a limitation; however, open-ended written survey responses from supervisors provided an avenue to address supervisor concerns and assisted in providing recommendations for supervisors to manage their Honours related activities during the pandemic (see below). We recommend future survey questions address supervisors transition to working-from-home and whether supervisor were, for example, in a carer role, and how this impacted their Honours supervisor duties.

Our small sample also prevented us from performing Honours program (e.g., Medical Sciences vs. Psychology) specific analyses, or stratifying for sex, age, or cultural background. Additionally, we did not distinguish between the testing of human subjects online compared to face-to-face, or capture the *duration* of disruptions to Honours experience when measuring the impact of the pandemic.

Practical Implications and Recommendations

During 2020, Honours students and supervisors surveyed in this study were expected to rapidly adjust to new strategies for conducting research, including working remotely. Moving forward, research students around the world remain concerned about whether they will be able to initiate and complete their research lab work (Blankstein et al., 2020; Elmer and Durocher 2020). In the lead up to survey participation, the College Crisis Initiative Data Dashboard (August 2020) indicated that only a quarter of the surveyed 2981 US universities and colleges planned to open their campuses in person, suggesting ongoing disruption to research training. Based on the outcomes of this study, we address practical implications for moving research projects forward and recommend strategies for addressing the situation of COVID-19 uncertainty. Explicit curricular and extracurricular environmental strategies can be put in place, including 1) online as well as face-to-face support mechanisms to strengthen relatedness with peers, supervisors, and the wider university community (note that many institutions offer totally online Honours programs; we could learn from their experience; see

Rodafinos et al., 2018, and 2) opportunities to further develop self-management, which is the capacity to effectively pursue meaningful goals and to be flexible in the face of set-backs (Cranney et al., 2016), and includes skills such as time management and resilience (e.g, Stallman, 2011). Resilient individuals are more capable of dealing with uncertainty and seeking necessary social support (Ozbay et al., 2007) which should mitigate against the psychologically adverse consequences of COVID-19 (Labrague, 2021).

Based on the findings reported in this paper (including the detailed comments and suggestions provided by both students and supervisors, as reported also in the **Supplementary Material**), we make the following specific recommendations:

- Preparing a contingency research plan, which is entirely executable remotely, is a recommended strategy to reduce the adverse aspects of COVID-19 restrictions on the project, including the associated stress response (Ozbay et al., 2007). Key considerations in developing an appropriate contingency plan include acknowledging at the early stages that scientific research rarely goes exactly as planned, identification of possible challenges to the research methods and likely solutions, and instilling attitudes of perseverance and optimism to assist the research process.
- Prior to project commencement, discussion should occur between Honours students, supervisors, and Honours program convenors to determine if the planned research is feasible. Can the research questions be addressed, the hypotheses tested, and the experiments carried out in a COVID-safe way? If not, modifications to adjust the project questions and hypotheses could be effective in managing expectations. Strategies such as expanding the literature review to a systematic review or meta-analysis, that could comprise the entire research project if it becomes impossible to collect new empirical data, should be considered as a back-up plan, from the outset.
- Stringent accreditation standards maintained by the academic discipline may dictate the research requirements to achieve an Honours degree and the minimum requirement for further (Masters or PhD) study. Therefore, any revision of the proposed student project should be discussed with the program convenor to ensure that the student remains capable of achieving the relevant standard for degree completion.
- There are detrimental effects of working remotely, including limited ability to connect with others, and reliance on support networks external to the university for social connection and support. We recommend implementation of wellbeing interventions to ensconce students in a wider research community, including a digital platform to create a community environment, overcome the limited human interactions, and foster a social presence (Chen and Jang, 2010; Kim et al., 2011; Fiock, 2020; Munoz et al., 2021; see also https://teaching.unsw.edu.au/healthyuni-main/cc-practical-examples.
- Until the pandemic eases, line managers should take measures to lighten the load of supervisors, for example by 1) monitoring supervisor's teaching and administrative load, and finding creative solutions to provide institutional support for Honours students, and 2) encouraging prospective Honours students to take program leave if the project requires access to campus.
- Pre-pandemic, Honours supervisors had expertise in supervising in a face-to-face setting, but little experience of how to supervise remotely (see Thorpe, 2010). Furthermore, a lack of universal online teaching experiences meant Honours students and their supervisors were unprepared for remote learning and solely online communications. Major challenges to supervision include difficulty in connecting Honours students with academic support systems remotely, loss of incidental student learning through peers, and building relationships and communicating with students solely online. Therefore, strategies that closely replicate the organic traditionally on-campus experiences need to be sourced and built into online supervision communication strategies (Fiock, 2020; Munoz et al., 2021). For example, use real-time online communication platforms such as Teams, or Slack.
- Honours supervisors could develop ways to engage and motivate students online, to reduce isolation (e.g., create an online community with synchronous e-meetings, for research collaboration), and promote self-directed learning and autonomy (e.g., gather specific feedback on a regular scheduled basis and provide avenues for students to seek additional assistance if required). Supervisors may need to provide more scaffolds for students who are less comfortable with autonomous learning, which is key to Honours progress. The long-term benefits of online reframing of the Honours supervisory approach during COVID-19 include enabling Honours supervision of a project internationally or during sabbatical leave.

CONCLUSION

To our knowledge, this is the first study to incorporate both student and supervisor perspectives on the impact of COVID-19. This dual data set provides a unique opportunity to compare student and supervisor impact perceptions and wellbeing during the COVID-19 pandemic. Further, this study focuses specifically on the Honours program, which is an essential training ground for future researchers in a number of English-speaking countries. This is important because the Honours experience is distinct in many ways (predominantly research focussed, short timeline), although many of the same issues have been reported in doctoral training (e.g., Wang and DeLaquil, 2020). Despite the restricted

conclusions drawn (e.g., due to small sample size), our findings provide interesting insights into the perceptions and wellbeing of Honours students and supervisors during the COVID-19 pandemic. If the recommendations are implemented, such measures should not only buffer the negative impact of future pandemic restrictions, but also facilitate a more constructive approach to, and productive result for the Honours experience for both students and supervisors, in both pandemic and non-pandemic times.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the UNSW Human Research Ethics Committee (approval number: HREAP 3403), and participants gave their informed, written consent to take part in this study.

AUTHOR CONTRIBUTIONS

NK, JC, and BS contributed to conception and design of the study. ES organized the database. ES performed the statistical analysis. JC, ES, NK, and BS wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.758960/full#supplementary-material

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Undergraduate Biology Students Received Higher Grades During COVID-19 but Perceived Negative Effects on Learning

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Institutions across the world transitioned abruptly to remote learning in 2020 due to the COVID-19 pandemic. This rapid transition to remote learning has generally been predicted to negatively affect students, particularly those marginalized due to their race, socioeconomic class, or gender identity. In this study, we examined the impact of this transition in the Spring 2020 semester on the grades of students enrolled in the in-person biology program at a large university in Southwestern United States as compared to the grades earned by students in the fully online biology program at the same institution. We also surveyed in-person instructors to understand changes in assessment practices as a result of the transition to remote learning during the pandemic. Finally, we surveyed students in the in-person program to learn about their perceptions of the impacts of this transition. We found that both online and in-person students received a similar small increase in grades in Spring 2020 compared to Spring 2018 and 2019. We also found no evidence of disproportionately negative impacts on grades received by students marginalized due to their race, socioeconomic class, or gender in either modality. Focusing on in-person courses, we documented that instructors made changes to their courses when they transitioned to remote learning, which may have offset some of the potential negative impacts on course grades. However, despite receiving higher grades, in-person students reported negative impacts on their learning, interactions with peers and instructors, feeling part of the campus community, and career preparation. Women reported a more negative impact on their learning and career preparation compared to men. This work provides insights into students' perceptions of how they were disadvantaged as a result of the transition to remote instruction and illuminates potential actions that instructors can take to create more inclusive education moving forward.

Keywords: grade disparity, sense of community, peer interactions, biology interest, career preparation

INTRODUCTION

In the early months of 2020, the COVID-19 pandemic led to an unprecedented disruption of the normal mode of course instruction across most institutions of higher education. In the United States, most universities abruptly stopped conducting in-person classes and closed their campuses in March 2020 (Baker et al., 2020; Hartocollis, 2020). Mid-semester, many students and instructors were forced into learning and teaching remotely, respectively, for the first time due to the need for social distancing as a response to the pandemic (Johnson et al., 2020; Moralista and Oducado, 2020). Syllabi, teaching approaches, and assessments had to be modified to account for this altered mode of learning; most instructors only had one to two weeks to redesign their courses before remote instruction began. This abrupt shift to remote learning has been distinguished from online learning in general (Hodges et al., 2020) and it is commonly assumed that this abrupt shift adversely affected student learning (Kimble-Hill et al., 2020; Gin et al., 2021). There are many factors directly associated with the shift to remote learning that could have affected student learning (Hodges et al., 2020; Gin et al., 2021), which are in addition to the stress experienced by students in other aspects of their lives affected by the pandemic (e.g., health, employment, isolation, issues of societal inequalities).

The pandemic affected people across various social identities such as age, nationality, racial/ethnic background, LGBTQ+ status, and socio-economic status. Despite being termed as "the great equalizer" by politicians like New York's Governor Andrew Cuomo and celebrities such as Madonna (Gaynor and Wilson, 2020; van Buuren et al., 2020), it had differential impacts on people along the lines of power and privilege in our society due to various systems of oppression including, but not limited to, racism, classism, sexism, and ableism (Copley et al., 2020; Garcia et al., 2020; Gaynor and Wilson, 2020; Lokot and Avakyan, 2020; Mein, 2020). In the United States, case and death rates have been higher among Black, Hispanic/Latinx, and Native American people than white people (Gold et al., 2020; Karaca-Mandic et al., 2020; Wortham, 2020). COVID-19 infections and deaths were also higher for people living in areas with higher poverty levels compared to areas with little or no poverty (Krieger et al., 2020; Chen and Krieger, 2021). Further, these more vulnerable communities experienced more negative financial impacts such as job losses or reduced working hours due to the economic shutdowns (Moen et al., 2020). When considering the educational impact of this crisis, these differential medical and financial impacts may have contributed to more negative educational consequences for students with marginalized social identities.

In addition to health and financial impacts, several other factors may have differentially exacerbated the negative effects of the COVID-19 pandemic on student learning in Spring 2020. Losing access to student housing and meal plans contributed to housing and food insecurities for many students, including low-income students, international students, first-generation students, and Black, Hispanic/Latinx, and Indigenous students (Chen et al., 2020; Lederer et al., 2020; Barber et al., 2021). Heightened housing and food insecurities impacted off-campus students as well (Goldrick-Rab et al., 2020). Moreover, poor internet connection and lack of a quiet or safe space to study made it more difficult for students to complete their assignments and succeed during remote instruction (Means and Neisler, 2020; Ramachandran and Rodriguez, 2020; Tigaa and Sonawane, 2020; Villanueva et al., 2020; Barber et al., 2021). For example, one recent study of college students in introductory sociology courses showed that more than 50% of all students experienced occasional internet problems during remote learning in Spring 2020 (Gillis and Krull, 2020). In the same study, about 90% of the students reported distractions in their new workspace and about 65% of the students reported the lack of a dedicated workspace (Gillis and Krull, 2020). While these issues negatively affect all students, students from low-income families, first generation to college students and Black, Hispanic/Latinx, and Indigenous students were more likely to be disproportionately impacted by poor internet connections or distracting environments (Barber et al., 2021). Another factor that likely affected remote learning in Spring 2020 is additional caregiving responsibilities necessitated by remote learning in K-12 schools and greater health risks for older family members (Collins et al., 2020). These additional responsibilities would reduce available time for coursework and could affect academic outcomes. Likely due to societal gender roles that assume women take on primary caregiving, these responsibilities are reported to have disproportionately affected women (Alon et al., 2020; Collins et al., 2020; Fortier, 2020). Needing to work jobs that require frequent interaction with others at places such as grocery stores and pharmacies is yet another element influencing student learning during the pandemic, especially for Black, Hispanic/Latinx, immigrant students, and those from low-income households (McCormack et al., 2020). Working such jobs could increase students' risk of contracting COVID-19 and may cause greater anxiety in their daily lives (Pappa et al., 2020; Parks et al., 2020). All these factors are likely to differentially affect students depending on their locations along the various axes of power and privilege.

A limited number of studies have examined the educational impact of the pandemic on students. Several publications have reported that students were less engaged (Perets et al., 2020; Wester et al., 2021) and struggled with their motivation to study after the transition to remote learning in Spring 2020 (Al-Tammemi et al., 2020; Gillis and Krull, 2020; Means and Neisler, 2020; Petillion and McNeil, 2020), although one study on public health students at Georgia State University did not report lower motivation among students (Armstrong-Mensah et al., 2020), perhaps because of the heightened awareness of the relevance of public health during a global pandemic. It has also been demonstrated that the transition to remote learning had a negative impact on student relationship-building, specifically the extent to which students interact with each other in and out of class (Jeffery and Bauer, 2020; Means and Neisler, 2020), and on students' sense of belonging in the class (Means and Neisler, 2020; Wester et al., 2021). In response to the pandemic, several universities changed course policies to extend the deadline for course withdrawals or to allow greater access to pass/fail grading options (Burke, 2020). For example, Villanueva and colleagues

(Villanueva et al., 2020) found higher course withdrawal rates among general chemistry undergraduates after students were offered an extended deadline for withdrawing from the course. Despite these negative student experiences, some studies have reported small increases in student grades in Spring 2020 compared to similar courses in previous years (Gonzalez et al., 2020; Loton et al., 2020; Bawa, 2021). Similarly, a nationwide analysis of scores on a microbiology concept inventory showed no decline and even some improvement in student learning gains in Spring 2020 (Seitz and Rediske, 2021).

There is some evidence for differential impacts of the transition to remote learning for students with different social identities. For example, a report based on survey data from 600 undergraduates in STEM courses across the United States showed that women, Hispanic students, and students from low-income households experienced major challenges to continuing with remote learning more often than men, white students, and students from middle- or high-income households, respectively (Means and Neisler, 2020). Another survey study found that the likelihood of lower-income students delaying graduation because of COVID-19 was 55% higher than higher-income students (Aucejo et al., 2020).

In contrast to students in in-person degree programs whose mode of learning changed drastically, the crisis did not fundamentally change the mode of learning for students who were already enrolled in fully online degree programs. Although other aspects of the lives of online students were still affected by the pandemic, online learning was not new to them or their instructors, courses did not need to be modified halfway through the term, and students expected to complete all coursework remotely when they signed up for the course. Therefore, comparing the impact of the pandemic on the grades of online and in-person students might allow us to tease apart the influence of the rapid transition to online learning from the stress of living through a global pandemic. One prediction would be that online students would experience less of a negative impact on learning due to the pandemic compared to their in-person counterparts because their educational modality did not change. An alternative prediction is that the differences in the student populations online and in person, specifically the higher percentage of individuals in the online program who hold one or more marginalized social identities and may be more vulnerable to the negative effects of the pandemic outside the class, would lead to greater negative impacts for online students as a result of the COVID-19 pandemic. Specifically, we know that the percentage of women, older students, students who are primary caregivers, and students from low-income households are consistently higher in online programs compared to in-person programs (Wladis et al., 2015; Cooper et al., 2019; Mead et al., 2020). These are groups that have been unequally disadvantaged during the pandemic in general. Therefore, it is important to control for demographic variables when comparing the effects of the COVID-19 pandemic on grades between students in online and in-person degree programs. Even though grades are an imperfect measure of learning (Yorke, 2011), it is important to examine them because receiving poor grades in STEM courses has been shown to have a major effect on students' trajectories in college (Weston et al., 2019).

The biology program at Arizona State University (ASU) offers a unique opportunity to examine the impact of the emergency transition to remote learning on undergraduates. First, ASU offers equivalent in-person and fully online biology degree programs that have aligned curricula. This allows for comparison of the experiences of students in an in-person program transitioned to remote learning to the experiences of students enrolled in an online program prior to the COVID-19 pandemic. Our approach is akin to the "difference-in-difference" approach as we compare students' grades before and during the pandemic in our "treatment group," i.e., students who experienced an abrupt transition to remote learning, to the "control group," i.e., students in the online program who did not experience an abrupt transition. However, we do not intend to make causal claims, but instead view the comparison to the online program courses as helping us in understanding the results from the courses that transitioned to remote learning. Second, ASU has a large, diverse population of students that allows for the examination of the extent to which the transition affected students with different social identities. Science, technology, engineering, and math (STEM) disciplines, such as biology, have long been exclusionary spaces dominated by relatively wealthy white men (Noordenbos, 2002; Hill et al., 2010; Ong et al., 2011). Underrepresentation of women, people of color, people with disabilities, and people with low socioeconomic status is well documented in the sciences (National Science Foundation and National Center for Science and Engineering Statistics, 2019). Therefore, it is important to examine the impact of the transition to remote learning on STEM students with social identities historically underrepresented in the sciences, for which ASU's biology program provides a suitable context.

In this study, following the recommendation from Hodges et al. (2020) we use the term "remote" to refer to in-person courses that transitioned abruptly to online instruction, while using the term "online" for courses that were designed to be online from the beginning. One important difference between the online and in-person programs after the transition to remote learning in Spring 2020 was that courses in the online program were fully asynchronous. In contrast, the courses in the in-person program were generally taught synchronously using web conferencing (e.g., Zoom) for lectures and typical in-class activities.

This study uses course grades during the Spring 2020, Spring 2019, and Spring 2018 semesters and survey data from instructors and students about the Spring 2020 semester to examine the impacts of the abrupt transition to remote learning due to COVID-19 during the Spring 2020 semester. While previous studies have examined the impact of the abrupt transition to remote learning on either student grades or instructional practices or student experiences, our study looks at all three of these in the same student population. Thus, our study gives us a more holistic understanding of the impact of the transition to remote learning on student learning in undergraduate STEM courses.

Specifically, our research questions were:

1. Did the abrupt transition to remote learning due to the COVID-19 pandemic affect grades for undergraduate students in an in-person biology program during the Spring 2020 semester? Was this effect on grades different from that found in the equivalent online biology program during Spring 2020? To what extent did the abrupt transition to remote learning disproportionately affect students with identities historically underrepresented in STEM?
2. What changes did in-person biology instructors make to their assessment practices after the abrupt transition to remote learning in Spring 2020 and to what extent do these explain any differences in student grades observed?
3. To what extent do in-person biology students perceive that their learning, interactions with peers and instructors, career preparation, interest in science, and feeling a part of the biology community were affected because of the abrupt transition to remote learning? To what extent did the abrupt transition to remote learning disproportionately affect these perceptions for students with identities historically underrepresented in STEM?

METHODS

Positionality of the Authors

We acknowledge that our own identities influence the research questions that we ask and how we may interpret the data. Our author team includes individuals who identify as men, women, white, South Asian, Jewish, first-generation college-goers, first-generation immigrants, military veterans, and members of the LGBTQ+ community; members of our team grew up in middle class families in the United States, except KS who grew up in India. All the authors are committed to diversity, equity, and inclusion in the sciences and conduct education research focused on equity. This paper was motivated by our concerns regarding social inequities and how they are perpetuated and, in some cases, may be amplified in undergraduate science classrooms.

Data Collection

To understand the context of our data collection, it is necessary to briefly summarize the university's academic policy responses to the COVID-19 pandemic. All in-person instruction was shifted to remote learning at the midpoint of the 15-week Spring 2020 semester. Online degree programs operate on a 7.5-week schedule, so although these students did not experience a change in learning modality, the societal effects of the pandemic would have been present in the Spring 2020 "B"-term. Hybrid or fully remote learning remained the norm in Fall 2020 when the surveys for this study were collected. This research was conducted under a protocol approved by the Arizona State University institutional review board (STUDY #9105).

Student Grades and Demographics

We obtained course grades and student demographic information from the university registrar for Spring 2020 and two spring semesters prior to the pandemic for comparison, Spring 2019 and Spring 2018. Note that for the online degree program, the Spring 2020 "A"-term was completed prior to widespread COVID-19 spread in the United States, so those course enrollments are treated as "pre-COVID." The population of interest is undergraduate biology majors enrolled in either the in-person biology degree program or the fully online biology degree program. Therefore, we obtained course grades for 42 STEM courses that are core courses taken by students in these biology majors, including general biology courses, biochemistry, chemistry, physics, mathematics, and statistics. See **Supplementary Table S1** for the full list of courses.

Our initial grades analysis dataset included a total of 25,100 student-course enrollments, with 8,323 from the Spring 2020 pandemic semester and the remainder from Spring 2018 or 2019. Of these, 19,181 course enrollments were in-person courses and the remaining 5,919 were in online degree program courses.

The demographic variables we collected for this study were gender, race/ethnicity, and two proxies for socioeconomic status (college generation status and federal Pell grant eligibility). Federal Pell grants are given to undergraduate students in the United States based on financial need, and the eligibility criteria take both income and assets into account (Federal Pell Grants, 2021). Therefore, it is an appropriate proxy for socioeconomic status for college students in the United States. The transition away from an in-person lecture and having to adapt to a large change mid-semester could also have negatively affected the learning of students with disabilities (Gin et al., 2021) as changing learning environments have presented novel challenges for deaf and hard of hearing students (Lynn et al., 2020) and students with disabilities more broadly (Gin et al., 2021). However, because we are using institutional data in these analyses and data on disabilities is protected by federal law, we were not able to examine the impact of the transition on students with disabilities in this study, nor were we able to explore other identities not routinely collected by the university registrar.

Instructor Survey

To explore changes in instructional practices in the Spring 2020 semester for instructors who had to transition to remote learning, we created a preliminary survey with several open-ended questions regarding changes in instructional practices, such as ways that they may interact with students and assessments used after the transition to remote learning (a copy of the survey questions analyzed is provided in the **Supplementary Material**). We contacted all of the biology instructors whose Spring 2020 courses transitioned to remote learning (132 in total); 27 instructors responded to the survey (20% response rate). Faculty members were recruited first via email, then verbally encouraged to participate at several follow-up virtual events attended by many of those in the recruitment group.

Building on the open-ended responses from the preliminary instructor survey, we created a second survey that asked in more detail about instructional changes in response to the pandemic. To assess cognitive validity, we conducted two think-aloud interviews with biology faculty members who taught in person during Spring 2020 and had to transition to remote learning (Beatty and Willis, 2007). These think-aloud interviews indicated

that the instructors understood the questions. We then distributed this revised survey to all biology instructors who taught in-person courses in Spring 2020 (n = 132). In the event that they taught multiple courses, the survey asked them to respond based on their largest course size. This was done because large course instructors are subject to greater practical constraints when considering how to shift instruction to remote learning and because the larger sizes mean that a greater number of students in total are impacted by these decisions. The survey first asked instructors to identify any changes they made in their course. This question used a multiple-selection format with 1) 24 options provided, 2) an option to say that no changes were made, and 3) an option to describe other changes not listed. The survey also asked instructors to report the extent to which they tried to reduce cheating in their course, the extent to which they made their course more flexible, and the extent to which they made their course easier. Each of these questions was answered using a six-point Likert scale from strong agreement to strong disagreement with no neutral option and they were asked to explain each answer (a copy of the survey questions analyzed is provided in the **Supplementary Material**). While instructors also experienced many of the same personal challenges resulting from the pandemic that students did, our focus was on the student experience and therefore we only asked instructors about instructional changes.

A total of 43 out of the 132 biology instructors who were contacted completed the second survey (33% response rate) based on their experiences teaching an in-person biology course that shifted to fully remote instruction in the Spring 2020 semester. Of these, 18 had taught an in-person course that transitioned during Spring 2020 with at least 100 students.

Student Survey

To explore student perceptions of learning during Spring 2020, we surveyed in-person biology students during Fall 2020 to ask specifically about their experiences during the Spring 2020 semester when their in-person courses rapidly transitioned to remote learning.

Our survey contained both closed-ended and open-ended questions. We asked students to think about the largest biology course they took in the Spring 2020 semester to answer the questions that were course-specific, (i.e., impact on grades, impact on learning, and perceived instructional changes). Asking about the largest class made it more likely that student survey responses would be comparable to instructor survey data. To assess cognitive validity of survey items, we conducted six think-aloud interviews with undergraduate students and iteratively revised survey items until no further changes were suggested (Beatty and Willis, 2007). The final survey contained questions about the perceived impact of the rapid transition to remote learning on student learning, grades, interest in their biology major, interest in learning about scientific topics, feeling a part of the biology community at the university, and career preparation. Each question was answered using a seven-point scale from "strong negative impact" to "strong positive impact." In addition, we asked about the impact of the transition on the amount of time spent interacting with instructors and other students, and the amount of time spent studying. These items were also answered using a seven-point scale ranging from "greatly decreased" to "greatly increased." During our think-aloud interviews with undergraduate students, the necessity of a "neutral" option for these survey items was brought up by multiple students. Therefore, we used a seven-point scale for these items instead of the six-point scale used in our instructor survey. We also asked students about perceived instructional changes to the course in terms of measures to prevent cheating, increase flexibility, and make the course easier. These were on a six-point scale from "strongly agree" to "strongly disagree" with no neutral option for consistency with the instructor survey (see **Supplementary Material** for the analyzed survey questions).

We included some demographic questions at the end of the survey so we could test for any differential effects on student experience by social identities, specifically gender, race/ethnicity, college generation status and eligibility for federal Pell grants. For race/ethnicity, we asked students two questions: whether they identified as Hispanic/Latinx and whether they identified as Black/African American, Native American/Alaska Native, or Native Hawaiian/Pacific Islander. Students that selected "yes" to either of these questions were grouped together as BLNP for our analyses. We grouped students in this manner because all these groups are historically underrepresented in the sciences and our sample sizes for the student survey were not large enough to allow us to disaggregate race/ethnicity data.

In Fall 2020, we used a convenience sampling approach to recruit eight biology instructors who agreed to distribute our survey to students in their classes. The survey was sent to a total of 1,540 students in these eight courses and students were offered a small amount of extra credit for completing the survey. A total of 798 students completed the survey, resulting in a response rate of 51.8%. However, only 601 of these students were enrolled in the in-person biology degree program in Spring 2020. Of these students, 70 reported that they did not take any biology courses in Spring 2020 and 21 students had missing data. After removing these students, we were left with responses from 510 students who had taken in-person biology courses that had transitioned to remote learning in Spring 2020 (**Table 1**). The demographics of student survey respondents included in the analyses largely reflect the demographics of in-person students in the course grades dataset. However, Pell-eligible students, white students, and Hispanic/Latinx students were slightly under-represented among survey respondents (**Table 1**). Asking students to think about the largest in-person biology course they took in Spring 2020 for the survey gave us data for 25 courses, although for 13 of these courses, we had fewer than 10 respondents.

Data Analysis

Student Grades and Demographics Analyses

Course grades were analyzed on a 0–4.33 scale (A+ = 4.33, A = 4.0, A– = 3.66, ... E = 0). Two students identified as non-binary gender and were excluded from the analyses due to small sample size. Grades other than A–E (e.g., withdraw grades) were excluded from analysis; this was a total of 2,404 student-course enrollments, or 9.6% of the total dataset. The decision to remove

TABLE 1 | Demographics for unique students in the in-person and online course grades and survey data set. Pell eligibility and college generation status are included as proxies for socioeconomic status. BLNP refers to Black, Latinx, Native American, and Pacific Islanders.

	Grades dataset		Student survey
	In-Person Students	**Online Students**	**In-person Students**
Characteristic	*N* = 4,164[a]	*N* = 2,040[a]	*N* = 510[a]
Gender[b]			
Man	1,482 (36%)	519 (25%)	165 (32%)
Woman	2,682 (64%)	1,521 (75%)	345 (68%)
BLNP			
N	2,754 (66%)	1,324 (65%)	358 (70%)
Y	1,410 (34%)	716 (35%)	152 (30%)
Race/Ethnicity			
White	2,037 (49%)	1,188 (58%)	219 (43%)
Asian	583 (14%)	103 (5.0%)	98 (19%)
Black	208 (5.0%)	170 (8.3%)	17 (3.3%)
Hispanic	1,023 (25%)	428 (21%)	108 (21%)
Native	58 (1.4%)	31 (1.5%)	6 (1.2%)
Two or more races	255 (6.1%)	120 (5.9%)	38 (7.5%)
Decline to state	—	—	24 (4.7%)
Pell Eligible			
N	2,416 (58%)	816 (40%)	336 (66%)
Y	1,748 (42%)	1,224 (60%)	174 (34%)
College Generation Status			
Continuing Generation	2,846 (68%)	1,144 (56%)	357 (70%)
First Generation	1,318 (32%)	896 (44%)	153 (30%)

[a]n *(%)*

[b]*Three of the women among the survey respondents also identified as nonbinary and one of the men also identified as non-binary and as transgender. They were included in the analyses with the binary gender they selected.*

these grades from analysis is consistent with prior studies (Matz et al., 2017; Mead et al., 2020). To control for prior academic performance, we use "GPAO," which refers to a student's grade point average in other courses, including both STEM and non-STEM courses (Huberth et al., 2015; Matz et al., 2017). Entries with missing GPAO were excluded; this occurs for first-semester students who enroll in a single course or who withdraw from all courses. After all exclusions, our final dataset contained 22,314 student-course enrollments.

In Spring 2018 and 2019, the non-letter grades were almost exclusively W or "withdraw" grades. In Spring 2020, about a third of the non-letter grades were "Y" grades, which is designated as "satisfactory" work at a level of a C or higher. In normal circumstances, most students would not be eligible to receive a Y grade, but this was relaxed in response to the unique circumstances of the pandemic. There were no policy changes made regarding withdrawals and the withdraw dates were consistent across the three terms studied. The combined proportion of non-letter grades increased in Spring 2020 compared to 2018 and 2019, rising to 14.6% from 13.8% for online courses and to 9.5% from 7.5% for in-person courses. Looking in detail, the withdraw percentage decreased in both modalities but this was largely offset by the number of students taking the Y grade. We can infer from this that students employed a strategic approach to the Y grade in Spring 2020 that is similar to the approach ordinarily taken to the withdraw option. We will return to this issue in the discussion.

To determine the direction and significance of the effect of the shift to remote learning on student grades, we performed a linear mixed-effects regression on the numerical course grades. The fixed effects in the model included a dummy variable for the Spring 2020 ("COVID-19") semester, whether the student was enrolled in the in-person or online degree program, an interaction between these two variables, and the GPAO term. We included random effect terms for course section, to account for the fact that each section was graded differently, and for each student, to account for the fact that most students are represented multiple times across the grades data. We examined and report intraclass correlation coefficients (ICC) for each model to quantify the contribution of the random effects.

To determine the direction and significance of the effect of the shift to remote learning on grades received by students with identities historically underrepresented in STEM, we added interaction terms between the dummy variable for the Spring 2020 ("COVID-19") semester and each of the demographic terms to the model described above. We again controlled for GPAO and included random effect terms for course section and student in this model (see **Supplementary Table S2** for model specifications). From this model, we performed stepwise removal of terms and made model selections based on AIC and BIC values and statistical comparisons using likelihood ratio tests to arrive at a final regression model.

Instructor Survey Analyses

We summarized the changes in instructional practices based on the frequency of selection of practices by instructors. To understand the extent to which changes in assessment practices made by instructors might explain differences in

student grades in Spring 2020 compared to previous semesters, we examined data from 10 instructors who responded to our survey who had taught the same course in Spring 2020 and either Spring 2019 or 2018. We performed course-level linear regressions on the relative grade difference using the following variables as predictors: total number of changes made, use of lockdown browsers for exams, whether they made efforts to reduce cheating, and whether they worked to make the course easier. All variables were dichotomous except number of changes made. The question about making the course more flexible was not included because all ten of the instructors who had taught the same course in Spring 2020 and Spring 2019 or 2018 agreed with this question.

Student Survey Analyses

We calculated the total percentage of students that reported negative impacts on their learning, amount of time studying and interacting with peers and instructors, career preparation, interest in science, and feeling a part of the biology community. To analyze the open-ended data, we used open-ended coding methods to identify themes that emerged from student responses (Strauss and Corbin, 1990). We used constant comparison methods to develop the coding scheme; student responses were assigned to a category and were compared to ensure that the description of the category was representative of that response and not different enough to require a different category. Inter-rater reliability was established by having two coders (S.E.B. and R.A.S.) analyze 20% of the data, after which one person coded the rest of the data. For student perceptions of the positive impact of the transition to remote instruction on learning codes: Two raters compared their codes and their inter-rater reliability was at an acceptable level (k = 0.88). For student perceptions of the negative impact of the transition to remote instruction on learning codes: Two raters compared their codes and their inter-rater reliability was at an acceptable level (k = 0.88). We report out any code that at least 10 students mentioned.

For eight of the Spring 2020 courses in our dataset, we had data from both the instructor and more than 10 students for each course. For these courses, we assessed if student responses to perceived instructional changes to the course aligned with the instructional changes as reported by the instructors. We analyzed the strength of this relationship through Spearman rank correlations between the median Likert value for students in each course and the strength of the instructor's agreement using a Likert scale.

To examine demographic differences in the perceived impact on students, we used ordinal mixed model regressions with the Likert scale option chosen by students as the outcome and gender, race/ethnicity, Pell-eligibility, and first-generation to college status as predictors. We used course section as a random effect with varying intercepts in all the models to account for the nested nature of our data.

All statistical analyses were performed in R (R Core Team, 2019) and made use of the *lme4* (Bates et al., 2015, 4), *lmerTest* (Kuznetsova et al., 2017), *performance* (Lüdecke et al., 2020), *sjPlot* (Lüdecke, 2020), and *ordinal* (Christensen, 2015) packages.

RESULTS

Students Received Higher Grades in Spring 2020 Compared to Previous Semesters in Both Online and In-Person Programs and Across Demographic Groups

Overall, our linear mixed effects regression results show that the Spring 2020 semester was associated with a positive grade shift of 0.41 grade units (**Table 2**). Students earned higher grades in Spring 2020 courses compared to students enrolled in those courses in Spring 2019 and Spring 2018. Results also show that this Spring 2020 grade effect was not significantly different between the online and in-person programs (**Table 2**). The online program is associated with lower course grades overall, which is consistent with our prior work (Mead et al., 2020).

Our final regression model (Model 3) showed no significant negative interactions for any of the demographic variables that we examined, including gender, race/ethnicity, and socioeconomic status (**Figure 1**; **Table 2**). Contrary to our prediction, the modelling shows positive, but mostly non-significant, interaction effects for all groups compared to their historically overrepresented counterparts. The two statistically significant interactions indicate that women have a Spring 2020 effect 0.05 greater than men and that Pell-eligible students have an effect 0.09 greater than non-Pell-eligible students.

Most Instructors Surveyed Made Several Changes to Courses in Spring 2020 Including Increased Flexibility

Overall, most instructors who responded to the survey reported making changes to their in-person courses when they needed to transition to remote learning during the COVID-19 pandemic, including being more flexible and making the course easier (**Table 3**). Focusing on the large courses, about 60% of instructors agreed that they took steps to reduce cheating. Nearly all large course instructors (94%) agreed that they made changes to be more flexible to help students who were experiencing challenges and most (78%) agreed that they made it easier for students to do well.

From our list of 24 options (**Table 4**, See **Supplementary Table S3** for the full set of options), on average, instructors of large courses selected about five changes. The most frequently selected changes were generally related to time and deadline extensions as well as conducting open-book exams. Changing the weighting or number of exams or changing the difficulty of questions on quizzes or exams were less commonly selected. Thirteen respondents added open-ended comments in addition to the provided choices. Five of these related to changes needed to replace planned fieldwork or labs. The remainder detailed specific content-related adjustments or discussed changes to increase instructor availability to students.

Within the subset of surveyed instructors who taught the same class in Spring 2020 and one of the prior Spring terms, our linear regression showed that none of the instructional changes in

TABLE 2 | Linear regression results for courses in in-person and online degree program. These models show interaction effects among each demographic category and the COVID-19 semester. Model 3 is the final result of a model selection process starting from Model 2.

	Model 1			Model 2			Model 3		
Variable	**Beta**	**SE[a]**	***p*-value**	**Beta**	**SE[a]**	***p*-value**	**Beta**	**SE[a]**	***p*-value**
(Intercept)	0.11	0.039	0.006	0.33	0.043	<0.001	0.32	0.043	<0.001
GPAO	0.89	0.010	<0.001	0.87	0.010	<0.001	0.87	0.010	<0.001
Spring2020	0.41	0.027	<0.001	0.32	0.034	<0.001	0.34	0.032	<0.001
Campus									
In-Person	—	—		—	—		—	—	
Online	–0.26	0.057	<0.001	–0.24	0.057	<0.001	–0.27	0.050	<0.001
Spring 2020 * Campus									
Spring 2020 * Online	–0.11	0.114	0.3	–0.13	0.114	0.3			
Woman				–0.05	0.017	0.002	–0.05	0.017	0.002
Pell Eligible				–0.08	0.017	<0.001	–0.08	0.017	<0.001
First Generation				–0.09	0.018	<0.001	–0.08	0.015	<0.001
Race/Ethnicity									
White				—	—		—	—	
Asian				0.04	0.025	0.15	0.06	0.022	0.008
Black				–0.19	0.035	<0.001	–0.17	0.031	<0.001
Hispanic				–0.11	0.020	<0.001	–0.10	0.018	<0.001
Native				–0.16	0.066	0.016	–0.13	0.058	0.022
Two or more races				–0.11	0.034	<0.001	–0.09	0.030	0.002
Spring 2020 * Woman									
Spring 2020 * Woman				0.05	0.024	0.030	0.05	0.024	0.033
Spring 2020 * Pell Eligible									
Spring 2020 * Pell Eligible				0.08	0.025	0.002	0.09	0.023	<0.001
Spring 2020 * First Generation									
Spring 2020 * First Generation				0.02	0.026	0.5			
Spring 2020 * Race/Ethnicity									
Spring 2020 * Asian				0.06	0.034	0.10			
Spring 2020 * Black				0.07	0.051	0.2			
Spring 2020 * Hispanic				0.02	0.029	0.5			
Spring 2020 * Native				0.08	0.098	0.4			
Spring 2020 * Two or more races				0.07	0.047	0.2			
Model Information and Fit		Model 1			Model 2			Model 3	
AIC		51,061			50,893			50,887	
BIC		51,125			51,085			51,023	
$R\text{-squared}_{marginal}$		0.370			0.379			0.380	
$ICC_{conditional}$		0.253			0.251			0.250	
No. Observations		22,314			22,314			22,314	

[a]*SE, Standard Error*

assessment practices were significant predictors of the difference in grades received by the analyzed students in Spring 2020 compared to previous two Spring semesters (**Supplementary Table S4**). Greater instructor flexibility could be associated with the increase in grades across all courses, but we were not able to test this relationship because all ten of the instructors in this subset reported increasing flexibility in their courses.

Students Perceived Many Negative Impacts on Their Learning, Sense of Community, and Career Preparation due to the Transition to Remote Learning, but Some Students Also Reported Positive Impacts

About 56% of students reported that they think the transition to remote learning negatively impacted their grade, although our grade analysis suggests this is unlikely considering that the average student earned higher grades. However, almost 70% of students said the transition to remote learning negatively impacted their learning in the same course (**Figure 2**). We analyzed the reasons why students felt that the transition to remote instruction either positively or negatively affected their learning (**Tables 5**, **6**). For the 30% of students who thought that it positively impacted their learning, they said it did so because lectures were recorded so they could review them or see more of them (18.3%), they felt as though they could learn at their own pace (15.0%), they felt like remote learning allowed them to engage with the material in a more active learning way (11.7%), or they felt more comfortable learning at home as opposed to in a large classroom (8.3%). There was also a subset of students who felt as though they had more time in general during the pandemic, which allowed them to focus more on studying (16.7%). For the 70% of students who reported that the pandemic negatively impacted their learning, 27.2% of students reported that they felt as though they understood less and remembered less during remote instruction (**Table 6**). Students also reported a loss of concentration or focus (24.6%), fewer opportunities to interact with others and ask questions (17.0%), and having less motivation or interest (9.9%). Less common responses included: feeling overwhelmed by greater

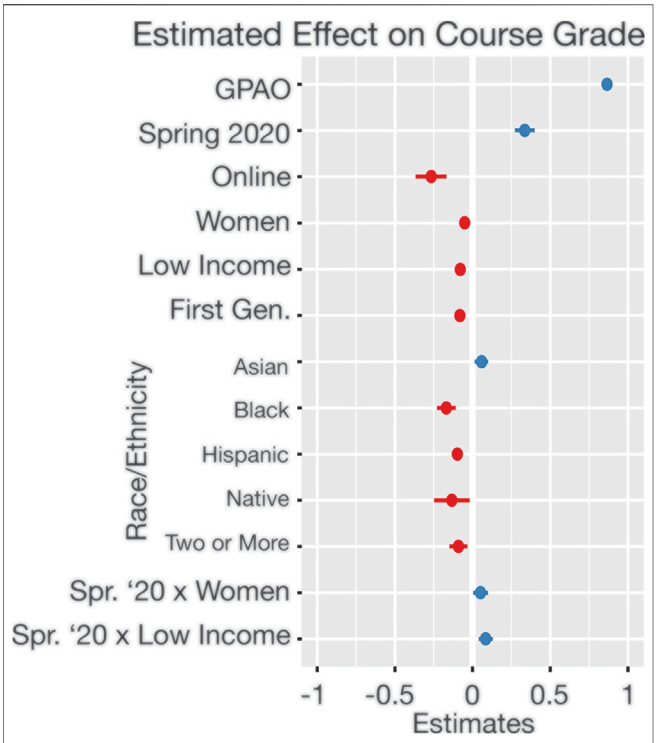

FIGURE 1 | Regression estimates of effect on course grade. Results are shown from the final model (Model 3) after model selection. Full model specifications, including reference categories for categorical variables, are provided in **Table 2**. All predictors shown are statistically significant. Error bars are ± 2SE.

amounts of work after the transition to remote learning (5.9%), lack of hands-on learning, particularly in lab courses (4.0%), general stress associated with the pandemic that increased distractions outside of coursework (3.7%), procrastination and less accountability (3.1%), and technical issues (2.8%).

Our analyses of the closed-ended Likert scale data showed that a large proportion of students (67.1%) reported that the transition to remote learning in Spring 2020 had a negative impact on their career preparation. A relatively smaller, but still significant, proportion of students reported a negative impact of the transition to remote learning on their interest in their biology major (31.5%) or interest in learning about scientific topics (37.1%). However, many more students (66.9%) reported a negative impact of the transition to remote learning on their feeling of being a part of the biology community at the university. See the **Supplementary Material** for full Likert scale responses for each of the survey items.

Most students reported that the amount of time they spent on interactions with instructors and other students, both in and outside of class, decreased as a result of the transition to remote learning. In fact, about 63% of students said that the amount of time they spent interacting with other students in class and outside of class greatly decreased in Spring 2020, which was the strongest response option (**Supplementary Table S11**). However, student responses were fairly split on the amount of time spent studying for a course, with about 45% of students reporting an increase in the amount of time they spent studying and 41% reporting a decrease (**Figure 2**).

We compared student and instructor perceptions of the adjustments made in Spring 2020. For the eight courses where both student and instructor data were available, this comparison showed that students' perceptions of instructional practices were

TABLE 3 | Summary of in-person instructor survey responses about the changes they made to their course after the transition to remote learning in Spring 2020.

Survey Item	Large Class Instructors *N* = 18	Small Class Instructors *N* = 25	All Instructors *N* = 43
Made more flexible	94%	84%	88%
Made easier	78%	56%	65%
Tried to reduce cheating	61%	32%	44%
Number of changes selected[a]	4.7 (3.2)	3.1 (3.5)	3.8 (3.4)
Zero changes selected	5.6%	24%	16%

[a]*Mean (SD)*

TABLE 4 | Frequencies of selection of fixed choice options for course changes by in-person instructors after the transition to remote learning in Spring 2020. This table only shows options chosen by ≥25% of respondents; for full results, see **Supplementary Table S4**.

Response Option	Frequency *N* = 43 (%)
Gave individual students extensions on deadlines for out-of-class assignments that I wouldn't have normally provided	37
Extended the deadline or allotted more time than I usually provide to complete out-of-class assignments	33
Increased the amount of time students were allotted to complete a quiz or exam	33
Gave students more opportunities to miss class and not lose participation/attendance points but still gave participation/attendance points for class	26
Reduced or eliminated penalties for out-of-class assignments that were submitted late	26
Changed assessments such as exams or quizzes from closed-book to open-book	26
In addition to delivering my content online I made a significant change to my course that is not reflected above	30

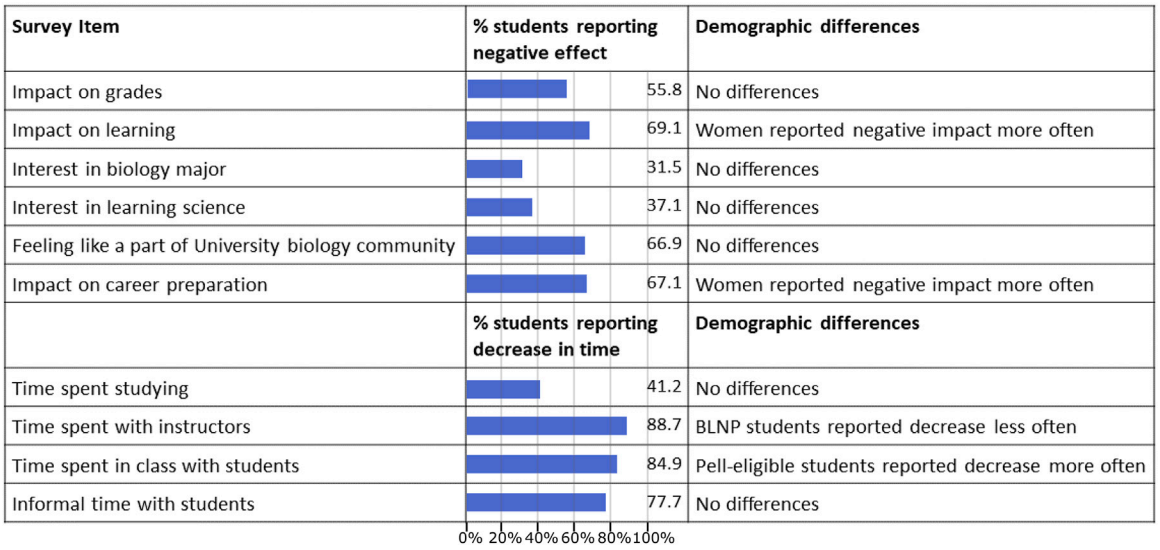

FIGURE 2 | Percentage of students who reported a negative impact or reported a decrease in the time spent on various activities during Spring 2020 along with ordinal regression results on demographic differences. BLNP refers to Black, Latinx, Native American, and Pacific Islanders. Pell eligibility and college generation status were included as proxies for socioeconomic status. The reference groups for the regression analyses were: men, non-BLNP students, continuing-generation students, and students who were not eligible for Pell grants.

not correlated with instructor's perception of their own practices. Spearman rank correlations were not statistically significant for any of the three questions about instructional practices posed to instructors and students, i.e., whether instructors took steps to reduce cheating in their course, whether instructors tried to make their course more flexible, and whether instructors tried to make the course easier. Visual examination of our data shows that students tended to slightly overestimate instructor efforts to reduce cheating and slightly underestimate instructor efforts to make the course easier and more flexible (**Supplementary Figure S1**).

We did not find significant demographic differences in the student Likert responses to most of the survey items. In **Figure 2**, we describe the few demographic differences we found through our ordinal mixed models (see full ordinal regression results in the **Supplementary Material**). Although most students reported that the time spent with instructors decreased or greatly decreased during the pandemic, the proportion of BLNP students that chose these options was lower than non-BLNP students. Pell-eligible students were more likely to report that time spent with other students in class greatly decreased compared to students that were not Pell-eligible. Lastly, women were significantly more likely than men to report negative impacts on their learning in a course and on career preparation.

DISCUSSION

Contrary to our predictions, transition to remote learning due to the COVID-19 pandemic in Spring 2020 did not have a negative effect on student grades and instead had a small positive effect across demographic groups among students enrolled in the in-person and online biology degree programs. Our instructor surveys showed that instructors who had to transition to remote learning increased flexibility and made several other changes in assessment practices that might have contributed to the slight increase in student grades in the in-person courses. Despite this increase in grades, our student surveys revealed several negative impacts of the transition to remote learning, particularly on students' perceived understanding of course content, interactions with other students and instructors, feeling like a part of the biology community at the university, and career preparation. These negative impacts do not seem to have a stronger effect on students with certain social identities over others for the most part. However, women were more likely to report negative impacts on their learning and career preparation compared to men, a result consistent with concerns about widening gender inequities due to the COVID-19 pandemic. Additionally, Pell-eligible students reported a decrease in the amount of time spent in and outside of class interacting with other students more often, which is consistent with concerns regarding logistical difficulties for students from less wealthy backgrounds. Together these findings suggest that instructor responses were effective in mitigating negative impacts on student grades across all demographic groups examined in this study, and notably did not seem to induce any new inequities based on demographics, but that the abrupt transition to remote learning still led to a diminished perception of learning and career development during the Spring 2020 semester for many students.

The observed mismatch between grades and student perceptions of their learning might be because students underestimated their learning (Carpenter et al., 2020). Some studies have shown that student perceptions of learning can be

TABLE 5 | Positive impacts of the transition to remote learning on student learning experiences.

Category	Description	Percent $n = 60$ (%)	Example quotes		
Lectures were recorded	Students indicated that they could go back and review the lectures if they needed and they missed fewer classes because they had the recordings	18.3	"Recorded lectures greatly helped me understand the content taught."	"Since all lectures from the point of the transition were moved to Zoom, the fact that things were recorded allowed the possibility for me to go back to the recording and stop at points that I needed in order to take notes on certain slides to further my understanding of the topics in case I missed a couple words or explanations through the fast explanations."	"Lectures were recorded and posted online, allowing for the opportunity to review material."
Had more time in general	Students indicated that the pandemic allowed them to have more time to dedicate to coursework and the online nature of courses gave them more time to study	16.7	"I had more time to stay home and actually teach myself the material."	"I do feel like I have more time to really understand the material."	"I had more time to study in quarantine."
Learn at own pace	Students indicated they could decide when to engage with the material and had autonomy over the pace	15.0	"Allowed me to learn at my own pace."	"I could watch lectures on my own time throughout the week."	"I liked being able to watch the lecture videos all at once."
Engaged with material in more of an active learning way	Students indicated that they engaged in the material before the lecture, they taught themselves more, and they had the opportunity to engage with other students in active learning online	11.7	"The instructor posted additional lecture videos for students so we were familiar with the material before the actual Zoom lectures."	"I use some of the PowerPoints to answer practice questions and improve my understanding more independently."	"Because of the online format, we're able to do small group discussions of papers in breakout rooms. That helps [me] to understand more complex material."
Felt more comfortable learning at home and not in a classroom	Students indicated that they felt they learned better by being at home or not in a large classroom	8.3	"Being able to study in my own space comfortably helped me learn a little bit better."	"Not being in lecture with other people distracting me allowed me to take better notes."	"I felt more comfortable with online learning than having a large in-person classroom; there is something different about the ambient and inclusivity about digital learning."

positively correlated with their grades (Anaya, 1999; Kuhn and Rundle-Thiele, 2009; Rockinson-Szapkiw et al., 2016). However, a recent study comparing the effects of active and passive (i.e., lectures) instruction on student learning found that students who received active instruction scored higher on the learning assessment but perceived that they learned less than their peers who received passive instruction (Deslauriers et al., 2019). Thus, even though it has been shown that students, on average, learn more from active learning (Freeman et al., 2014; Theobald et al., 2020), students' perception of learning might not match their actual learning. A meta-analysis showed that student perceptions of their learning are more strongly related to affective outcomes, such as motivation and satisfaction, and have a much weaker relationship to learning outcomes, such as scores (Sitzmann et al., 2010). However, one reason for this may be that grades are often not an accurate measure of student learning (Yorke, 2011). Given this background and our results that instructors were more flexible with grading after the transition to remote learning in Spring 2020, we think it is likely that the increase in grades does not actually reflect an increase in student understanding of the course material. In contrast, students earned higher grades while self-reporting that they learned less, which we find concerning for the extent to which their completion of these college courses is preparing them for their future courses and careers.

The slight increase in average student grades in Spring 2020 compared to previous semesters is consistent with other studies that have examined student grades in Spring 2020 at other institutions (Gonzalez et al., 2020; Loton et al., 2020; Bawa, 2021). Interestingly, no significant interaction was observed between instruction mode and the Spring 2020 effect, indicating that the increase in grades was similar for courses that experienced the emergency transition to remote learning and courses in the online degree program that did not experience a transition in modality. Although we did not survey the online instructors, this suggests that both in-person and online instructors may have been responsive to the public health and economic crisis due to the COVID-19 pandemic and been more lenient and flexible in their grading. Our models show no evidence that the shift in grades in the Spring 2020 term exacerbated pre-existing demographic grade gaps. In fact, for women and Pell-eligible students, the Spring 2020 grade shift was

TABLE 6 | Negative impacts of the transition to remote learning on student learning experiences.

Category	Description	Percent *n* = 353 (%)	Example quotes		
Less understanding/ comprehension/ retention	Students indicated that online learning or video lectures were generally difficult to comprehend. Students indicated that the online format made them feel like they focused more on memorization and less on understanding or that they felt as though they retained and remembered less. They felt like they studied less because of open-note exams and were just trying to pass	27.2	"It felt like I went from going to class and understanding the material to just memorizing to get assignments done. This is especially true for the lab portion of the class."	"Did not comprehend and retain as much information as I could have in person."	"Because everything was more for completion, I focused on getting the assignments answered rather than understanding material. I cannot remember any material from that course."
Loss of focus/ concentration	Students indicated they felt as though they could not focus or concentrate as well online, and often cited more distractions	24.6	"The online teaching didn't click as well with me and I felt it was difficult to focus online because of the distractions that are not present in a classroom, but are present at home."	"I found it more difficult to focus on the coursework compared to when I had my biology lecture in person."	"I found it more difficult to focus over Zoom."
Fewer interactions/ opportunities to get help	Students indicated that online was anti-social, less personal, and they interacted less frequently with other students and the instructor. Specifically, they were not able to clarify their thinking, ask questions of students or instructors, and felt like they were on their own	17.0	"Not being in person to ask questions felt a little limiting. When going on campus I was also able to ask classmates questions before and after class."	"It was harder to learn the material without being able to engage with the teacher. She did most of her lectures as pre-recorded ones."	"For all my biology courses, it would have been better to have an in-person class where I could ask my friend beside me to explain small things or even the TA's who were walking around."
Students had less motivation/interest/ effort	Students indicated that online they had less motivation, less interest in the topics, and put in less effort. Students discussed a lack of connection with or engagement in the material	9.9	"It was more difficult to engage and interact with the material so I was less interested in actually learning it."	"The feeling of determination and want to learn slipped for some reason for myself personally and I just slid by in the course instead of actually trying to learn the material."	"It's incredibly hard to absorb information from a digital perspective, think about it, we (students) watch tons of videos online in our free time, watching an online lecture is like watching a super boring YouTube video. I think professors need to think of ways to make things more engaging!"
Overwhelmed by work/increased work	Students indicated they felt as though online learning increased the total amount of work in the course, increased the pace of the course, and/or the course felt rushed	5.9	"I felt the class was sped through [because] it moved online and it was all rushed and I didn't feel like I was retaining anything."	"I felt like we were being forced to do more work for not having to attend in person."	"I felt as though I couldn't learn anything because there was so much that needed done, so I was trying to meet deadlines."
Lack of hands-on learning	Students indicated that online there were not opportunities for hands-on learning, specifically doing experiments in labs	4.0	"It was more difficult to learn the material by attending the online calls for lectures and labs. The hands-on connection was not there."	"With everything online, the topics were more impersonal. Usually being able to look at the cadavers and doing hands-on activities facilitated learning for me."	"Concepts became harder to understand, particularly for lab. This is because there was no hands-on learning."
Pandemic stress	Students indicated they felt stressed in general by the pandemic. Students worried about their health, employment, housing, schooling of their children, and other issues outside of academics that interfered with their learning	3.7	"It was difficult to pay attention to lectures knowing that my safety was uncertain and I may not have a place to live."	"It is difficult to remember the Krebs cycle when the world is burning down around you."	"So many students like myself were going through a "grieving" period when the second quarter of this semester started, some of us had lost family members, had moved back in to abusive households, and to add the heavy load of school was anything but easy."

(Continued on following page)

TABLE 6 | (*Continued*) Negative impacts of the transition to remote learning on student learning experiences.

Category	Description	Percent *n* = 353 (%)	Example quotes		
Procrastination/less accountable/less incentive to do well	Students indicated they felt as though they procrastinated on work and were less accountable for attending class and doing their work in the course	3.1	"In class, I was held accountable to pay attention and to focus. The lectures were really long and when I was at home I was spacing out and talking to my roommates etc. I also let myself get behind in lecture because I knew they were going to be available to watch at a later time."	"I did not feel as motivated right away to keep up with topics on my own. Skipping lectures became easier than in-person ones."	"Again, since the lectures in [an introductory biology course] had no clicker questions, I didn't attend them as regularly as I should have."
Technical issues	Students indicated experiencing technical issues online that took up time, including internet issues or not being able to access materials	2.8	"As classes transitioned, lots of technical difficulties amongst other things caused extreme stress and anxiety."	"Sometimes the computer could skip a word or two that the professor said. This would make it a little harder to keep track of what was being lectured."	"Sometimes not all the material was covered in class due to technology difficulties or the professor was not able to use this online platform."

slightly more positive than for men and non-Pell-eligible students, respectively. Thus, the grade increase in Spring 2020 did not fall along the lines of power and privilege in our society and benefited students with all social identities. A similar result was found in a study on student scores at Victoria University in Australia where the researchers found statistically significant but very small differences in the impact of COVID-19 on student scores between demographic groups (Loton et al., 2020).

The instructor surveys show that among our study population, most instructors made accommodations related to deadlines and stated that they took steps to make their courses easier for students to do well. Other studies have also reported greater flexibility among instructors in Spring 2020, including instructors in general chemistry courses at a liberal arts college in the United States (Villanueva et al., 2020). A survey study of faculty members and administrators across the United States found that 64% of faculty members changed the kinds of exams or assignments they asked students to complete in the course and about half of them lowered expectations on the amount of work from their students in the Spring 2020 semester (Johnson et al., 2020). Additionally, many universities expanded access to pass/fail grading structure instead of the more traditional A-F letter grades for students, with some institutions even making the pass/fail grading structure mandatory for all courses (Burke, 2020). Arizona State University allowed faculty members to use the range of grading options that have always been available, but perhaps not used as often prior to Spring 2020. This included the traditional A through E grading scale, plus the use of the I or Incomplete grade (allowing students to complete coursework within 1 year of the end of the term) and the Y grade which indicates "Satisfactory" work at a level of C or higher, similar to the Pass grade at other universities. Thus, our study affirms other reports that the focus across colleges and universities to make courses more flexible and less stressful for students in Spring 2020 may have off-set potential drops in student grades. While we see the benefit of this flexibility for students, particularly that we did not see demographic differences in these grade increases, we do find it concerning that students still felt as though they learned less. We encourage instructors to be thoughtful of what they are doing to make their courses flexible. Some of these changes may have eliminated difficulty unrelated to course content and/or learning goals (e.g., timed exams) and retaining these changes could make courses more equitable and inclusive moving forward. Such changes can be made while maintaining the quality of teaching and providing students with ways to engage in deep learning so that they are not disadvantaged at a later timepoint because they have not learned as much as they needed to in that earlier course.

Many students recognized the positive impact of greater instructor flexibility and changes in assessment practices on their grades, while recognizing the negative impact of the transition on their understanding of the course material. This is consistent with other survey studies that show that students perceived a negative impact on their learning or were less satisfied with their learning after the transition to remote learning (Loton et al., 2020; Means and Neisler, 2020; Petillion and McNeil, 2020). In our study, most students also reported negative impacts on interactions with other students and instructors, career preparation, and a feeling of being a part of the biology community at the university. These are also consistent with other studies on student experiences (Jeffery and Bauer, 2020; Means and Neisler, 2020). A larger survey study of in-person students at Arizona State University across various degree programs, the same institution where our study was conducted, found several striking negative impacts on career preparation due to COVID-19. According to this study, 13% of students delayed graduation, 40% suffered the loss of a job/internship, and 29% of students expected to earn less by age 35 (Aucejo et al., 2020).

We found similar perceptions of negative impacts on student learning, interactions, and career preparation across demographic groups with few significant differences. We found that women were more likely to report negative impacts on their learning and career preparation compared to men. This is not surprising given the greater childcare obligations with school closures and that women spend more time doing unpaid care work compared to men (Fortier, 2020). In an interview study of engineering students, women reported having to spend more time on domestic duties while men described having more free time after the transition to remote learning during the Spring 2020 semester (Gelles et al., 2020). Together this suggests that the COVID-19 pandemic has exacerbated gender inequities and could have long-term negative impacts on women's education and careers that are not captured in simply examining student course grades. We encourage future studies to explore how the COVID-19 pandemic affected the persistence of women in STEM careers.

The only survey item in which we found a significant difference between BLNP and non-BLNP students was the time spent with instructors, where BLNP students chose the option "greatly decreased" less often. Previous studies show that BLNP students often have more interactions with faculty members compared to white students, although they also have negative interactions with faculty members more often (Lundberg and Schreiner, 2004; Park et al., 2020). Still, their greater experience of interacting with faculty members might have prepared them better to communicate with instructors during emergency remote learning. High-quality interactions with faculty members have been shown to have positive effects on student learning (Lundberg and Schreiner, 2004; Cole, 2011; Tovar, 2015). However, BLNP students did not report less negative impacts on learning compared to non-BLNP students. This suggests that even though BLNP students reported a decrease in the time spent with instructors less often, it might not have translated into benefits for their learning.

We also found that students from less wealthy backgrounds (operationalized through federal Pell grant eligibility) more often reported a reduction in time spent with other students in class after the transition to remote learning. Pell-eligible students were also 1.2 times more likely to be working a job after the transition to remote learning and 1.5 times more likely to be working more than 20 h a week compared to students that were not eligible for federal Pell grants (**Supplementary Table S12**). With greater availability of recorded lectures, Pell-eligible students may have attended fewer synchronous sessions, thus further reducing their interactions with other students. Although the decrease in interactions with other students is not desirable, making lectures available for students to watch later might offer students greater flexibility in juggling coursework with other work/family responsibilities. Indeed, some students reported positive impacts on learning after the transition to remote learning due to the availability of recorded lectures and being able to learn at their own pace (**Table 5**). Overall, instructors may need to find a balance between asynchronous learning to make learning more accessible with synchronous learning to foster peer interactions.

The transition to remote learning had a negative impact on students' interest in their biology major or interest in learning about scientific topics in about a third of the students. A similar study of students enrolled in a general chemistry course at a large public university in the southern United States found no significant change to students' identities and intention to pursue a career in science due to COVID-19 (Forakis et al., 2020). However, we did not find any demographic differences in student responses to questions about science interest, which is encouraging given the importance of increasing representation of women, Black students, Latinx students, and students that grew up in low-income households in STEM. Almost two-thirds of students reported a negative impact of the transition to remote learning on students' feelings of being a part of the biology community at the university, which is alarming, although not surprising, given that students reported spending less time interacting with both instructors and their peers. Creating opportunities for increasing interactions using various modes of synchronous and asynchronous communication (e.g., online office hours, discussion boards, apps) might help students feel a greater sense of community and social presence of others in the class.

Instructor responses to our survey items about whether they took steps to prevent cheating, increased flexibility, or made the course easier are in broad agreement with student responses to those survey items. Most students seem to recognize their instructors' efforts during the transition to adapt their courses to the online modality as well as the public health and economic crisis. However, students' underestimation of instructor flexibility and changes to make courses easier suggests that communication between students and instructors might need to be strengthened. Instructors may have needed to use more "instructor talk," which is defined as any discussion that is not specific to the course content, to signify the changes that they were making to the courses and why they were making these changes (Seidel et al., 2015). It is also possible that the steps that instructors took might not have been sufficient to reach students' needs or expectations. Because instructors tend to be in better financial situations than their students, perhaps they underestimated some of the student challenges. Setting up robust systems of communication among students, instructors, student support staff members, and administrators might improve the academic climate for all stakeholders and prepare us better for future emergencies or needs to change instruction rapidly. Indeed, an interview study with engineering students found that faculty members communicating care and increasing flexibility was a key element for supporting students (Gelles et al., 2020). In another study, students indicated the need for constant communication from instructors during remote learning (Murphy et al., 2020). Thus, developing stronger communication with students and improving "instructor social presence" in online courses, i.e., the sense that the instructor is connected and available for interactions, is critical (Pollard et al., 2014; Richardson and Lowenthal, 2017; Oyarzun et al., 2018). This may be done through casual conversations on discussion boards, leveraging social media, and using time in class and during office hours to build classroom community.

Limitations

Prior work shows that grades are an imperfect measure of student learning. Thus, we are limited in our ability to accurately measure the effects of the abrupt transition to remote learning due to COVID-19 on student learning (Allen, 2005; Yorke, 2011; Schinske and Tanner, 2014). Moreover, student perceptions of negative impacts of the transition on their learning that we observed might be attributed to the abrupt transition itself or the difficulty of learning during a pandemic. Surveying students in the online program about their experiences in the Spring 2020 semester could have helped us tease apart these two factors more. Similarly, because we surveyed only in-person instructors, we do not know the extent to which the online program instructors made changes to their instruction or course policies. However, the similarity of Spring 2020 grade shifts across instruction modes in our regression models suggests that accommodations were made in response to the pandemic even in courses that did not undergo a change in instruction mode. We also had a relatively low response rate from in-person instructors that shifted to remote learning, and it is possible that instructors that were more flexible were more likely to respond to our survey. In spite of the overall low response rate, the dataset includes responses from most instructors that taught large enrollment courses required for biology majors.

In our course grade analysis, we excluded all non-letter (A–E) grades, yet we know that the percentage of non-letter grades increased somewhat in Spring 2020. Because many of the non-letter grades indicate poor course performance, it is possible that our decision to exclude these data has created a positive grade bias in favor of the Spring 2020 term. To test for this possibility, we recoded all non-letter grades as 0.0 ("E" or fail). This is an extremely conservative standard as it is quite possible that most students who received Y grades would not have failed and that some of them would not have chosen to withdraw under normal circumstances. Rerunning our final model (model 3) with these alternative grades reduces the regression coefficient associated with the Spring 2020 term from 0.34 to 0.28. Although this is not a trivial difference, we are confident that this sensitivity test demonstrates that our overall conclusions have not been unduly affected by our treatment of the non-letter grades.

Another limitation of our study is the relatively small sample size for our survey dataset which caused us to group data from Black/African American, Hispanic/Latinx, Native American/Alaska Native and Pacific Islander/Native Hawaiian students for analyses. The histories and experiences of racial oppression of these groups in the United States are different from each other and grouping them together erases these differences. Similarly, grouping white and Asian students together into a group is problematic as well, because there are several different ethnicities included in the category of "Asian" in the United States which includes ethnicities that are underrepresented in STEM in the United States (Teranishi, 2002). Despite limited statistical power, we ran ordinal regressions on the survey data with disaggregated race/ethnicity data and have included the results in the **Supplementary Material**. We found some significant effects by race/ethnicity in those analyses. Specifically, Asian students perceived being negatively impacted less often on grades, sense of community, and career preparation. Also, Black students reported a positive impact on the amount of time studying more often and multiracial students reported a negative impact on grades more often.

The choice to ask instructors and students to respond about only their largest courses does mean that our conclusions regarding those survey data are primarily relevant to larger courses. That said, the analysis of course grades was not conditional on course size and, as indicated by **Table 3**, we did receive a number of responses from instructors of smaller courses. Another limitation is that we did not separate the survey responses from students that opted to receive a Y grade from students that took the course for a letter grade. Student perceptions of their learning in a course might be affected by this choice. However, given that this was a relatively small proportion of the student population, we do not expect it to have a significant impact on our overall conclusions.

Finally, the indicators of socioeconomic status we used (federal Pell grant eligibility and first-generation status) are coarse measures that do not capture socioeconomic status accurately. However, these were the only indicators that we could access from the university registrar.

Beyond COVID-19: Preparing for the Next Emergency

Instructors responded to the rapid transition to remote learning in Spring 2020 with greater flexibility in grading and students received higher grades on average. This shows that instructor response was effective in preventing grade declines for students and doing so equitably across the student population. However, student perceptions of the Spring 2020 semester were less positive, including a sense of diminished learning, loss of community, and reduced career preparation. Even if students' perceptions of their learning are not accurate, perceived learning losses might still have important effects on students' confidence in the course content or interest in pursuing a career in biology. Similar learning losses may have occurred in the Fall 2020 semester and Spring 2021 as the COVID-19 pandemic continued to spread in the United States and worldwide.

As we look ahead, these students affected by the pandemic may need more support in subsequent courses, especially in courses that build on prior learning. Dedicating class time to reminding students of important concepts at the beginning of each course or course module could be one form of support. However, upper-level courses may not have class time to spare, so adding supplemental tutorials or instruction may be an alternative way to counteract these potential learning deficits of pre-requisite knowledge. Further, the loss of feeling a part of the biology community needs to be addressed. More intentional community-building exercises in classes or in the larger department outside of classes could be ways to heal the damage to students' sense of belonging.

Although COVID-19 may only affect college education for a particular timeframe, it is important to garner lessons from this

experience to prepare for the next emergency, which could be global such as a pandemic, or local such as a natural disaster. Building robust networks of communication among students, instructors, and staff members, and offering greater training and support for online teaching for instructors are steps that could help us prevent some of the challenges associated with the rapid transition to remote learning experienced during the COVID-19 pandemic. We hope that some of the flexibility afforded to students during the pandemic is carried on even after in-person courses resume as instructors may have a better understanding of the myriad of challenges that college students experience daily. This could include making video recordings of in-person class sessions available as standard practice. Lastly, as the COVID-19 pandemic reminded us, our classrooms and universities do not exist in isolation and are a part of the larger society and are therefore affected by the larger societal forces and power structures that impact student learning in our institutions. Therefore, we must continue to strive toward social justice inside and outside our higher education institutions.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Arizona State University Institutional Review Board. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

KS, CM, and SB conceptualized the study and all authors contributed to the study design. KS and CM collected the data and analyzed all the quantitative data. SB and RS analyzed students' open-ended responses on the survey. KS, CM and SB wrote the first draft of the manuscript. AA, JPC, PL and SB acquired funding for the project. All authors contributed to the review and editing of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.759624/full#supplementary-material

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BRIEF RESEARCH REPORT
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Confounding Factors Affecting the Emotional Intelligence Amongst Jordanian Nursing and Midwifery Undergraduate Students During the COVID-19 Pandemic's Outbreak: A Cross-Sectional Study Using USMEQ-i

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Objective: This aim of this study was to determine which variables from the demographic data most affect the EI regarding the COVID-19 outbreak and the lockdown amongst the nursing and midwifery students in Jordan.

Background: Emotional intelligence (EI) is the ability to recognize, express, comprehend, motivate, influence and regulate emotions proposed the first EI model, which includes three constructs: emotion assessment and expression, emotion consumption and emotion control. During the COVID-19 outbreak and lockdown, face-to-face study methods have been replaced by online teaching, which has caused many psychological effects.

Method: A cross-sectional approach was used to measure EI for nursing and midwifery students. The tool was completed online by nursing and midwifery students using Google Forms. All of the findings were received online and then analyzed accordingly. In this study, USMEQ-i was used to gather data from the participants.

Results: The general EI score for the student respondents falls into the average score ($M = 39.6$). Regarding the difference between males and females, the results showed no significant difference. Moreover, the general linear regressions analysis of independent variables on EI score showed four significant factors. Nursing students who study in Years 1 and 4 had significantly higher EI scores than those in Years 2 and 3. EI ability decreased when a student's economic status changed from luxurious to middle income. Moreover, an increase in age significantly decreased the value of EI. This study indicates that all nursing and midwifery students who enrolled in general nursing program tended to have higher EI scores than others ($p = 0.006$).

Conclusion: Year of study, age, average lifestyle and enrollment in a nursing program were found to be the most significant factors associated with EI amongst Jordanian nursing and midwifery students. This issue needs to be researched further, such that appropriate steps can be taken to address it.

Keywords: emotional intelligence, Jordanian nursing students, COVID-19 outbreak, COVID-19 lockdown, USMEQ-i

INTRODUCTION

Emotional intelligence (EI) is the ability to recognize, express, comprehend, motivate, influence and regulate emotions (Mayer and Salovey, 1997; Goleman, 1998a,b; Mayer, 2005). Salovey and Mayer (1990) proposed the first EI model, which includes three constructs: emotion assessment and expression, emotion consumption and emotion control. They described EI as "a type of social intelligence that entails the ability to track one's own and others' feelings and emotions, to distinguish between them and to use this knowledge to direct one's thought and behaviour" (Salovey and Mayer, 1990). Therefore, a person with a high EI can communicate more effectively, reduce anxiety and stress, settle disputes, strengthen relationships, sympathize with others, and overcome life's obstacles. EI has an impact on people's lives because it has an impact on human behavior and relationships. More emotionally intelligent students can better control their emotions and empathize with others around them. This can help them enhance their self-motivation and communication skills, both of which are necessary for pupils to become more confident learners. Students who lack emotional intelligence, on the other hand, may get disengaged from school, which will have an adverse effect on their academic achievement (Kant, 2019; Sánchez-Álvarez et al., 2020).

The illness caused by the COVID-19 coronavirus has had a worldwide effect never seen before. Many studies highlighted the detrimental psychological impact of COVID-19 on society which includes people's severe suffering and cognitive dissonance (Saladino et al., 2020; Testoni et al., 2021). The most susceptible members of the community, such as teenagers and students, may suffer mental health repercussions as a result of the confinement used to contain the epidemic (Liébana-Presa et al., 2020).

EI has two primary constructs based on different models, namely, personal and social competency. These constructs are related to the modern results described by Arifin et al. (2012) and Gupta and Bajaj (2018). The capability to fully understand one's own and others' internal states, desires, resources and intuitions, as well as their consequences, is referred to as social competence (Yusoff et al., 2010; Arifin et al., 2012). Personal competence is described as the ability to maintain self-control, over reactive emotions and impulsive thoughts, as well as the ability to foster and direct emotional impulses toward desired outcomes, and the ability to align and collaborate with others in a community or organization to accomplish mutual goals (Yusoff et al., 2010; Arifin et al., 2012).

Regarding social behavior, EI has a positive relationship with communication skills (Austin et al., 2007), with empathy (Austin et al., 2005) and with group emotional competence (Amundson, 2005). EI also has a positive relationship with coping ability (Humphreys et al., 2005). McCallin and Bamford (2007) found that team members need EI to work effectively with their work partners, and low EI leads to poor teamwork, high anxiety level and poor job satisfaction. Conversely, Oginska-Bulik (2005) found a negative relationship exists between perceived stress in work settings and EI and that depression has a negative relationship with EI.

The present study aims to determine which variables from the demographic data most affect the EI regarding the COVID-19 outbreak and the lockdown amongst the nursing and midwifery students in Jordan. In this current study, the EI covers seven domains (Emotional Control, Emotional awareness, Emotional Conscientiousness, Emotional Commitment, Emotional Fortitude, Emotional maturity, and Emotional Expression), (Yusoff et al., 2010). Face-to-face study methods have been replaced by online teaching (Khraisat et al., 2020), which has caused many psychological effects (Nishimura et al., 2021).

Confounding Factors Affecting EI

Personal Factors

Many psychologists have realized the importance of genetics and the environment in assessing intelligence (Brackett et al., 2011). Personal factors, such as gender, ethnicity and hometown location may affect the EI level of individuals (Khraisat et al., 2015). The relationship between the variables of EI is crucial in understanding EI and the factors affecting it. Most studies have considered age and gender as the most influencers of EI (Kuss and Griffiths, 2017; Lewis et al., 2017; Wilson, 2020).

Family Factors

Family influences are one of the most critical aspects of demographical contexts that influence EI. Parents have the most direct influence on their children's EI. Kaur and Jaswal (2005) proposed that a significant relationship exists between family and EI. The degree of EI is often influenced by the family's economic situation (Wahyudi, 2018). According to some reports, having a higher economic status correlates with having a higher EI score (Harrod and Scheer, 2005).

Academic Factors

Previous research on the connection between EI and academic success has shown conflicting findings (Thomas and Allen, 2021). Years of education, bachelor's or diploma, varieties of curriculums used and new instructional methodologies used within the university or school are all academic factors (Tapia et al., 2006). Many studies have found that EI has a positive effect

on academic achievement (Aithal et al., 2016; AkbariLakeh et al., 2018; Astatke, 2018; Jan and Anwar, 2019; Johar et al., 2019; Rabha and Saikia, 2019; Li, 2020).

General Effects of EI

On the basis of a large body of research, EI is a determinant of performance in many organizational environments (Habibah et al., 2007; Alam and Ahmad, 2018). Emotionally intelligent doctors can sustain a positive patient–doctor relationship, show more understanding, communicate effectively and collaborate as team members (Khraisat et al., 2015; Ravikumar et al., 2017). There has been considerable research used on topics of workplace performance and social relations. EI has been found to have a positive relationship with the scale and content of social networks (Tang et al., 2020); strong partnerships, visible family care and fewer crises with close friends (Stein, 2017); and greater optimism, stronger appreciation of others' emotions and positions in social contexts, improved public speaking skills and greater marital fulfilment and performance (Singh and Gosain, 2021). EI has also been negatively connected to opioid and alcohol abuse, deflector activity and a strained relationship with groups (González Yubero et al., 2019); and absenteeism with no justification, insularity from learning regions and desolation (Dobrushina et al., 2020).

A growing body of evidence suggests that EI forecasts significant results in various fields (Mayer et al., 2008). In terms of improved social relationships for children, children's EI reliably forecasts promising social and academic results (MacCann et al., 2020), and the ability of children to regulate their emotions tends to affect their social well-being (MacCann et al., 2020). In terms of better social relationships for adults, Obeid et al. (2021) found that adults with higher EI have higher self-perceived competence in responding to their mates' life activities and have a higher self-perception of social ability and useless destructive interpersonal tactics. Individuals with high EI are perceived more positively by others; people view people with high EI as more fun to be around, empathic and compassionate, and more socially adept than those low in EI (Gupta and Bajaj, 2018). In terms of better family and intimate relationships, EI is linked to certain elements of family and personal relationships (Bucich and MacCann, 2019). Regarding better academic achievement, Karthigeyan and Nirmala (2012) stated that EI is associated with higher academic achievement as recorded by teachers. EI also aids academic achievement by increasing the desire to make the most of one's analytical abilities (Sadipour et al., 2017). "The degree to which men use their skills differs rather than the overall total of their abilities" (Hargittai et al., 2019). In terms of better social relationships during work, EI is linked to better relationship results and negotiation outcomes and greater workplace success (Allen et al., 2020). Other findings by Mayer et al. (2008) in relation to high EI are better psychological well-being, better performance in the medical context, better doctor–patient relationship, increased empathy, increased teamwork and communication skills, and increased stress management and organizational commitment abilities.

METHODS

The primary purpose of this study was to determine the EI level for the nursing and midwifery students in Jordan and identify confounding factors from the demographic data most affect the EI during the COVID-19 outbreak and the lockdown.

Study Design and Participants

This study used a cross-sectional approach to measure EI amongst Jordanian nursing and midwifery students during the COVID-19 lockdown. The reference population in this current study was all the nursing and midwifery students regardless year of study, or the university. In this current study, the student was defined as any individual above 18 years who is enrolled in a recognized nursing or midwifery program in Jordan by ministry of higher education. The tool was completed online by nursing and midwifery students using Google Forms. All of the findings were received online and then analyzed accordingly. The total number of respondents to this current study was 1,100 students.

Instruments

The questionnaire developed for this study consisted of eight items regarding socio-demographic data of nursing and midwifery students including age, gender, nationality, program name, year of study, CGPA, marital status, and economic status.

In this study, USMEQ-i was used to gather data from the participants. The advantages of this tool are as follows. The questionnaire structure is uniform for all the respondents. The questionnaire is a quick and effective data collection method. The questionnaire is also a valid tool for gathering certain data, as evidenced by data analysis. Collecting data from vast samples and other instruments are complex. USMEQ-i saves time and money. The USMEQ-i used in this study consisted of 13 items related to EI and four items for faking index (Arifin et al., 2012). For all the questions in the inventory, the responses were measured on a Likert scale of 0 to 4 (0 = not like me; 1 = a bit like me; 2 = quite like me; 3 = a lot like me; 4 = totally like me). The USMEQ-i scores were interpreted based on the recommended guideline provided in the USMEQ-i manual (mean domain score: 0–1.20 = low; 1.21–2.80 = average; 2.81–4.00 = high; Yusoff et al., 2010). Consent was considered received from the students by having them fill out the online forms willingly.

Validity and Reliability of USMEQ-i

USMEQ-i has been tested and found to have strong construct validity and internal consistency (Yusoff et al., 2010, 2011; Arifin et al., 2012; Yusoff, 2012). Cronbach's alpha values ranged from 0.8 to 0.9 (Yusoff, 2012), indicating high internal consistency.

Ethical Approval

The studies involving human participants were reviewed and approved the institutional review board at Al-Balqa Applied University which granted the ethical approval for this study (26/3/2/1065).

The participants provided an electronic informed consent, not a written one. The reason for not providing the written informed consent is that the researchers clearly stated in the beginning of the survey that participant's agreement to complete the survey

considered as written informed consent and this means that they willingly and freely agree to participate in the study. Survey was created on Google Forms; no physical or face-to-face interviews were done. No legal guardian or next of kin gave an informed consent because age for inclusion in the study was 18 years and above.

Data Analysis

SPSS data sheet was used to enter the completed forms. The data were double-checked for completeness and cleaned for missing information. SPSS version 27 was used to analyse the data. For categorical variables, demographic characteristics of respondents were defined in terms of frequencies and percentages. General linear model (GLM) was used to check which demographic variables have the greatest influence on EI. The GLM was used to describe the relationship of several independent variables to USMEQ-I score. Moreover, it allows the researchers to identify the predictors factors of a continuous dependent variables by controlling the confounders. It also determines the relationship strength of each independent variable. A p-value ≤ 0.05 was considered as the significance level. Prior to the study, the assumptions of each mathematical evaluation were double-checked.

RESULTS

This study aimed to determine the factors affecting the emotional intelligence amongst Jordanian nursing and midwifery undergraduate students during the COVID-19 pandemic's outbreak. The researchers used an online questionnaire using the USMEQ-i tool. Year of study, age, average lifestyle and enrollment in a nursing program were found to be the most significant factors affecting the EI score.

A total of 1,100 subjects met the inclusion criteria and were identified as respondents for this study. The data below describes their socio-demographic profile.

The demographic data were analyzed using descriptive analysis, and the results are shown in **Table 1**. The majority of respondents were female ($N = 870$; 79.1%) while the age group was mainly 21 years or more ($N = 616$; 56.0%). The majority of surveyed students were single ($N = 901$; 81.9%). More than two-thirds of the surveyed students had excellent or very good CGPA ($N = 797$). It was observed that the majority of the students were living a middle lifestyle. Regarding the year of study, it was found that all the students were almost equally distributed between year 2 and year 4. However, number of students from year 1 was the highest. A limited number of students was non-Jordanians ($N = 39$; 3.5%).

This study showed that the general EI score for the respondents falls into the average score ($M = 39.6$). The general linear regressions analysis of independent variables on EI score showed four significant factors (**Table 2**). Nursing students who study in Years 1 and 4 had significantly higher EI scores than those in Years 2 and 3. EI ability decreased when a student's economic status changed from luxurious to middle income. In this current study, economic status was categorized as follows: (low family income of <750 JDs per year, middle family income of 750– < 2,900 JDs per year and luxurious family income of 2,900–9,000 JDs). Moreover, an increase in age significantly decreased the value of EI score. This study indicates that all nursing and midwifery students who enrolled in general nursing program tended to have higher EI scores than others, who are enrolled in both the midwifery program and the combined program (Nursing and Midwifery), ($p = 0.006$).

DISCUSSION

This study aims to fill several important gaps in the research on Jordanian nursing and midwifery students. Generally, it seeks to identify the level of EI amongst them and check the association between demographic data and EI. The mean EI score amongst all the participants of this study was 2.33. Based on the primary author of USMEQ-i, this result is considered as average (Yusoff et al., 2010). The study's findings were supported by evidence of EI's beneficial effects on students. Additionally, during the pandemic COVID-19 it has been argued that EI might be utilized as a tool to increase student's happiness, which would lead to better quality of life (Mascia et al., 2020).

On the basis of the general linear regression analysis, Years 1 and 4 have the highest EI score amongst Jordanian nursing and midwifery students whereas students from year 2 and 3 have non-significant EI score. In comparison to these findings, Sharon and Grinberg (2018) found that EI levels increased in Year 2 students. Another study done by Parker et al. (2021) found that EI score increases with age and their study revealed that the EI scores had a reasonably good rank-order stability overtime, and this is consistent with the findings of the current study for year 4 students. Similarly, Chew et al. (2013) discovered that EI is substantially linked with final-year student. In addition to the previously mentioned studies, the findings of this current study are supported by Khraisat et al. (2015), who found that EI level increases over time. The possible explanation for the significant results of EI amongst year 1 students is that the previous studies have been conducted in various contexts, and the present work was conducted during the COVID-19 lockdown, in which the study mode was switched from face-to-face to online learning.

Another aspect that influenced the students' EI levels was their age. The findings indicated that students aged 21 or more have a higher EI level than others. The findings of this study support those of Chen et al. (2016) as well as Gardner and Lambert (2019), who found an important positive association between EI and age. The authors were unable to find numerous studies that contradict this result except for one study done by Rappold (2017), which revealed no statistical significance of EI scores amongst different level of students.

The results showed that nursing students have higher EI levels than students from midwifery and other specialties, which is consistent with the study of Sharon and Grinberg (2018), who indicated that EI level has a positive relationship with nursing students' progress in their studies. Many possible causes of this variance can be said to have this effect. One cause is that the nursing curriculum encompasses courses from many different sciences, including biology, chemistry, social sciences

TABLE 1 | Demographic data analysis.

Variable	Frequency (%)	Variable	Frequency (%)
Gender		**Age**	
Male	230 (20.9)	21 or more	616 (56.0)
Female	870 (79.1)	20 or less	484 (44.0)
Program		**Economic status**	
General nursing	653 (59.4)	Luxury life	58 (5.3)
Midwifery	184 (16.7)	Middle life	941 (85.5)
Combined (nursing and midwifery)	263 (23.9)	Very poor life	101 (9.2)
CGPA		**Marital status**	
Excellent	282 (25.6)	Single	901 (81.9)
Very good	515 (46.8)	Married	182 (16.5)
Good	273 (24.8)	Divorced	14 (1.3)
Fair	30 (2.7)	Widow	3 (0.3)
Nationality		**Academic degree**	
Jordanian	1,061 (96.5)	BSc students	697 (63.4)
International	39 (3.5)	Diploma students	403 (36.6)
Year of study			
First year	379 (34.5)		
Second year	228 (20.7)		
Third year	290 (26.4)		
Fourth year	203 (18.5)		

TABLE 2 | General linear regressions analysis of independent variables on emotional intelligence.

Variable	Adjusted b (95% CI)	*t* statistic	*P*-value
Year of study			
Year four	5.157 (2.702, 7.613)	4.121	<0.001
Year one	2.754 (1.98, 4.409)	3.264	0.001
Program type (nursing)	1.953 (0.559, 3.346)	2.750	0.006
Age	−2.840 (−4.424, −1.256)	−3.518	<0.001
Economic status (middle)	−2.800 (−5.144, −0.456)	−2.344	0.019

Multiple linear regression: the model reasonably fits well, Model assumptions were met, there were no Interaction and multicollinearity problem.

and medicine; this supports the conclusion of a study that was done by Sánchez-Ruiz et al. (2010) who found that the curriculum has a significant effect on the sub-dimensions of EI. Other causes include the majority of nursing instructors being females, which can affect nursing students positively in the matter of EI as reported by (Codier et al., 2015; Phipps et al., 2015). In addition, the mode of study in nursing is mixed, that is, male and female students study together in the field of nursing, whereas midwifery students are all females; the presence of students of other sex can positively affect the levels of EI. This is congruent with the findings of Meshkat and Nejati (2017) who reported that females scored higher EI than males; this has a positive effect on males in that they will try to appear more emotionally intelligent in front of their female colleagues. Moreover, nursing is a 4-year program, whereas midwifery is a 2-year program. Lastly, the number of respondents from nursing students was 653, whereas midwifery respondents were only one-third of this number. This factor could be another explanation of the higher EI amongst nursing students compared with midwifery students. Back to the effect of nursing curriculum on EI, the findings of the current study are incongruent with the results of Rappold (2017), who found that nursing curriculum does not improve EI.

Furthermore, the results showed that the average economic status of the students affects the EI level, in terms of luxurious or poor lifestyle. The results are consistent with a number of studies which found that EI is strongly associated with socioeconomic status (Takeuchi et al., 2019; Rajesh et al., 2021; Schmalor and Heine, 2021). The stability of students' economic status influences EI positively. However, students with low socioeconomic status had higher levels of emotional intelligence than those with higher socioeconomic status, according to the findings of (Boakye, 2017).

STRENGTHS AND LIMITATIONS OF THE STUDY

This current study is not without limitations. Firstly, it was conducted only amongst Jordanian students. Secondly, a cross-sectional design was used instead of the cohort to measure the EI score during the times of the pandemic of COVID-19 during which lockdown was imposed by the higher authorities worldwide and Jordan is not an exception. Therefore, clinical practicum of students was negatively affected as the students

were unable to attend clinical settings. However, the researchers managed to get a large sample size, which has a positive impact on the generalisability of the study findings.

CONCLUSION

In conclusion, years of study, age, average lifestyle and enrolment in a nursing program were found to be the most significant factors associated with EI amongst Jordanian nursing and midwifery students. This issue needs to be researched further, such that appropriate steps can be taken to address it.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The institutional review board at Al-Balqa Applied University granted Ethical approval for this report, which was given the code 26/3/2/1065. The participants provided an electronic informed consent.

AUTHOR CONTRIBUTIONS

RA and AA-R contributed to conception and design of the study, and wrote sections of the manuscript. RA organized the database and performed the statistical analysis. AA-R wrote the first draft of the manuscript. Both authors contributed to manuscript revision, read, and approved the submitted version.

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Identified Motivation as a Key Factor for School Engagement During the COVID-19 Pandemic-Related School Closure

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On March 16, 2020, French schools suddenly closed due to the COVID-19 pandemic, and middle school students were asked to study from home with no direct interactions with teachers or classmates. However, school plays an important role in the development of social, intellectual, and mental competencies and can counteract the negative effects of adverse life events on learning and early school dropout. In this study, we investigated how the unusual context of school closure during the COVID-19 pandemic affected school engagement. Specifically, we focused on inter-individual differences in the motivational determinants of school engagement. We thus performed an online survey of 170 students focusing on the time spent on mathematics assignments, motivation regulation, implicit theories of intelligence, such as adopting a growth or a fixed mindset about his/her intellectual abilities, and optimism. Importantly, the students participated in the online survey during the first lockdown period, with schools closed (T1), and the second lockdown period, with schools remaining open (T2). During T1, identified motivation positively predicted the time spent on math homework assignments: the more the students thought that working on math exercises was useful for their future life, the more time they spent studying. Importantly, the link between identified motivation and school engagement was specific to T1, when schools were closed, as indicated by a significant interaction between identified motivations by type of lockdown. These results suggest that having self-determined motivation is of particular importance when students are deprived of social and intellectual interactions with classmates and teachers. This finding paves the way toward the development of wise rational interventions that target identified motivation and can be applied during challenging societal times and adverse, common life events to keep students engaged with school.

Keywords: motivation, school engagement, COVID-19, middle school, self-regulated

INTRODUCTION

On January 30, 2020, the WHO declared the spread of the acute respiratory syndrome-causing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) across the world to be a public health emergency and warned of a global pandemic (World Health Organization, 2020). In the following weeks, strict lockdowns, with school closures, were implemented in many countries throughout the world to contain the spread of the virus. However, it also left many households unprepared for dealing with the situation. For example, in France, the experience of the COVID-19 pandemic-related school closures differed between households, depending on access to the Internet and computer equipment (Institut National de la Statistique et des Etudes Economiques, 2020). Studies from education and social psychology have shown that experiencing long periods of school closure has negative effects on learning, motivation, and psychosocial well-being of the students (Sprang and Silman, 2013; Benke et al., 2020a,b; Dorn et al., 2020; Guessoum et al., 2020; Magklara et al., 2020; UNESCO, 2020; Bernabe-Valero et al., 2021; Garcia-Esquinas et al., 2021; Rajmil et al., 2021). Their direct interaction with friends and teachers at school has also been shown to counteract the negative effects of stressful life events on the well-being and mental health of the students (Shahar et al., 2009). This is quite important, as stressful life events are closely linked to early school dropout and demotivation (Dupéré et al., 2018). It is therefore critical to identify the individual factors that contribute to school engagement when schools are closed during adverse life events. This is important because it would make it possible to detect those students who are at risk of the negative consequences of pandemic-related lockdowns on health or school dropout and to design interventions that could help in keeping such students engaged. Although it is still unknown how inter-individual differences may contribute to school engagement during the pandemic-related lockdown, we tested three main individual characteristics that are associated with school engagement, namely, motivation regulation, intelligence mindset, and optimism.

First, an important body of research has shown that different types of motivational states or regulations can influence school engagement. Notably, the self-determination theory of motivation proposes that behavior is regulated by goals that can be placed on a spectrum from intrinsic to extrinsic (Deci and Ryan, 1985, 2012). For example, motivation of a student to do homework can be driven by external regulators, such as obtaining good grades or meeting the demands of parents. It can also be driven by identified regulators, such as the desire to act in coherence with his/her own attitudes, values, and needs, or by intrinsic regulators, such as curiosity and interest. The intrinsic and identified regulations (IR) of motivation have been shown to positively affect school achievement and have a more sustained effect on school engagement, whereas extrinsic regulators are associated with more maladaptive outcomes (Vasconcellos et al., 2020; Guay et al., 2021). However, intrinsic and identified motivation can also have different effects. Burton et al. (2006) showed that IR is positively associated with both greater well-being and better grades. In contrast, intrinsically motivated students have been shown to experience greater well-being after their mid-term exams, regardless of the grades obtained. Consistent with these results, Liu et al. (2019) provided longitudinal evidence that intrinsic motivation (IM) positively affects school performance in the long term, whereas identified motivation has a more acute, short-term performance-enhancing effect.

Second, another stream of research has shown that school engagement is strongly determined by the implicit theories of intelligence (ITIs) (Dweck, 1986, 2008; Dweck and Leggett, 1988). ITI proposes that humans hold strong beliefs about how malleable their intelligence is from very early on. Such beliefs are also referred to as fixed or growth mindsets. Students who adopt a fixed mindset of intelligence believe that intelligence is inherent and does not change during their lifetime. On the contrary, students who adopt a growth mindset of intelligence believe that intelligence is malleable and can evolve throughout life with experience and training. Importantly, these mindsets have an impact on the attitudes of students toward school. Students with a growth mindset are more prone to adopt learning goals that are defined by the intention to learn new things, rather than performance goals (Dweck, 1986; Blackwell et al., 2007). Adopting a growth mindset over a fixed mindset has also been found to positively affect school performance and well-being (Claro et al., 2016; Sarrasin et al., 2018; Sethi and Shashwati, 2019). Furthermore, mindset is particularly important for performance in mathematics because a fixed mindset concerning math skills has been shown to be more frequent among students and teachers than for other disciplines (Gunderson et al., 2017).

Third, it has been shown that optimism protects against school dropout through its effect on motivation and adjustment to stressors (Hoy et al., 2006; Huan et al., 2006; Solberg Nes et al., 2009; Tetzner and Becker, 2018). More precisely, optimistic students are more motivated to persist because they have better expectations concerning outcomes and cope better with stressors by managing, decreasing, or eliminating them. In mathematics, optimism has been associated with achievement, as pessimistic students have already experienced lower achievement in primary school (Yates, 2002). In older students, optimism predicts better adjustment of students to the transition from high school to college (Chemers et al., 2001).

We explored how (1) motivation regulation, (2) intelligence mindset, and (3) optimism impacted the personal time students engaged in mathematical exercises with the aim to assess how inter-individual differences may have contributed to school engagement during the pandemic-related lockdown. We focused on time spent on mathematics homework assignments because helping middle school students to achieve a good level in mathematics is a daily and complex mission, especially when schools are closed. The 2019 Program for International Student Assessment (PISA) study has shown that the proficiency of French middle school students in mathematics is among the lowest of European countries (Schleicher, 2019). Numeracy skills are a source for inter-individual differences in income, health, and unlawful behavior (Parsons and Bynner, 2005; Butterworth

et al., 2011). We thus conducted an online study across students who attended the 6th−9th grades of middle school in the Paris area. The data were collected in two groups at different periods during the COVID-19 pandemic in 2020. This year was characterized by two major waves of SARS-CoV-2 contagion in France, leading to strict lockdowns of economic and social life, with major individual restrictions in everyday life. However, the two lockdowns differed by one factor, i.e., school closure. The first lockdown period from March to June 2020 involved school closures and homeschooling, whereas schools remained open during the second lockdown period from October to December 2020. This provided us with the unique opportunity to investigate the effects of closed schools on school engagement by keeping other confounding contextual factors of the lockdown constant.

MATERIALS AND METHODS

Ethical Considerations

The study protocol was approved by the Academy of Versailles and was conducted in accordance with the Declaration of Helsinki. All participants and their parents gave their informed consent.

Participants

Participants were recruited from eight different public middle schools in Paris, selected, and governed by the Academy of Versailles. The principals of the eight selected middle schools agreed to send the questionnaire to their students by email. Participants all attended the 6th−9th grades. In total, 276 middle school students participated in an online survey study. Among them, 183 (mean age ± SEM = 12.9 ± 0.1 years, range = 10–15 years old) provided complete survey responses. From these sample data, 13 students were excluded because the individual survey responses were identified as being outliers, scoring three SDs above or below the sample mean of the respective variables. Therefore, a total sample size of 170 responses was included, with 97 responses for group 1, who were tested during the first lockdown period (T1, April to June 2020), with schools closed, and 73 responses for group 2, who were tested during the second lockdown period (T2, November to December 2020), with schools opened (**Table 1**). During the lockdown with schools closed, middle schools were recruited at the end of the lockdown period, allowing us to collect data during the last month of school closure. During the lockdown with schools opened, middle schools were recruited earlier, allowing us to collect data during the entire lockdown period. Among the participants, 30 participants were from 6th grade, 49 from 7th grade, 38 from 8th grade, and 53 from 9th grade.

Participants came from eight different middle schools. All analyses were, therefore, controlled for potential differences in time spent on math homework between the schools by entering the schools as a random effect in all linear mixed-effect analyses. Moreover, the two testing period groups were matched for general success rates in the national, final middle school examinations (e.g., "Brevet des Collèges"), as indicated by a non-significant difference in success rates [$t_{(6)} = 0.65$, $p = 0.27$, two-sampled, one-tailed t-test]. This success rate refers to the percentage of students who attained the minimum score necessary to pass the national examination at the end of middle school. This percentage of students can be consulted online and can act as a ranking of middle schools on quality and school performance.

TABLE 1 | Lockdown conditions were comparable in T1 and T2, except that schools were closed during the first lockdown and open during the second one.

Restrictions	1st Lockdown (T1) April to June 2020	2d Lockdown (T2) November to December 2020
Middle Schools	Closed	Open
Work life	Remote	Remote
Shops and restaurants	Closed, except for alimentary shops	Closed, except for alimentary shops
Cultural and recreational places	Closed	Closed

Moreover, the two groups (T1 and T2) were matched in terms of average age [$t_{(168)} = 0.43$, $p = 0.67$ two-sampled, one-tailed t-test], level of IM [$t_{(168)} = -0.49$, $p = 0.69$], IR [$t_{(168)} = 0.49$, $p = 0.69$], extrinsic regulation [ER, $t_{(168)} = -1.03$, $p = 0.85$], growth mindset [$t_{(168)} = 0.59$, $p = 0.72$], and optimism [$t_{(168)} = 0.22$, $p = 0.59$].

Online Survey

The study was designed as an online survey using Qualtrics software (Qualtrics, Provo, UT, USA). The survey link was sent to the participants *via* an intranet message (PRONOTE, Index Education) by the principal of each middle school, respectively. Students responded using their home computer, smartphone, or tablet.

The survey involved 33 questions measuring the following variables:

School Engagement in Mathematics

To measure the mathematics engagement, students rated how much time they spent doing math homework assignments each day during the previous 7-day week. They used a 5-point Likert scale from 0 (no work in Math) to 4+ (4 h of work or more) for each day of the previous week.

The time spent by students on mathematics was averaged across all days (mean total ± SEM = 3.6 ± 2.6 h/week, range = 0–14 h/week; **Table 2** for group differences) and square-root transformed to improve the normality of residuals in the statistical analyses.

Motivation Regulation

To assess how motivation in doing math homework assignments was regulated, students completed the French version of the Elementary School Motivation Scale (Guay et al., 2010). The questionnaire involved nine items measuring IM, identified (IR), and extrinsic regulation (ER). For each item, participants had to rate whether they agreed to the statements on a binary "Yes/No" scale (e.g., "In life, it is important to learn how to do math" or "I do math to please my parents or my teacher"). "Yes" responses for each statement were summed to yield the total scores, ranging from 0 to 3, for intrinsic ($N = 170$, mean ±

TABLE 2 | Linear mixed effects model of time spent on math homework in $N = 170$ middle school students tested during two periods of COVID-19 related lockdown with schools closed (group 1) and open (group 2).

Fixed effects	β_i	**SE**	**t**	***p***	**95%CI**
(Intercept)	1.74	0.09	20.01	4.4e-03	1.59–1.91
Group	−0.03	0.07	−0.49	0.63	−0.15–0.09
Intrinsic	0.09	0.07	1.27	0.21	−0.04–0.20
Extrinsic	−0.01	0.06	−0.21	0.83	−0.12–0.10
Identified	**0.18**	**0.08**	**2.31**	**0.02**	**0.04–0.32**
Mindset	2.1e-03	0.06	0.03	0.97	−0.11–0.11
Optimism	−0.11	0.06	−1.79	0.07	−0.23–0.00
Grade	**−0.08**	**0.04**	**−2.04**	**0.04**	**−0.16–0.01**
Group by Intrinsic	−0.02	0.06	−0.29	0.77	−0.13–0.09
Group by Extrinsic	0.08	0.06	1.32	0.19	−0.02–0.20
Group by Identified	**−0.14**	**0.07**	**−2.02**	**0.04**	**−0.27–0.02**
Group by Mindset	−0.09	0.06	−1.57	0.12	–0.2–0.02
Group by Optimism	0.05	0.06	0.88	0.38	−0.05–0.17
Group by Grade	0.06	0.04	1.46	0.15	−0.02–0.13
Intrinsic by Extrinsic	0.02	0.08	0.28	0.78	−0.12–0.16
Intrinsic by Identified	0.02	0.07	0.37	0.71	−0.10–0.15
Intrinsic by Mindset	5.8e-03	0.07	−0.08	0.93	−0.13–0.13
Intrinsic by Optimism	−0.11	0.06	−1.77	0.08	−0.22–0.00
Intrinsic by Grade	−1.8e-03	0.04	−0.04	0.96	−0.08–0.08
Extrinsic by Identified	0.10	0.07	1.36	0.18	−0.03–0.24
Extrinsic by Mindset	0.06	0.06	0.97	0.33	−0.06–0.16
Extrinsic by Optimism	−0.11	0.06	−1.62	0.11	−0.22–0.02
Extrinsic by Grade	0.02	0.04	0.53	0.59	−0.05–0.10
Identified by Mindset	−0.04	0.08	−0.51	0.61	−0.17–0.11
Identified by Optimism	0.11	0.06	1.64	0.10	−0.01–0.22
Identified by Grade	0.03	0.04	0.69	0.49	−0.05–0.11
Mindset by Optimism	0.07	0.06	1.20	0.23	−0.04–0.19
Mindset by Grade	−8.7e-03	0.04	−0.20	0.84	−0.08–0.07
Optimism by Grade	0.05	0.04	1.11	0.27	−0.03–0.13
Random Effects					
		Variance			
School (8 levels)	(Intercept)	2.3e-09			
Days Off (4 levels)	(Intercept)	1.0e-02			
Residuals	0.53	0.53			
Observations = 170; REML = 460.8					

Group designates a regressor that compared students tested during the first COVID-19 related lockdown period with schools closed (group 1) to students tested during a second COVID-19 related lockdown period with schools open (group 2). Significant main effects and interactions are highlighted in bold.

SEM = 1.6 ± 0.09), identified (mean ± SEM = 2.6 ± 0.05), and extrinsic motivation (mean ± SEM = 1.03 ± 0.07). All scores were *z*-scored for the analyses. Notably, we explored different motivational profiles within the sample and how they related to school engagement when schools were closed and when they were opened by conducting a cluster analysis, which is reported in the **Supplementary Material**.

Implicit Theories of Intelligence (ITIs)

The ITIs were assessed using the 3-Item Growth Mindset Scale (Dweck, 1999, 2006). Participants had to indicate to what degree they agreed with the three statements using a 6-point Likert scale, ranging from 1 (strongly agree) to 6 (strongly disagree).

Notably, we replaced "tu" ("you") with "je" ("I") in the French version to ensure that responses of students reflected how much they think their intelligence can grow with training, rather than merely reciting scientific facts about intelligence (De Castella and Byrne, 2015).

Scores for ITIs were obtained by averaging the scores for the three items. Higher scores indicate stronger growth mindsets ($N = 170$, mean ± SEM = 3.8 ± 0.1, range = 1–6). The scores were *z*-scored for the analyses.

Optimism

Optimism was measured using the Revised Life Orientation Test Scale (LOT-R; Scheier et al., 1994), which is frequently used to assess optimism and pessimism in adults and adolescents (Creed et al., 2002). The questionnaire involved 10 statements about the future (**Supplementary Material**), and participants rated how much they agreed with these statements using a 5-point Likert scale ranging from 0 (strongly disagree) to 4 (strongly agree). Scores were obtained by summing the responses of six non-filler items ($N = 170$, mean ± SEM = 13.88 ± 0.28, range = 0–24), with higher scores indicating more optimistic views of the future and lower scores indicating more pessimistic views. The scores were *z*-scored for the analyses.

Demographic Variables

At the end of the survey, students indicated their age, grade, and school and could declare if they did not understand some of the questionnaire items. Following the recommendations of the French National Commission for Information Technology and Individual Freedom (CNIL, 2013), we did not collect information about gender because crossing information about the middle schools, grade, and age with gender could threaten the anonymization of the data.

Statistical Analyses

All statistical tests were conducted using R (RStudio Team, 2019). Three analyses were performed. The first analysis directly compared the two samples to test our main question, i.e., how school closure during the COVID-19-related lockdown influenced school engagement in mathematics and interacted with psychological variables such as type of motivation, optimism, and growth mindsets. Then, a second and a third analysis, respectively, were performed to describe each sample more precisely. Our approach consisted first of a group comparison to test how school closure influenced (1) how much the students engaged in math assignments and (2) to what extent this engagement was predicted by intrinsic, extrinsic, or identified regulators of motivation, mindset, and optimism. We thus performed a linear mixed-effect regression analysis using the fitlme function of the lmerTest package in R. As shown in equation 1 below, the model fitted the time spent on mathematics (SqMATH, square-root transformed) and included the following fixed effects for Group (i.e., group 1, which was tested during the lockdown period with schools closed, coded −1 and group 2, which was tested during the lockdown period with schools

open, coded 1), IR (z-score), IM (z-score), growth mindset (z-score), optimism (z-score), and grade (coded −2, −1, 1, and 2 for the 6th−9th grades). Importantly, the comparisons of interest involved fixed effects regressors for the interaction between group and regulation type (identified, intrinsic, and extrinsic), mindset, and optimism, respectively (highlighted in bold, equation 1). The model further controlled for fixed effects of the interactions between group and grade, between different types of regulation (intrinsic, identified, or extrinsic), between different types of regulation and optimism, mindset, or grade, between the level of optimism and mindset or grade, and between mindset and grade. Two random effects regressors nested the intercept by the number of holidays and the middle school to control for these two potential confounders across all participants.

$$\begin{aligned}\text{SqMATH} = {} & \text{Group} + \text{Intrinsic} + \text{Identified} + \text{Extrinsic} \\ & + \text{Mindset} + \text{Optimism} + \text{Grade} + \text{Group} * \text{Intrinsic} \\ & + \text{Group} * \text{Identified} + \text{Group} * \text{Extrinsic} + \text{Group} * \text{Optimism} \\ & + \text{Group} * \text{Mindset} + \text{Group} * \text{Grade} + \text{Intrinsic} * \text{Identified} \\ & + \text{Intrinsic} * \text{Extrinsic} + \text{Identified} * \text{Extrinsic} \\ & + \text{Intrinsic} * \text{Mindset} + \text{Intrinsic} * \text{Optimism} \\ & + \text{Intrinsic} * \text{Grade} + \text{Intrinsic} * \text{Group} + \text{Identified} * \text{Mindset} \\ & + \text{Identified} * \text{Optimism} + \text{Identified} * \text{Grade} \\ & + \text{Identified} * \text{Group} + \text{Extrinsic} * \text{Mindset} + \text{Extrinsic} * \text{Optimism} \\ & + \text{Extrinsic} * \text{Grade} + \text{Extrinsic} * \text{Group} + \text{Mindset} * \text{Optimism} \\ & + \text{Mindset} * \text{Grade} + \text{Optimism} * \text{Grade} \\ & + (1|\text{DaysOff}) + (1|\text{School}) \end{aligned} \quad (1)$$

We then more precisely characterized the two groups, respectively. We thus tested which model better fit the data with the buildmer package from R for each group. This package performs backward stepwise elimination based on the change in log-likelihood (https://CRAN.R-project.org/package=buildmer). The likelihood ratio test is largely used to compare nested models and avoid overfitting (Glover and Dixon, 2004; Lewis et al., 2011).

The best model for group 1 followed equation 2:

$$\text{SqMATH} = 1 + \text{Identified} + \text{Grade} + (1 \mid \text{DaysOff}) + (1 \mid \text{School}) \quad (2)$$

The best model for group 2 followed equation 3:

$$\text{SqMATH} = \text{Identified} + \text{Identified} * \text{Extrinsic} + \text{Extrinsic} + \text{Optimism} + \text{Optimism} * \text{Mindset} + \text{Mindset} + (1 \mid \text{DaysOff}) + (1 \mid \text{School}) \quad (3)$$

All descriptive statistics included the estimated coefficients (β), t-values (with approximate degrees of freedom following Satterthwaite), and 95% CI. *Post hoc* two-sampled, two-tailed t-tests were conducted on the average time spent on math homework. The threshold for statistical significance in all analyses was $p < 0.05$.

RESULTS

Impact of School Closure vs. Schools Being Open During the COVID-19-Related Lockdown

A linear mixed-effects model of time spent on math homework showed a main effect of IR {β = 0.18, $t_{(141)} = 2.31$, $p = 0.02$,

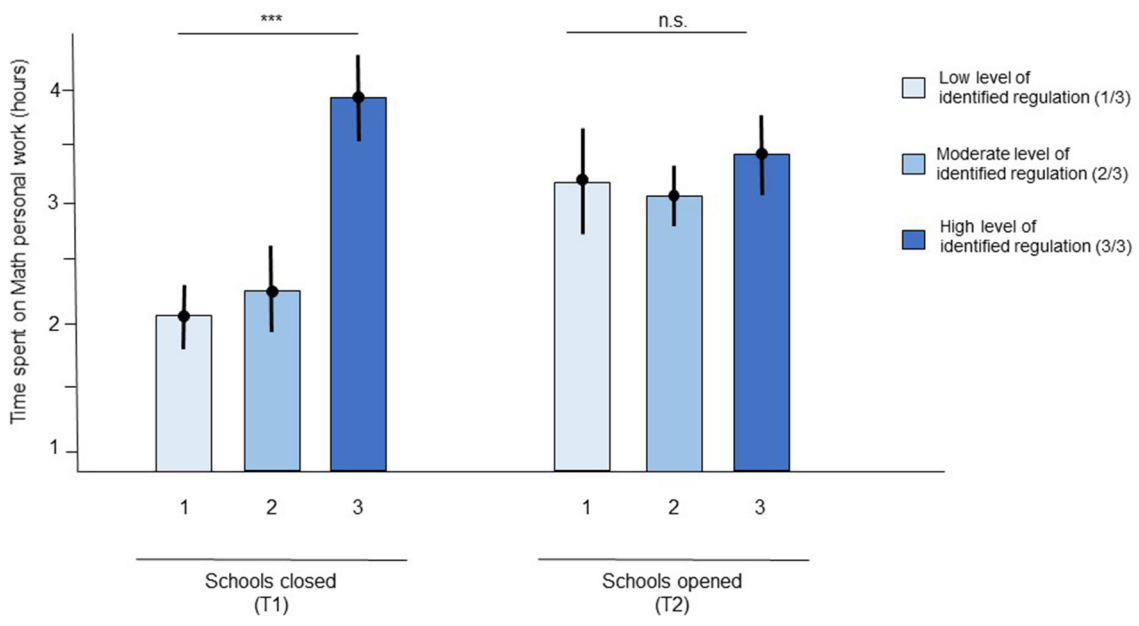

FIGURE 1 | Time spent on personal work in Math was influenced by identified regulation only during the first lockdown with school closed. Means are represented by a dot and standard errors of the mean by the errors bars. *** indicates that the main effect of identified was significant with $p < 0.01$ during the lockdown with schools closed. n.s. indicates that the main effect of identified regulation was non-significant ($p > 0.05$) during the lockdown with schools opened.

95% CI [0.04, 0.32]}, and grade {β = −0.08, $t_{(141)}$ = −2.04, p = 0.04, 95% CI [−0.16, −0.01]}, with non-significant effects of intrinsic regulation {β = 0.09, $t_{(141)}$ = 1.27, p = 0.21, 95% CI [−0.04, 0.20]}, ER {β = −0.01, $t_{(141)}$ = −0.21, p = 0.83, 95% CI [−0.12, 0.10]}, growth mindset {β = 2.1e-03, $t_{(141)}$ = −2.04, p = 0.97, 95% CI [−0.11, −0.11]}, and optimism {β = −0.11, $t_{(141)}$ = −1.79, p = 0.07, 95% CI [−0.23, 0.00]} (**Table 2**). Students who either had high levels of IR or were in earlier grades spent more time on math homework than students who had lower levels of IR or were in higher grades. Importantly, the main effect of IR was driven by a significant negative interaction between IR and group {β = −0.14, $t_{(141)}$ = −2.02, p = 0.04, 95% CI [−0.27, −0.02]} (**Figure 1**). *Post hoc t*-tests showed that students with low IR worked less on math assignments and those with high IR worked more [$t_{(95)}$ = 2.84, p = 3.30e-03] but only in the group tested during the COVID-19-related lockdown with schools closed. This difference was non-significant in the group tested during the COVID-19-related lockdown with schools open [$t_{(72)}$ = 1.43, p = 0.08]. No other interactions were detected. Notably, no main effect of group was found {β = −0.03, $t_{(141)}$ = −0.49, p = 0.63, 95% CI [−0.15, 0.09]}, suggesting that students spent a similar amount of time doing math homework when schools were closed and when they were open.

School Engagement in Group 1, During a COVID-19-Related Lockdown With Schools Closed

We tested how time spent on math homework was determined during the first lockdown period with schools closed. The model that fits this dataset best included two regressors, namely, IR and grade (**Table 3**). Consistent with our main results, this model confirmed that IR predicted the engagement of students {β = 0.23, $t_{(94)}$ = 2.89, p = 4e-3, 95% CI [0.07, 0.38]}. The more the students were driven by IR, the more they engaged in doing math homework. We also re-detected the main effect of grade {β = −0.12, $t_{(94)}$ = −2.55, p = 0.01, 95% CI [−0.22, −0.03]}. *Post hoc t*-tests showed this main effect to be driven by significant differences between 6th and 8th graders [$t_{(47)}$ = −2.96, p = 2.5e-3] and 6th and 9th graders [$t_{(42)}$ = −2.73, p = 4.6e-3]. The differences between students in the 7th and 8th grades [$t_{(51)}$ = −1.32, p = 0.09] and those in the 7th and 9th grades were borderline non-significant [$t_{(46)}$ = −1.33, p = 0.09].

School Engagement in Group 2, During a COVID-19-Related Lockdown With Schools Open

The statistical model that best described this dataset, which was collected during the second lockdown period with schools open, included four regressors, namely, identified and ER, optimism, and mindset, and two interaction regressors, namely, identified by ER and optimism by mindset (**Table 4**). There was a significant interaction between identified and ER (β = 0.15, $t_{(65)}$ = 2.09, p = 0.04, 95% CI [7e-3, 0.29]}, which indicates that additional regulation by external gratification (reward, good scores) had a positive impact only for students with the highest level of IR [score of 3/3: $t_{(48)}$ = 2.47, p = 0.01]. No significant interactions were found with ER on the time spent on math homework for students who scored medium or low on IR [score of 2/3: $t_{(15)}$ = −2.10, p = 0.97; score of 1/3: $t(4)$ = −1.07, p = 0.82]. Moreover, an interaction between optimism and mindset {β = 0.17, $t_{(65)}$ = 2.05, p = 0.04, 95% CI [0.01, 0.34], **Figure 2**} indicated that students with a fixed mindset and low levels of optimism spent more time on math homework than students with low levels of optimism and a growth mindset and students with high levels of optimism and growth or a fixed mindset.

TABLE 3 | Linear mixed effects model of time spent on math homework in N = 97 middle school students tested during the COVID-19 lockdown with schools closed.

Fixed effects	**β_i**	**SE**	**DF**	**t**	***p***	**95%CI**
(Intercept)	1.78	0.07	94	24.33	2e-16	1.63–1.92
Identified	0.23	0.08	94	2.89	0.005	0.07–0.38
Grade	−0.12	0.05	94	−2.55	0.012	−0.22–0.03
Random Effects						
		Variance				
School (5 levels) (*Intercept*)		0.00				
Days Off (4 levels) (*Intercept*)		0.00				
Residual		0.52				
Observations = 97; REML = 219.1						

TABLE 4 | Linear mixed effects model of time spent on math homework in N = 73 middle school students tested during the COVID-19 lockdown with schools open.

Fixed effects	**β_i**	**SE**	**DF**	**t**	***p***	**95%CI**
(Intercept)	1.63	0.11	1.90	15.21	5e-03	1.38–1.86
Identified	0.10	0.08	64.5	1.29	0.20	−0.05–0.26
Extrinsic	0.12	0.08	64.7	1.49	0.14	−0.03–0.28
Optimism	−0.05	0.08	65.4	−0.70	0.49	−0.21–0.11
Mindset	−0.08	0.09	65.9	−0.96	0.34	−0.25–0.11
Identified * Extrinsic	0.15	0.07	65.0	2.09	0.04	0.007–0.3
Optimism * Mindset	0.17	0.08	64.6	2.05	0.04	0.01–0.34
Random Effects						
		Variance				
School (5 levels) (*Intercept*)		0.01				
Days Off (4 levels) (*Intercept*)		0.00				
Residuals		0.48				
Observations = 73 ; REML = 169.9						

DISCUSSION

This study explored the source of inter-individual differences in psychological states and how they affected school engagement in mathematics during the COVID-19 lockdown when schools were closed compared to when they were open. We explored the contribution of motivation regulation, intelligence mindset, and optimism and focused on the time students spent doing math

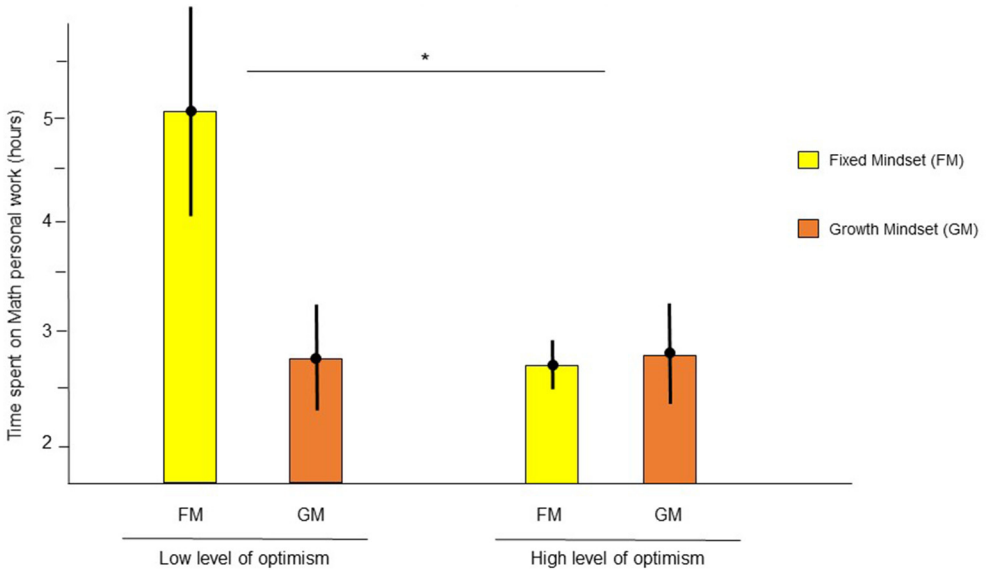

FIGURE 2 | Time spent on personal work in Math was more impacted by mindset for pessimistic students than optimistic students. Means are represented by a dot and standard errors of the mean by the errors bars. *indicates that the interaction between mindset and optimism was significant with $p < 0.05$.

assignments, as achieving good numeracy skills is one of the biggest challenges in middle school. Our results converged on the finding that the IR of motivation drove school engagement, specifically during the lockdown when schools were closed. This principal finding emphasizes the importance of school for developing competencies and constructing a professional path. Schools play a central role in the social construction and integration of adolescents (Vincent, 2008). Moreover, the academic and social aspects of school are not independent in middle school, as the social aspects of school have been shown to influence achievement and motivation (Day et al., 2014; Ladd and Kochenderfer-Ladd, 2016). Closing schools during the COVID-19 pandemic led to thousands of middle school students being deprived of appropriate study environments, as well as social interactions with peers and teachers. Crucially, our results show that such deprivation particularly affected students with a low level of identified motivation. Identified motivation implies that actions are driven (regulated) in coherence with his/her own attitudes, values, and needs. Thus, students who did not observe a value in mathematics in terms of their needs, attitudes, and values worked less during the first lockdown, when schools were closed than students surveyed during the lockdown of social and economic life, but with schools remaining open.

Overall, within the whole sample, younger students in the lower middle school grades spent more time on math homework than older students in the higher middle school grades, irrespective of whether the schools were closed or not. Such a decrease in engagement by grade is consistent with the well-documented decrease in performance and motivation in mathematics during middle school (Cayouette-Remblière and Moulin, 2019). Interestingly, the student group that was surveyed during the lockdown period with the schools open showed a positive impact on ER, specifically for students with high IR. This result is consistent with those of similar studies conducted in normal health and societal contexts that showed that ER is beneficial if coupled with greater personal motivation (Cameron et al., 2001; Cerasoli et al., 2014).

We did not find a positive main effect of growth mindset across all students, which is in contrast to the literature, which favors the hypothesis that a growth mindset positively affects school performance and engagement (Sarrasin et al., 2018). A recent impact study conducted on 23,000 French middle school students found that a growth mindset positively determined school performance in terms of the grades of the final examination but not engagement in terms of time spent on homework (Huillery et al., 2021). Our findings are consistent with this conclusion. However, more studies are needed to better determine the mechanisms through which mindset affects school engagement. Future studies should consider asking students to rate what they think about their intelligence in a specific field, such as math, to test the hypothesis of stronger mindset effects on school engagement in a specific field.

We did not find a main effect of optimism, which runs contrary to previous work showing a positive effect of optimism on school achievement counteracting dropping out (Solberg Nes et al., 2009). These findings suggest that potential variables that mediate the effects of optimism on school achievement do not involve school engagement. Interestingly, although there were no overall main effects of growth mindset or optimism, the two variables interacted when predicting school engagement for the students who were surveyed during the second lockdown, with schools open. Students with a fixed mindset together with more pessimistic views of the future worked more on math exercises than optimistic students with a fixed mindset. There

was no difference in school engagement between pessimistic and optimistic students who adopted a growth mindset. For fixed mindset students with low optimism scores, and thus more pessimistic views of the future, focusing on work can be a coping strategy to deal with emotions emerging from a context with high uncertainty concerning the future (emotion-focused coping, Lazarus and Folkman, 1984). However, the previous study has also shown that the study environment moderates the impact of mindset in school engagement. We showed that adopting a growth mindset is not sufficient to change attitudes and engagement toward scholarship if the study environment does not value and encourage effort and training (Walton and Yeager, 2020). The idea that innate abilities in science are necessary to be good in math is widely shared (Gunderson et al., 2017). It is therefore possible that leaving schools open during an adverse lifetime event, such as the COVID-19-related lockdown, created a study environment that allowed fixed mindset students to work harder to counteract worries about the potential negative effects of the pandemic on their future life and career. There is a small but growing body of research that has studied the role of coping strategies during the COVID-19 pandemic, but it has focused mainly on dealing with the increased health risks of COVID-19 (Baloran, 2020; Gerhold, 2020). Future studies are needed to understand the role of going to school during adverse life events and the complex interactions between anxiety and fears and growth vs. fixed mindsets and optimism.

Although our results highlight the importance of IR, in particular, when schools are closed, our study also involves some limitations such as the sample size and sample selection. In fact, student participation was voluntary. Thus, we cannot exclude that the responding participants were also those who were the most motivated. In addition, although the pandemic situation was similar during the two lockdown periods, the first lockdown was a novel, unprecedented experience, whereas it was more familiar when students experienced it the second time. The COVID-19 pandemic-related lockdowns of social and economic life provided a unique opportunity to study the effects of this collective adverse real-life event and how its potential negative effects on school engagement were further enhanced by school closure or attenuated by keeping schools open. Obtaining such data, for the first time, comes with the absence of randomization and the resulting sequential testing biases. We could at least partially rule out confounders due to such biases on school engagement *per se* because school engagement was matched between the two groups. However, we called for more studies to explore the impact of familiarity with experiencing a stressful adverse life-event situation and that of sequential surveying on the interactions between school engagement and motivation regulation, mindset, and optimism.

Previous studies have shown a positive impact of identified motivation on school performance and for avoiding dropout. Importantly, this positive effect was observed across grades and education levels from elementary school (Burton et al., 2006) and high school (Nishimura et al., 2011) to university (Black and Deci, 2000). It also generalizes across diverse educational subjects such as science (Black and Deci, 2000), physical (Boiché et al., 2008), and language education (Joe et al., 2017). Thus, it is very likely that identified motivation has played an important role in school engagement for students from different schools and grades, especially during such an adverse event as the combination of lockdown and school closure. It is possible that during the lockdown with schools closed, time spent on homework was also influenced by diverse other, more pragmatic factors such as access to a computer, food, and electricity, adult supervision, or attending online courses with teachers. These personal data, however, could not be collected due to reglementary policies assuring the full anonymity of the survey responses. However, during the first lockdown, we had the opportunity to collect some data about COVID-19 fear, frustration linked to experiencing a lockdown, and the number of people living under the same roof during the lockdown. A correlational analysis reported in **Supplementary Material** revealed that the number of people under the same roof had a significant, positive impact on the time spent on mathematics homework. Further studies including more demographic data and additional data from teachers and students with no access to the Internet are thus important to better understand how strong the impact of identified motivation is when students are deprived of direct interactions with teachers and classmates.

In this study, we focused on the time students spent on mathematics homework as an indicator for school engagement in mathematics following the participation-identification model of school engagement (Finn, 1989; Finn and Zimmer, 2012). The model proposes that school engagement of students can be decomposed into a behavioral component, i.e., participation, and a psychological component, i.e., identification, both components reinforcing each other (Finn, 1993; Virtanen et al., 2021). However, participation is more strongly linked to school dropout (Archambault et al., 2009), which is more likely to occur during adverse life events (Shahar et al., 2009). Given these interactions and the adverse context of the COVID-19 pandemic, we considered that the behavioral participation component of school engagement was most relevant. We further reason that participation can be approximated by how much time the students allotted for mathematics homework, which reflects a specific type of school engagement, motivated by the commonly shared concern of improving math skills throughout middle schools. However, our findings in this specific type of school engagement do not allow inferences on how identified motivation determines school engagement more generally. More work is, therefore, needed to identify the general behavioral components of school engagement under adverse life events, when students are deprived of direct interaction with peers and teachers at school. Moreover, it was not possible to take into account how much attendance to online courses determined the time spent on math homework. When schools were closed during the lockdown, there were no guidelines concerning online courses, and the conditions to attend these courses varied much across teachers, schools, and households. We also cannot rule out confounds by the sources of inter-individual differences in school performance and time management. The previous study has shown that spending more time doing homework does not always lead to better school performances (De Jong et al., 2010; Kitsantas et al., 2011), and students with lower math skills may

spend more time than their peers for the same amount of homework. The scope of our findings is limited to the behavioral participation component of school engagement in mathematics. We, therefore, encouraged more studies to better understand how school performance and school engagement interact and are moderated by inter-individual differences in the capacity to manage time.

CONCLUSION

Our findings shed light on the psychological determinants of school engagement when schools are closed during a pandemic. In particular, we showed that the IR of motivation predicted school engagement in mathematics. This finding provides new evidence that may be useful for the implementation of wise interventions (Walton and Wilson, 2018), such as utility value interventions that help students to understand how valuable knowledge can be for them outside the classroom (Hulleman et al., 2010, 2017; Harackiewicz et al., 2016; Canning et al., 2018). These interventions could easily be carried out online as they usually ask students to write a short essay about the relevance of a specific knowledge they learn at school. Results show that even such a short exercise could help students to change their perception of school subjects and help them to increase interest and grades (Hulleman et al., 2010; Harackiewicz et al., 2016; Canning et al., 2018). Targeting identified motivation with such wise interventions during adverse lifetime events, such as a pandemic-related lockdown and school closure, could therefore be of relevance to maintain the engagement of students in studying for school during such challenging periods.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/ repositories and accession number(s) can be found below: https://github.com/leacombette/COMBETTECAMENENROTGESCHMIDT.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

LC, J-YR, and LS conceived and designed the study. LC collected and analyzed the data. EC assisted with data analyses. LS and J-YR supervised the data analysis. LC and LS wrote the first draft of the manuscript. All authors contributed to the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.752650/full#supplementary-material

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Addressing the Interactive Effects of Maltreatment and COVID-19 Related Stressors on the Neuropsychological Functioning in Children

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INTRODUCTION

The novel coronavirus disease (COVID-19) has as of mid of October 2021, affected over 220 countries (with over 237,655,300 confirmed cases and 4,846,980 deaths; WHO, 2021a) and unprecedented disruption in the daily lives of people worldwide. Efforts to slow viral transmission, including quarantine and school closures (Baron et al., 2020; Engzell et al., 2021), have introduced profound changes in family routines and children circumstances. The conditions created by the COVID-19 pandemic (Bridgland et al., 2021; Calvano et al., 2021; Gadermann et al., 2021) have heightened the likelihood for both life stressors (Brown et al., 2020; Griffith, 2020; Achterberg et al., 2021; Mohler-Kuo et al., 2021; Spinelli et al., 2021) and childhood maltreatment (CM; Bérubé et al., 2020; Lawson et al., 2020; Rodriguez et al., 2021; Wong et al., 2021), while clinical and social services are weakened and resources for support are reduced (Jentsch and Schnock, 2020; Usher et al., 2020).

CM is already highly prevalent and widespread (Gilbert et al., 2009; Stoltenborgh et al., 2012; Hillis et al., 2016; UNICEF, 2021). It is estimated that one out of two children aged 2–17 years old experience some form of CM each year (Hillis et al., 2016), emotional abuse affects one in three children (Stoltenborgh et al., 2012), and one in four children lives with a mother who is the victim of intimate partner violence (UNICEF, 2021). Given the lockdowns, social restrictions and living in confinement coupled with massive economic disarray, we could expect a dangerous increase in the negative consequences of CM (Garstang et al., 2020; Pereda and Díaz-Faes, 2020), affecting those who, before COVID-19, have already suffered CM, but also putting children at risk for CM who were previously unaffected. Additionally, the protective measures for preventing the spread of the virus have heightened the risk for specific types of CM [e.g., online abuse or bullying, criminal, child sexual exploitation (Kuehn, 2020), and domestic violence (Evans et al., 2020; Pereda and Díaz-Faes, 2020; Rodriguez-Jimenez et al., 2020; UN Women, 2020; Cappa and Jijon, 2021)].

The clinical implementation of measures for the detection of CM is a priority. Even with the vaccine's anticipated impact on preventing the spread of the disease, new waves of COVID-19 pandemic are hitting many parts of the world driven by new variants of the virus (WHO, 2021b). There will be long lasting health, economic, developmental, and social impacts of COVID-19. It is plausible to believe that, after COVID-19, problems will not disappear for children who will continue to suffer the consequences of this crisis. It is, therefore, critical to understand and strengthen the well-being of children with pre-existing vulnerabilities (as a history of CM), and highlight key research targets to advance our knowledge of the challenges those affected by CM and stressful events (Bridgland et al., 2021) during COVID-19 are facing (Fares-Otero et al., 2020, 2021).

As a chronic stressor (Harkness et al., 2006; Wade et al., 2019; Rousson et al., 2020), CM contributes to alterations in the development and functioning of the brain (Teicher et al., 2012, 2016; De Brito et al., 2013; Mueller and Tronick, 2019), linked to neuropsychological deficits (Wilson et al., 2011; Samuelson et al., 2012; Spann et al., 2012; Blair et al., 2019), which lead to poor daily living skills (Kavanaugh and Holler, 2015; Meng et al., 2019), academic (Perez and Widom, 1994) and social maladjustment in children (Shonk and Cicchetti, 2001; Veltman and Browne, 2001; Stirling et al., 2008; Jaffee and Maikovich-Fong, 2011). Here, we propose that children exposed to CM and COVID-19 related stressors (Bridgland et al., 2021), would be more vulnerable to aggravation of neuropsychological deficits and thus, they would have higher likelihood for cognitive and social impairment through these (neuropsychological) deficits (than children without CM exposure). Therefore, it is important to identify and target neuropsychological alterations related to CM in the context of COVID-19.

OPEN QUESTIONS

Although there is strong theoretical and empirical evidence for interactive effects of CM and conditions related to the COVID-19 pandemic, several important open questions remain. These include: (1) The potential dose-response relation underlying the accumulation of experienced stress types and neuropsychological risk factors during COVID-19 pandemic; (2) The interplay between effects of CM and COVID-19 stressors, examining independent contributions of co-occurring chronic and acute stress, that may contribute to the onset and maintenance of neuropsychological problems in children; and (3) Moderators of these associations including COVID-19 stressor (interpersonal violence vs. other as loss of a loved one, parental divorce) and CM type (deprivation vs. threat; Johnson et al., 2021), severity of experiences (Ouellet-Morin et al., 2019), age at onset, frequency and timing of CM (English et al., 2005) and COVID-19 stressor, gender (Sternberg et al., 2006), prior experience of CM (Guo et al., 2020), and early adverse care histories vs. current adversity, might be considered.

A TAILORED NEUROPSYCHOLOGICAL REHABILITATION PROGRAM

There is a need for specific interventions targeting neuropsychological difficulties in CM victims (Nolin and Ethier, 2007; Pechtel and Pizzagalli, 2011; Wilson et al., 2011). It is, therefore, a critical time window for the development of novel interventions for children with CM, in order to reduce the burden and costs associated with cumulative adverse stress-related consequences of COVID-19. Neuropsychological rehabilitation (NR) is a theoretical framework and integrated approach (Wilson, 2008; Yi and Belkonen, 2011) that appears highly promising in terms of reducing neuropsychological problems in children. Within this background (see also **Figure 1**), we propose a NR program to guide treatment, discharge planning, and explore ways to combat neuropsychological problems tailored to the needs of children affected by CM and COVID-19 stressors.

The proposed NR program makes use of three mechanisms: (1) The child neuroplasticity allowing the brain to be malleable, i.e., cerebral mechanisms of neuronal renewal and changes (Pal and Elbers, 2018; Weyandt et al., 2020); (2) The preserved cognitive functions (training preserved functions may ensure correct functioning of altered ones); and (3) The resilience capacity, allowing positive adaptation in the face of adversity and environmental stressors (Charney, 2004; Masten, 2007; Cicchetti, 2013; McEwen et al., 2014; Kalisch et al., 2017). The program makes further use of classic principles of NR: compensation, substitution, and restoration or optimization (Zangwill, 1947) and integrates bottom-up and top-down approaches (Rauss and Pourtois, 2013) in three modules each of which is focused on specific (cognitive, behavioral, and social) domains: 1. Cognitive remediation, 2. Self-regulation learning, and 3. Social skills training.

Cognitive Remediation

We propose to combine (home-based) paper-and pencil (e.g., mazes, trail-making) and computerized tasks (van der Oord et al., 2014; Corti et al., 2020; Resch et al., 2021) (optionally timed and in adapted formats), with the attention training technique (by using auditory attentional exercises; Wells, 2002), self-monitoring attention and self-instructional training to engage children in executive control skills (Hallahan and Sapona, 1983; Diamond, 2012), selective and divided attention, and switching (Wells and Matthews, 1996; Ottowitz et al., 2002), and to increase top-down attentional control and flexibility, also related to delay gratification (Murray et al., 2018). Additionally, executive functioning can be trained by planning (e.g., using checklists, day planner, routines), management of time (limits) tasks, reasoning (e.g., analogies), spell out the rationale, and decision-making (on COVID-19 issues). It is important to encourage children to focus, remember and learn new information given, by using tasks of short duration to avoid fatigue and of a game format to avoid monotony, and to explore different ways of learning. An increased sense of the world being threatening in CM victims can increase child hypervigilance to (potential) threat. In addition, models of (past) threatening relationships may become activated during the COVID-19 pandemic (Kalia et al., 2020). Triggering of past traumatic memories and (possible) current ones (e.g., loss and grief) likely to be more frequent. It can be hard for children with a history of CM to place these current trauma experiences in perspective and understand that they are not permanent, and importantly, not their fault. These memories and worries could lead to attention, concentration problems and difficulty in daily planning. Children might be encouraged to manage unforeseen situations and to be flexible in order to change initial plans to adapt them to the (COVID-19) context.

Self-Regulation Learning

We propose to train self-regulation by using relaxation techniques (Ozamiz-Etxebarria et al., 2020), infant mindfulness-(school)based interventions (Sibinga et al., 2013; Tao et al., 2021), and emotional modulation by means of music and

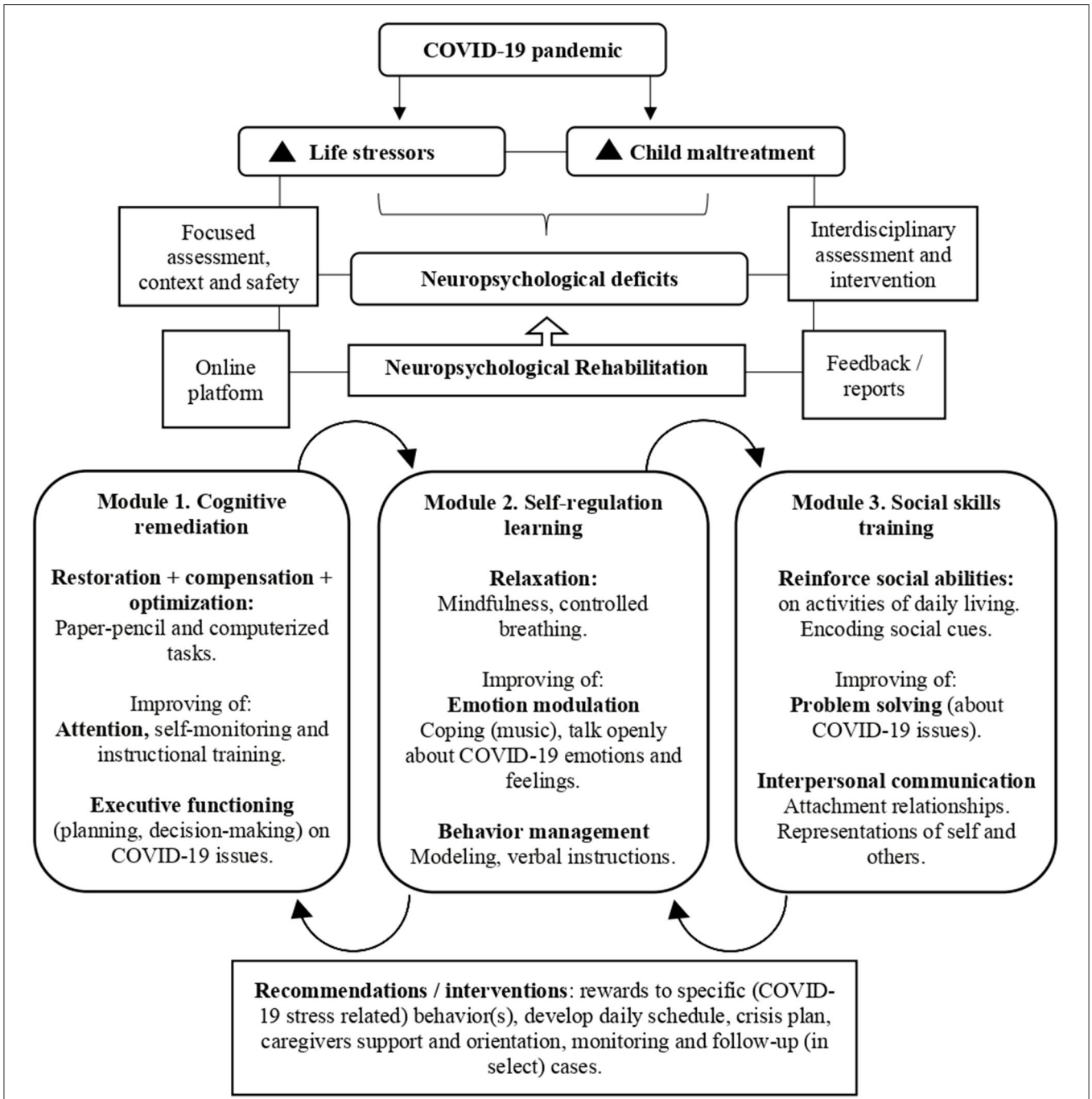

FIGURE 1 | Principles and activity modules of the neuropsychological rehabilitation program for children affected by maltreatment in the context of COVID-19 stressors.

coping behavior (Hillecke et al., 2005; von Georgi et al., 2009; Steinberg et al., 2021) to reduce COVID-19 anxiety levels, and to address stress management and behavioral difficulties (inhibitory control). The world during the COVID-19 pandemic has become a much more uncertain place. This creates anxiety for all, but particularly for children who have been reared in maltreating environments where their world in the past was also deeply uncertain. The increased wariness for bad things to happen [e.g., children may worry about contagion (Muñoz-Navarro et al., 2021) or that their caregivers become ill or lose their jobs or no longer be able to look after them] could be manifested in different kinds of feelings, particularly anxiety, but also behaviors such as irritability, aggression, and withdrawal. Thus, rules and norms (on COVID-19) should be explained to address issues of safety,

stabilize impulsive aggression against self and others, and process both the traumatic memories and trauma-related expectations (Streeck-Fischer and van der Kolk, 2000). Behavioral strategies can be included as: (a) Modeling: children are given examples of situations to demonstrate them how to react or behave; (b) Reinforcement: children are given verbalizations such as "you have done well!" or "you can do it better" as positive rewards for achievements or correct execution; (c) Verbal instructions: expected behavior has to be explained directly; and (d) Dramatization: children learn behavior while acting. Children might be asked "to talk to themselves" (Meichenbaum and Goodman, 1971) to select objectives and plan before acting, using instructions such as "think before acting" or "do it more slowly" to respond in an adaptive way, to help them to observe what is happening in present time and physically respond to current demands instead of recreating the traumatic past behaviorally and emotionally (van der Kolk, 2003).

Social Skills Training

Reinforcing social skills (in activities of daily living) can improve interpersonal communication (Cloitre et al., 2010), assertiveness, and problem solving (Tyler et al., 2021) on COVID-19 concerns. The improvement of social competence and communication involves empathy, respect of turns, verbal and non-verbal communication, by using techniques to train the performance on social skills (role-plays), to communicate and interact with each other (Ladd and Mize, 1983). The COVID-19 pandemic has had a major impact on children wider relationships. Children with CM have been losing out on the positive experiences of being with supportive people as friends or other family members. Differential sensitivity to the environment may have important implications for them in view of the deleterious consequences of CM on attachment relationships and on representations of self, caregiver and teacher. While a heightened sensitivity to social threat may be advantageous to children in the context of an adverse environment (Boyce, 2016), it can also become problematic in other situations. For instance, physically abused children are less accurate in encoding social cues, and are consequently more likely to respond aggressively to problematic social situations (Cicchetti and Valentino, 2006). The experience of CM may have meant a child was ignored and rejected, influencing their sense of self, and prior relationships with abusive adults (involving high anger exposure; Plate et al., 2019) may lead a child to believe others cannot be trusted. These vulnerabilities could be recovered through new positive experiences that encourage children to notice their strengths and weaknesses, by providing them strategies, support, and feedback (Prigatano, 1999).

PRINCIPLES OF PROGRAM IMPLEMENTATION

Interdisciplinary Assessment and Intervention

Interdisciplinary cooperation of child psychiatrists, pediatrists, psychologists, and social workers with experience in neuropsychological evaluation and rehabilitation is needed to address the need of CM victims in COVID-19 times. During the pandemic, children lost many sources of reward from family members, peers, and outdoor activities (Alonso-Martínez et al., 2021; de Figueiredo et al., 2021). This loose of reward may have been harder to deal with for CM victims. It is well-known that they are likely to show impairments in their reward system (Novick et al., 2018) manifested in a lack of motivation and low mood. These aspects (and maybe because of impaired attention; Boyd et al., 2019) warrant careful considerations of how to structure and deliver the proposed program.

Group sessions would allow children to practice with peers, whereas individual work promotes concentration and monitoring. Modules and tasks should be arranged based on an increasing level of difficulty, until it becomes possible for children to use the skills they would acquire (to jump to the next module). The modules should be organized to provide an order that children gradually acquire abilities that require building up from the most basic (i.e., attention) to the most demanding or complex processes (i.e., social behavior).

Optimal Use of Technology

To complement the NR program, we propose making (online) information and (psycho)education sessions available to caregivers, educators, and clinicians (joining an online consultation platform) to rapport building and provide them with information to recognize, report and respond to CM (Kimber et al., 2020; Thomas et al., 2020), the aftereffects of CM and clarification regarding possible cognitive, behavioral and affective changes, the rationale of the NR program, and suggestions or strategies needed (at home or the classroom) in COVID-19 times.

Focused Assessment of Problem, Context, and Safety Concerns

Besides discussing (current) neuropsychological issues, (possible) exhaustion and safety concerns might be considered. Carers of children with CM experiences always deserve particular attention, but especially so in this extraordinary period of lockdowns when caregiving in general (or cohabitation) can be extremely challenging. Within the household, parents are facing new demands with meeting basic and educational childcare needs and working remotely within in the home environment (Katz et al., 2021). We propose to review child's background, medical and developmental history, context, home environment and structure, usual and current supports. Home visiting-both in the form of physical services and remote access-should be delivered to offer children and their families appropriate professional support and to detect situations at risk for full-blown violence.

Feedback, Recommendations, and Interventions

Feedback and turn-around report addressed to the caregivers are a need. After neuropsychological assessment, caregivers may briefly sign-off, allowing the team to debrief and develop a plan. Subsequently, caregivers sign-on to receive feedback. A (short) report should be written addressed to

the caregivers (copy to referring health clinician and to the educators), formulated in lay language, with sufficiently detailed recommendations, *via* email communication (provided caregiver/parental permission). Reports might include consistent responses to specific (COVID-19 stress related) behavior(s), suggestions to adapt, simplify or develop daily activity schedule, safety assessment and crisis plan, and development of beginner communication systems. Importantly, intervention efforts are needed to strengthen positive parenting behaviors (validation, connection to resources). We recommend using emotion regulation and coping strategies (as cognitive reappraisal and self-compassion; Preuss et al., 2021) to foster parent-child relationships (Skopp et al., 2007; Austin et al., 2019) during such times of heightened stress, e.g., to respect for children feelings and opinions for COVID-19 questions.

DISCUSSION

Here, we proposed a novel NR program that might be helpful to reduce neuropsychological problems in children, taking into account the special needs of children affected by CM and COVID-19 stressors. Childhood is a sensitive period of neurological, cognitive, social, and emotional development, during which a neuropsychological intervention can make an important difference and shift the balance between risk and protective factors (Chinitz et al., 2017).

Current research on psychosocial impacts of the COVID-19 crisis has neither addressed the need for assessment and intervention targeting the neuropsychological functioning in children affected by CM. In our opinion article, we highlight the need for research aimed at a better understanding of the interactive effects of CM and COVID-19 related stressors on the neuropsychological function in children. We furthermore point out the importance of screening and monitoring CM and the necessity of the implementation of accurate evaluations of neuropsychological functioning in health care settings to prevent cognitive and social problems in maltreated children during and after COVID-19 pandemic and future crises.

A major challenge in our NR program is achieving a successful transfer to goal-attainment in real-life contexts. We believe that training neuropsychological functions as means to improve academic performance, is most promising in (maltreated) children, for whom both behavioral and domain-specific cognitive demands of formal schooling are quite novel challenges. An extra training and education for health professionals and educators on CM and its consequences on the neuropsychological functioning could contribute to the development of most adequate preventive and intervention measures and strengthen the collaboration between hospital services and schools.

Although the proposed NR program has a high theoretical foundation and a high potential to sustainably improve the neuropsychological functioning in children affected by CM in the context of the COVID-19 pandemic, many challenges regarding its implementation and empirical studies are needed to examine its feasibility, efficacy, and cost-effectiveness.

AUTHOR CONTRIBUTIONS

NEF-O: conceptualization, investigation, writing original draft, and writing—review and editing. ST: conceptualization, writing—review and editing, and supervision. Both authors approved the final version of the submitted manuscript.

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University Students' Basic Psychological Needs, Motivation, and Vitality Before and During COVID-19: A Self-Determination Theory Approach

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Self-determination theory assumes that the basic psychological needs for autonomy, competence, and relatedness are associated with motivational regulation. As these basic psychological needs may have been affected by the shift to distance learning, students' motivational regulation and vitality may have suffered as well. The purpose of this study was to examine the motivational regulation, satisfaction, or frustration of the basic psychological needs and vitality of university students before and after the transition to forced distance learning during the COVID-19 pandemic: Two student samples from Austria and Germany were studied: One was surveyed before the conversion to distance learning ($N = 1,139$) and the other at the beginning of forced distance learning ($N = 1,835$). The instruments used were the Scales for the Measurement of Motivational Regulation for Learning in University Students (SMR-L), the German version of the Basic Psychological Needs Satisfaction and Frustration Scale, a scale developed by the authors to differentiate the assessment of social relatedness, and the German version of the Subjective Vitality Scale. The results show that the satisfaction of basic psychological needs was significantly lower and the frustration thereof substantially higher during the distance learning period than before the pandemic. Intrinsic motivation and identified regulation were significantly lower during the forced distance learning period, and more controlled forms of motivation were higher than before the pandemic. Structural equation models showed that 42% of the students' vitality can be explained by motivational regulation and the satisfaction and frustration of their basic needs. Motivational regulation styles functioned (differentiated according to the degree of autonomy) as mediating variables between basic needs and vitality. In terms of theoretical implications, the distinction between approach and avoidance components of introjected regulation was shown to be adequate and necessary, as they explain the outcome vitality differently. The support and avoidance of frustration of basic

psychological needs should be considered in distance learning to promote the quality of motivation and students' vitality.

Keywords: basic psychological needs, motivation, vitality, university students, COVID-19, distance learning

INTRODUCTION

The COVID-19 pandemic necessitated a paradigm shift in terms of how we interact with each other. It also affected the higher education system. Starting in March 2020, most countries and over 90% of all students from around the world had to partially or completely switch to distance learning, especially during lockdown phases (United Nations Educational Scientific and Cultural Organization: UNESCO, 2020). The sudden and forced change to distance learning may have affected university students' learning as well as their motivational and psychological well-being. Initial studies show, for example, that rates of depression among students increased (Kaparounaki et al. 2020), whereas the quality of life and emotional well-being decreased, thus decisively changing significant prerequisites and conditions for learning processes (Adnan and Anwar, 2020; Bojović et al., 2020). Learners reported motivational and attentional problems, a lack of direct social interaction, stress, suboptimal support from teachers, and, in some cases, an increase in autonomy that enabled students to self-direct their learning (Händel et al., 2020; Kedraka and Kaltsidis, 2020; Wong, 2020). The few studies to date have consistently concluded that the lack of interaction with peers and instructors is a key problem (e.g., Händel et al., 2020), which has not only motivational and emotional impact, but also affects the success of learning (e.g., Richardson et al., 2015; Holzer et al., 2021).

The extent to which these abrupt changes (have) affected the motivation and psychological well-being of students in higher education compared to before the pandemic is largely an open question. It can be assumed that their motivation and vitality were decisively influenced by mandatory distance learning because of the lack of social interaction and feedback that promotes learning. Feedback goes hand in hand with the development of competence, which is associated with intrinsic motivation, especially in forced distance learning (Hartnett, 2015; Holzer et al., 2021). Moreover, research has shown that promoting or restricting autonomy undermines intrinsic motivation regardless of the learning setting (Ryan and Deci, 2017). The extent to which students in distance learning perceive themselves as autonomous still needs to be determined.

Based on the assumptions of Self-Determination Theory (SDT) (Ryan and Deci, 2017), this study investigated university students' basic psychological needs satisfaction (BPNS) and needs frustration (BPNF), their motivational regulation, and their vitality during forced distance learning and compares it with data that were gathered before the pandemic. The study examined the extent to which BPNS and BPNF can contribute toward explaining motivational regulation styles and vitality.

SELF-DETERMINATION THEORY

Motivation is generally understood as "any internal process that energizes, directs, and sustains behavior" (Reeve, 2016, p. 31–32). Or more briefly according to Baumeister (2016): "Wanting change"—wanting to effect change in the self or change in the environment. Accordingly, motivation theories ask about the why of actions, the quality of processes, and the outcomes of motivated behavior. With regard to motivation in learning, it can be assumed that learning motivation refers to the structures and processes that explain the genesis and effects of learning or of a learning action (see Schiefele, 1974).

If we take a closer look at theories of learning motivation, we find many approaches describing the genesis of learning motivation as a function of individual and environmental aspects. The respective focus, however, strongly varies. *Trait theories* underline personality traits which are more or less stable over situations and which regulate the learning processes. *Cognitive theories of action* have provided extensive studies of the learning environment (e.g., Heckhausen, 1989). They highlight learners' rational decision-making processes. Yet, both of these theoretical concepts show a predominantly cognitive approach and, therefore, they neglect emotional aspects, which are often unconscious, but very crucial for the development of learning motivation. SDT is one of the most prominent approaches, which systematically integrate emotional aspects (Ryan and Deci, 2017; see Müller et al., 2006).

Motivational Regulation

SDT distinguishes between intrinsic motivation and four types of extrinsic motivation. Intrinsic motivation characterizes behaviors that are enjoyable or pleasant and are thus exhibited "for their own sake" (Ryan and Deci, 2020). In education, intrinsic motivation is worth striving for, as it positively affects relevant outcomes such as vitality or achievement among students of different ages (Patrick et al., 2000; Chirkov and Ryan, 2001; Sheldon and Krieger, 2007; Taylor et al., 2014; Núñez and León, 2016; Thomas et al., 2018).

All behaviors characterized by extrinsic regulations are conducted because of external incentives (Ryan and Deci, 2017, 2020). Extrinsic motivational regulations differ, however, in terms of the strength of self-determination and associated outcomes (Ryan and Deci, 2020). They can be arranged according to an underlying continuum of self-determination, which is thought to be the origin of differential associations with outcome variables. *External regulation* is the outer end of the self-determination continuum. It characterizes behaviors stimulated by external pressures, contingent praise, and rewards (Ryan and Deci, 2020). Externally regulated behaviors are hardly self-determined and are associated with diminished vitality or

personal growth (Ryan and Deci, 2000a; Thomas et al., 2018). *Introjected regulation* is slightly more self-determined. It concerns behaviors that are exhibited due to poorly internalized social norms. They are characterized by ego-involvement, such as pride or shame, where self-esteem is dependent on outcomes and others (Ryan and Deci, 2020; Bieg et al., 2020). Recent research suggests that a distinction between an approach and an avoidance component should be considered because introjected approach regulation is positively related to well-being, life satisfaction, and positive affect, whereas introjected avoidance regulation shows insignificant associations with these outcomes (Assor et al., 2009; Sheldon et al., 2017). *Identified regulation* goes along with relatively high self-determination and characterizes behaviors conducted to achieve important personal goals. However, as the values are not completely internalized, a person with identified regulation may experience inner conflict when there are other attractive behavioral alternatives (Ryan and Deci, 2000a, 2020). Nevertheless, identified regulation is a meaningful predictor of learners' well-being, positive affect, life satisfaction, and academic achievement (Ryan and Deci, 2000a, 2020), including those at university (Sheldon et al., 2017; Thomas et al., 2018). The most self-determined type of extrinsic motivational regulation is *integrated regulation*. With integrated regulation, a behavior is conducted because of an important personal goal and without conflict because this person's value system is mature and stable (Ryan and Deci, 2000a). Unfortunately, integrated regulation is difficult to measure with standard questionnaires (Vallerand et al., 1992) and is thus excluded from the scope of this study. Overall, intrinsic motivation and extrinsic regulations are affected by environmental conditions, specifically, how well a particular environment facilitates the satisfaction of the three basic psychological needs (Ryan and Deci, 2020).

Amotivated behaviors fall outside this framework. This type of motivational construct must be considered in order to fully understand human behavior. These "behaviours are energised and they are explicable, but they are not considered motivated because they are not regulated by intentional processes" (Deci and Ryan, 1994, p. 3). Students with high scores on amotivation perceive their behaviors as caused by forces outside their control, and start asking themselves why they attend university at all (see also Müller and Louw, 2004).

Basic Psychological Needs Satisfaction and Frustration

SDT posits that the satisfaction of three basic psychological needs, namely autonomy, competence, and relatedness, foster intrinsic motivation and self-determined extrinsic regulations (Ryan and Deci, 2017). Autonomy is the need to experience volition regarding one's behavior. It is satisfied when a person has free choice and room to maneuvre. As long as the desired behavior is in harmony with one's endorsed values, he/she can experience autonomy even in situations with few or no alternatives (Ryan and Deci, 2020). Competence is the need to feel efficient and capable of bringing about change. It is satisfied when a person can rise to meet a challenge, but not when he/she completes easy tasks (Ryan and Deci, 2017). Relatedness is the need to feel connected with and cared for by other people. It can be satisfied when a person is cared for and treated with unconditional respect and appreciation (Ryan and Deci, 2000b; La Guardia and Patrick, 2008). The satisfaction of all three basic psychological needs is a predictor of vitality and autonomous types of motivation, whereas frustration predicts ill-being and controlled types of motivation (Bartholomew et al., 2011; Chen et al., 2015; Ryan and Deci, 2017). These impacts were shown empirically for university students (Cordeiro et al., 2016).

BPNS and BPNF have differential functions for psychological growth, especially in young people (Vansteenkiste and Ryan, 2013; Inguglia et al., 2018; Vansteenkiste et al., 2020). Thus, it should also be worthwhile to explore BPNS and BPNF separately for the study of motivational regulation and vitality in pandemic-induced distance learning. Learning environments can contribute toward BPNS and BPNF by supporting and/or thwarting students' basic psychological needs. Such changes in BPNS and BPNF affect the quality of students' motivation, well-being, and ill-being (Aelterman et al., 2019; Wang et al., 2019). BPNS can serve as a buffer in times of stress and promote psychological self-regulation, life satisfaction, and well-being (see Vansteenkiste and Ryan, 2013; Vansteenkiste et al., 2020), especially during the pandemic (e.g., Vermote et al., 2021).

Vitality

Subjective vitality is the physical and mental energy that originates from self-direction, autonomy, and intrinsic motivation. It is a dynamic concept in health psychology and refers to individuals' conscious experience of feeling alive and having energy (Ryan and Frederick, 1997). It represents a powerful resource that can help regulate purposive actions (Ryan and Deci, 2017). Subjective vitality is an indicator of psychological well-being (Ryan and Frederick, 1997). People who have high subjective vitality report being more active and productive, exhibiting better coping behaviors as well as experiencing more robust psychological health and well-being (Kawabata et al., 2017; Inguglia et al., 2018). Empirical evidence suggests that access to support for basic psychological needs increases subjective vitality (Vansteenkiste and Ryan, 2013). In addition, research has indicated that the relationship between BPNS or BPNF and outcomes such as vitality are mediated by motivational regulations (McDonough and Crocker, 2007; Alcaraz et al., 2015; Núñez and León, 2016). Accordingly, the present study also considered vitality and its dependence on BPNS, BPNF, and motivational regulation styles (see also Ryan et al. 2010).

DISTANCE LEARNING, MOTIVATION, AND WELL-BEING

The psychological impact of the pandemic can be described as wide-ranging, substantial, and probably long-lasting (Brooks et al., 2020). This also concerns learners in various educational institutions (Adnan and Anwar, 2020; Bojović et al., 2020;

Li et al., 2021). During the lockdowns to contain the spread of COVID-19, students had to cope with the general situation and were confronted with a completely new virtual teaching and learning culture associated with the loss of face-to-face contact in educational settings.

Previous meta-analyses show that virtual learning environments are generally not superior to traditional teaching-learning environments in terms of cognitive, emotional, and motivational outcomes (Krammer et al., 2020). There is evidence that blended learning formats yield slightly better results in terms of student achievement (Means et al., 2013; Schneider and Preckel, 2017). Ultimately, however, the impact of virtual learning environments depends on the quality of didactic implementation and, as in traditional learning environments, on teacher actions (teacher matters, e.g., Fryer and Bovee, 2016; Arghode et al., 2017). Studies focusing on motivation in virtual learning contexts have found that virtual learning environments do not motivate *per se* (e.g., Hartnett, 2015). Empirical research has presented mixed findings with higher (Rovai et al., 2007; Réka et al., 2015) and lower (Marchand and Gutierrez, 2012) intrinsic motivation and positive emotions in distance learning (Marchand and Gutierrez, 2012). However, before the pandemic, instructors mostly offered virtual teaching voluntarily, and those who did it generally had the necessary technical know-how to run such sessions. In this respect, the findings from this period cannot be directly compared with the exceptional situation of forced distance learning during the pandemic.

Studies based on SDT and related theories show that a lack of social presence and interaction (e.g., Bowers and Kumar, 2015; Butz and Stupnisky, 2017; Wang et al., 2019) seems to be the major impairment in distance learning when compared to face-to-face learning. For example, a study comparing distance and face-to-face learning among undergraduate students (Wang et al., 2019) found that BPNS was lower and BPNF was higher in online settings than in conventional settings. Other studies have demonstrated direct (Hsu et al., 2019) and indirect (Chen and Jang, 2010) associations between BPNS and autonomous motivation in distance learning. Some studies have also suggested that the importance of relatedness in explaining autonomous forms of motivation is lower in distance learning, with autonomy and competence being strong predictors of motivation in online settings (Huang et al., 2019; Wang et al., 2019; Martinek et al., 2021). This indicates that distance learning is not *per se* associated with negative effects.

Recent studies referring to the specific situation of forced distance learning during the COVID-19 pandemic show that students generally considered virtual learning more superficial and less sustainable (Chen et al., 2021). Students reported tension, overload, worry, emotional loneliness, and reduced well-being in connection with virtual learning (Kedraka and Kaltsidis, 2020; Sahu, 2020). This was especially true for courses held in the asynchronous mode. Synchronous settings, such as interactive virtual classes, question and answer sessions, and small group discussions were considered more supportive than asynchronous ones (Gewin, 2020; Chen et al., 2021).

Based on SDT, Wong (2020) examined whether students perceived the arousal and satisfaction of their basic needs for relatedness, competence, and autonomy within an online learning context. It turned out that students' basic psychological needs were only partially met through online learning. In particular, the need for relatedness suffered due to fewer social interactions with teachers and peers. Many students reported the lack of motivation and stress while starting their daily online sessions and had difficulty sustaining their attention (Wong, 2020). Similar to face-to-face settings, moderate associations between university students' autonomy satisfaction and intrinsic learning motivation were found in distance learning (Holzer et al., 2021). Other studies conducted during the pandemic showed that most students voted against the notion that online learning is more motivating than conventional learning (Adnan and Anwar, 2020). They argued that face-to-face contact is beneficial for learning in general (see also Händel et al., 2020 or Kedraka and Kaltsidis, 2020; Organization for Economic Co-operation and Development: OECD, 2020).

Very few studies since the inception of the pandemic have explicitly investigated motivation, BPNS, and vitality, as well as associations among these constructs. Arslan (2021) showed that, for example, loneliness and subjective vitality of college students are negatively correlated. Individuals with certain, relatively stable characteristics like morning-orientation, conscientiousness, openness, and low neuroticism seemed to cope better with the lockdown with respect to outcomes such as vitality, self-determined motivation, and BPNS (Staller et al., 2021).

RESEARCH QUESTIONS AND HYPOTHESES

This paper addresses differences in university students' motivational regulation styles, BPNS, BPNF, and vitality before and after the switch to distance learning during the lockdowns to contain the spread of COVID-19. According to the empirical findings reported above, autonomous motivation was assumed to be lower and controlled forms of motivation to be higher in forced distance learning settings during the COVID-19 pandemic. Owing to its higher autonomy and conceptual reference to self-esteem-enhancing contingencies, we assumed that introjected approach regulation would be lower during pandemic-induced distance learning than during face-to-face learning conducted previously. Somewhat higher values were expected to result from forced distance learning for introjected avoidance regulation. It was also assumed that the students experienced less BPNS and more BPNF during the distance learning phase. We expected relatedness to both peers and faculty members to be lower during forced distance learning (Wong, 2020). Research has also indicated that vitality decreased during the pandemic when compared to the period before it (e.g., Martínez-González et al., 2021).

We assumed that BPNS and BPNF can explain motivational regulation during forced distance learning. We examined the

predictive power of each basic psychological need on the investigated motivational regulations separately. The structural equation model also tests the extent to which motivational regulation serves as a mediator between BPNS (and BPNF) and students' vitality (McDonough and Crocker, 2007; Alcaraz et al., 2015). Owing to the high intercorrelations between BPNS and BPNF, we drew up separate models for each.

Hypotheses

1. The autonomous forms of motivation (intrinsic and identified regulation) are lower during forced distance learning than during regular face-to-face learning. Moderate to high effects are expected because both intrinsic motivation and identified regulation are sensitive to environmental changes.
2. Controlled forms of motivation (introjected and external regulation) are higher during forced distance learning than they were before the change to virtual learning environments was made. However, introjected approach regulation should decline in a differentiated manner. It is assumed that differences are smaller for controlled types of motivation than for autonomous ones because the former are generally less strongly associated with environmental variables (such as BPNS or BPNF) and are therefore less affected by changes such as the abrupt switch to distance learning.
3. BPNS is lower and BPNF is higher after the switch to forced distance learning. We expect social relatedness with the peer group and faculty to be significantly lower during forced distance learning.
4. Students' vitality is lower during forced distance learning than it was during regular face-to-face learning before the COVID-19 pandemic.
5. BPNS and BPNF explain the motivational regulations during forced distance learning. We expect correlations between BPNS and BPNF and the autonomous types of motivation to be higher than those between BPNS and BPNF and the controlled types of motivation.
6. Motivational regulations mediate the correlation between BPNS or BPNF and vitality.

METHOD

Sample

Sample 1 (Pre-COVID-19 Distance Learning)

Before March 2020, we collected data from 1,139 students from different study programs. Of the total sample (64% female, 34% male, and 2% no information), 45% were studying at Austrian and 55% at German universities or university colleges. The average number of completed semesters was 3.7 ($SD = 2.9$). As many as 45% of the students indicated that they were pursuing a teaching degree. The others were mostly pursuing majors in the social sciences and humanities. The average age was 21.1 years ($SD = 5.1$). Data exist for this sample on motivational regulation ($N = 1{,}139$), BPNS, BPNF ($N = 494$), relatedness with peers and faculty ($N = 730$), and subjective vitality ($N = 904$).

Sample 2 (During Forced Distance Learning)

A sample of 1,835 students from eight universities and university colleges in Austria (56%) and Germany (44%) participated in the online survey. Data are available for all students on the constructs collected. The mean age was 23.54 years ($SD = 5.77$). Of the total, 79% were female, 20.9% were male, and 0.4% did not provide gender-related information. The average number of completed semesters was 5.9 ($SD = 4.8$). Of the students surveyed, 56.4% were pursuing a teaching degree at the time of the survey. All other students were majoring in the social sciences and humanities. In our sample, 15.6% of the students were writing their thesis at the time of study and were therefore in one of the last semesters of their studies. Only 12.3% lived alone, 24.4% lived with one other person, 23% with two other individuals, and 23.4% with three or more. Most students (73%) were satisfied with their technical equipment for distance learning (internet, PC, etc.). Overall, the age structure and subjects studied in samples 1 and 2 were fairly similar, which justifies a comparison between both groups (cf. Martinek et al., 2021).

Measures

To measure motivational regulation style, we used the Scales for the Measurement of Motivational Regulation for Learning in University Students (SMR-L, Thomas et al., 2018), which differentiates between two autonomous (intrinsic and identified regulations) and two controlled types (introjected and external regulation) of motivation. To measure the introjected approach and avoidance regulation separately, we added three items to the scales (cf. Bieg et al., 2020). A total of 15 items were rated on a 7-point Likert scale that ranged from *does not apply at all* (1) to *applies completely* (7). The instrument captures the following scales (item examples are given in parentheses):

- Intrinsic regulation (*I really enjoy learning in my studies*).
- Identified regulation (*I am committed to my studies in order to achieve the goals I have set for myself*).
- Introjected Regulation ("Approach": *I want to show myself that I can be successful in my studies*; "Avoidance": *I am currently studying because otherwise I would have a guilty conscience*).
- External regulation (*I study primarily because I cannot get a well-paid job without an academic qualification*).

The items generally refer to face-to-face learning, which is why the word "online study" was used to define the distance learning context. The internal consistencies of the scales (Cronbach's alpha) were satisfactory (see **Table 1**). Confirmatory factor analyses revealed that the five-dimensionality of the instrument was superior to the two-dimensional factor solution (autonomous and controlled regulation) and the four-dimensional variant (without differentiation of introjected regulation): Five-factor solution: $\chi^2(76) = 390.503$, $p < 0.01$, $CFI = 0.975$, $RMSEA = 0.035$ (see also Thomas et al., 2018). The simplex structure of motivational regulation styles can be replicated (see the correlations).

BPNS and BPNF were assessed with the German version of the Basic Psychological Needs Satisfaction and Frustration

Scale (German version: Heissel et al., 2018; original version: Chen et al., 2015). The sample reliabilities were at least satisfactory, ranging from 0.70 to 0.90 (**Table 2**). A total of 24 items was rated on a 5-point Likert scale ranging from *does not apply at all* (1) to *applies completely* (5). A confirmatory factor analysis (CFA) revealed good factor validity [BPNS: $\chi^2(47) = 217.194$, $p < 0.01$, $CFI = 0.975$, $RMSEA = 0.032$; BPNF: $\chi^2(47) = 217.194$, $p < 0.01$, $CFI = 0.980$, $RMSEA = 0.032$]. The instrument captures the following scales (item examples are given in parentheses):

- BPNS Autonomy (*I feel free to choose what I do in my studies*).
- BPNS Competence (*I currently feel competent in my studies*).
- BPNS Relatedness (*I feel related to the people I spend time with during my studies*).
- BPNF Autonomy (*I currently feel forced to do many things in the course of my studies that I would not choose for myself*).
- BPNF Competence (*I am currently unsure of my abilities in relation to studying).*
- BPNF Relatedness (*I feel that the relationships I have made in the course of my studies are superficial*).

A well-established scale for the assessment of relatedness with peers and faculty was used (Müller and Thomas, 2018). The perceived relatedness with the peer group (e.g., I feel accepted by my fellow students) and the faculty (e.g., I have good contact with the lecturers) were measured with three and four items, respectively (**Table 3**). The items were answered on a 7-point Likert scale ranging from *strongly disagree* (1) to *strongly agree* (7). Internal consistency was satisfactory for both scales ($\alpha = 0.79$ and $\alpha = 0.84$, respectively). *CFA* provided a clear two-dimensional structure and was superior to a one-dimensional version [$\chi^2(11) = 35.308$, $p < 0.01$, $CFI = 0.986$, $RMSEA = 0.025$].

The German version of the Subjective Vitality Scale (Ryan and Frederick, 1997) was used to measure vitality (**Table 3**). The participants answered prompts (e.g., I do not feel very dynamic at the moment) on a 7-point Likert-type scale from *not true* (1) to *very true* (7). The instrument achieved good levels of scale reliability ($\alpha = 0.92$) and factor validity [$\chi^2(14) = 95.730$, $p < 0.01$, $CFI = 0.992$, $RMSEA = 0.041$].

Statistical Analyses

To test possible mean differences described in hypotheses 1 to 4, we used a t-test (procedure Scheffé). To analyze linear associations, we used Pearson correlations (**Table 4**). To test hypotheses 5 and 6, we computed two structural equation models using Amos 25.0 software (cf. Byrne, 2016) and standard fit indices (**Figures 1, 2**). Model goodness of fit was checked using root-mean-square error of approximation (*RMSEA*) and comparative fit index (*CFI*). Though the χ^2 statistic was reported, it had the disadvantage of being sensitive to sample size. For *RMSEA*, values above 0.05 and below 0.08 are considered good

TABLE 1 | Motivational regulations before and during the forced distance learning period.

			Before distance learning (*N* = 1,139)	During distance learning (*N* = 1,835)				
Scale	**Items**	**α**	**M (SD)**	**M (SD)**	**t[1]**	**df**	**p**	**Cohen's d**
Intrinsic motivation	3	0.84/0.90	4.67 (1.22)	3.32 (1.70)	−19.00	2,940	<0.001	0.90
Identified regulation	3	0.75/0.75	5.39 (1.14)	4.83 (1.36)	−8.54	2,940	<0.001	0.39
Introjected regulation								
Approach	3	0.74/0.79	4.60 (1.44)	4.30 (1.57)	−2.11	2,931	<0.001	0.10
Avoidance	2	0.61/0.72	3.49 (1.45)	3.73 (1.67)	9.12	2,931	<0.001	0.42
External regulation	3	0.75/0.70	4.30 (1.52)	4.51 (1.47)	2.32	2,937	<0.001	0.10

Scale: 1 = does not apply at all, 7 = applies completely. [1]t-test, Scheffé procedure for independent samples.

TABLE 2 | Basic psychological need satisfaction (BPNS) and basic psychological needs frustration (BPNF) before and during the distance learning period.

			Before distance learning (*N* = 494)	During distance learning (*N* = 1,177)				
Scale	**Items**	**α**	**M (SD)**	**M (SD)**	**t[1]**	**df**	**p**	**Cohen's d**
BPNS autonomy	4	0.76/0.72	3.51 (0.76)	3.14 (0.86)	08.71	2,227	<0.001	0.45
BPNS competence	4	0.88/0.90	4.00 (0.71)	3.28 (0.98)	14.94	2,229	<0.001	0.76
BPNS relatedness	4	0.84/0.79	4.32 (0.74)	3.07 (0.94)	27.11	2,228	<0.001	1.38
BPNF autonomy	4	0.84/0.84	2.75 (1.03)	3.60 (1.00)	−16.45	2,228	<0.001	0.84
BPNF competence	4	0.79/0.84	1.56 (0.66)	2.32 (1.04)	−15.50	2,227	<0.001	0.79
BPNF relatedness	4	0.74/0.70	1.81 (0.79)	1.99 (0.81)	−04.41	2,228	<0.001	0.23

Scale: 1 = does not apply at all, 7 = applies completely. [1]t-test, Scheffé procedure for independent samples.

TABLE 3 | Relatedness with peers and with faculty and vitality before and during the distance learning period.

			Before distance learning (*N* = 730/571[2])	During distance learning (*N* = 1,736)				
Scale	**Items**	**α**	**M (SD)**	**M (SD)**	**t[1]**	**df**	**p**	**Cohen's d**
Relatedness								
Peers	3	0.79/0.80	5.61 (1.08)	3.78 (0.94)	41.33	2,422	0.00	2.11
Faculty	4	0.78/0.84	4.46 (1.24)	3.33 (0.94)	24.53	2,424	0.00	1.25
Vitality	6	0.91/0.93	3.83 (1.19)	4.18 (1.36)	−5.35	2,322	0.00	0.27

Scale: 1 = strongly disagree to 7 = strongly agree. [1]t-test, Scheffé procedure for independent samples.
[2]There are 571 records for the vitality scale before distance learning.

and acceptable, respectively, and for the *CFI*, values above 0.95 but at least 0.90 should be achieved (Kline, 2011).

Procedure

Following the switch to forced distance learning and teaching during the COVID-19 pandemic, the students were surveyed using an online questionnaire between April and June 2020. Students were reached *via* individual online lectures. The completion of the online questionnaires took about 15 to 20 min on average. Before participating in the survey, the students were assured anonymity. They were given the option of retracting study participation or withdrawing at any time without any penalty. The students gave their consent to the use of their data for research purposes.

RESULTS

The mean values of all five motivational regulation types differed significantly before and after the introduction of forced distance learning (**Table 1**). In line with hypothesis 1, the students showed lower intrinsic motivation and identified regulation during the forced distance learning period. They also reported higher levels of controlled motivation and introjected approach regulation during forced distance learning.

BPNS and BPNF showed a significant difference in mean values in a comparison of the surveys conducted before and during the COVID-19 pandemic (see **Table 2**). The satisfaction of the basic needs for competence and relatedness were substantially lower during the forced distance learning period ($d = 0.76$ and 1.38, respectively). A different picture emerged for the BPNF when compared with the BPNS. The needs for autonomy and competence were obviously more frustrated during forced distance learning than before. According to the effect size, the frustration of relatedness differed only slightly.

A differentiated view of relatedness presents a distinction between relatedness with peers and faculty (**Table 3**). In both cases, there is a significant difference in terms of the disadvantage of forced distance learning. This difference is especially large for relatedness with peers. Relatedness with faculty was significantly lower during forced distance learning than before the changeover.

It was also assumed that the vitality of the students would be lower during forced distance learning than before. The results show that subjective vitality was somewhat higher during this time, although the effect size was small. This was, however, not true for first-semester students, for whom vitality during forced distance learning turned out to be lower than for students in other semesters [first semester: M = 3.58, SD = 1.14; two or more semesters: M = 4.20, SD = 1.37; $t(1811) = -3.743$, $p < 0.01$].

The following structural equation models were calculated to test hypotheses 5 and 6. In **Figure 1**, we modelled BPNS as a predictor of motivational regulatory style and vitality for all students in sample 2 (during the forced distance learning period). To avoid multicollinearity, relatedness was modelled as one variable and not differentiated into relatedness with peers and faculty. The differentiated modelling of relatedness did not provide any added explanatory value in the model.

The results show that variance in intrinsic motivation and identified regulation was well explained by BPNS ($R^2 = 0.64$ and 0.63, respectively). Autonomy ($\beta = 0.59$ and 0.70, both $p < 0.01$) and, to a lesser extent, competence ($\beta = 0.29$ and 0.13, both $p < 0.01$) both qualified as predictors of autonomous types of motivational regulation. Relatedness showed a small association with intrinsic motivation. The variance in the introjected approach regulation could be explained to 20%, with autonomy having the highest proportion ($\beta = 0.44$, $p < 0.01$). Introjected avoidance regulation was negatively associated with the satisfaction of the need for competence; however, external regulations could hardly be explained in this model (see **Figure 1**). Overall, 42% of the variance of the students' vitality was explained in this model, with the autonomous forms of motivation and the two scales of introjected regulation being positively and negatively associated with vitality, respectively. The satisfaction of all three basic needs directly explained vitality, with competence showing the highest explanatory value ($\beta = 0.37$, $p < 0.01$).

Figure 2 presents the relationship among the investigated variables with each BPNF as independent variables for the explanation of motivational regulation during forced distance learning. Consistent with our expectations in hypothesis 5, the autonomous types of motivational and introjected approach

TABLE 4 | Pearson correlations between all relevant variables (during distance learning).

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Intrinsic motivation	–												
2. Identified Regulation	0.57**	–											
3. Introjected Regulation (Approach)	0.34**	0.50**	–										
4. Introjected Regulation (Avoidance)	−0.18**	−0.04	0.32**	–									
5. External Regulation	0.06*	0.06*	0.27**	0.25**	–								
6. BPNS Autonomy	0.61**	−0.06*	0.30**	−0.18**	−0.01	–							
7. BPNS Competence	0.59**	0.45**	0.22**	−0.25**	0.03	0.57**	–						
8. BPNS Relatedness	0.23**	0.37**	0.13**	−0.09**	−0.03	0.32**	0.35**	–					
9. BPNS Relatedness (faculty)	0.45 **	0.10**	0.17**	−0.07**	−0.02	0.57**	0.50**	0.28**	–				
10. BPNS Relatedness (peers)	0.17**	−0.28**	0.11**	−0.08**	−0.03	0.25**	0.33**	0.65**	0.32**	–			
11. BPNF Autonomy	−0.56 **	−0.39**	−0.14**	0.25**	0.07**	−0.63**	−0.51**	−0.18**	−0.43**	−0.14**	–		
12. BPNF Competence	−0.45**	−0.35**	−0.09**	0.33**	0.04	−0.45**	−0.79**	−0.30**	−0.40**	−0.29**	0.46**	–	
13. BSNF Relatedness	−0.17**	−0.15**	−0.01	0.19**	0.10**	−0.25**	−0.43**	−0.58**	−0.25**	−0.59**	0.24**	0.44**	–
14. Vitality	0.48**	0.40**	−0.14**	−0.26**	−0.03	0.42	0.55**	0.29**	0.32**	0.26**	−0.42**	−0.51**	−0.30**

*$p < 0.05$; **$p < 0.01$.

regulation were negatively associated with the frustration of autonomy. The more the need for competence was frustrated, the lesser the students reported identified regulation ($\beta = -0.22$, $p < 0.01$) and intrinsic motivation ($\beta = -0.19$, $p < 0.01$). The learners' introjected avoidance regulation was explained by the frustration of competence ($\beta = 0.41$, $p < 0.01$) and thus better than by the BPNS. The frustration of relatedness could not explain any motivational regulation or vitality. As in in Model 1, external regulation was not explained in this model.

DISCUSSION

Based on SDT, this study investigated the extent to which university students' BPNS, BPNF, motivational regulation, and vitality differed between regular on-site education before COVID-19 and the initial phase of forced distance learning during the COVID-19 lockdown. We argued that the short-term and forced changeover to distance learning led to changes in basic support for psychological needs, thus curtailing BPNS and triggering BPNF. These changes were associated with low autonomous motivation. In line with our expectations as articulated in hypothesis 1, the mean scores of intrinsic motivation and identified regulation were considerably lower during forced distance learning than they were before (cf. Wong, 2020). The results show that the differentiation of introjected regulation was worthwhile, as approach and avoidance aspects were associated with distinct findings (see also Gagné et al., 2014). Introjected approach regulation, which is higher in self-determination than introjected avoidance regulation (see **Table 2**), was slightly lower during the forced distance learning period than during regular on-site learning, whereas introjected avoidance regulation was significantly higher during this time (confirmation of hypothesis 2). These findings suggest that students' motivational regulation during the pandemic was characterized by the avoidance of negative feelings such as shame or a guilty conscience. In line with other studies that used a differentiated assessment of introjected regulation, our results show that this differentiation is adequate and necessary (cf. Assor et al., 2009; Howard et al., 2017; Sheldon et al., 2017; Bieg et al., 2020). If introjected regulation is conceptualized as a single measure, it can yield indifferent, varying, and therefore difficult-to-interpret associations with outcome variables (e.g., Ng et al., 2012). Finally, external regulation was only slightly higher during than before the change to forced distance learning (hypothesis 2, see also Rovai et al., 2007). Small associations with various antecedents suggest that when it comes to university students, this regulation style is hardly dependent on factors related to the study environment (cf. Müller and Palekčić, 2005; Thomas et al., 2018).

Consistent with our expectations in hypothesis 3, BPNS was lower and BPNF was correspondingly higher during the initial forced distance learning phase. The difference in relatedness was particularly high (Wong, 2020). Relatedness

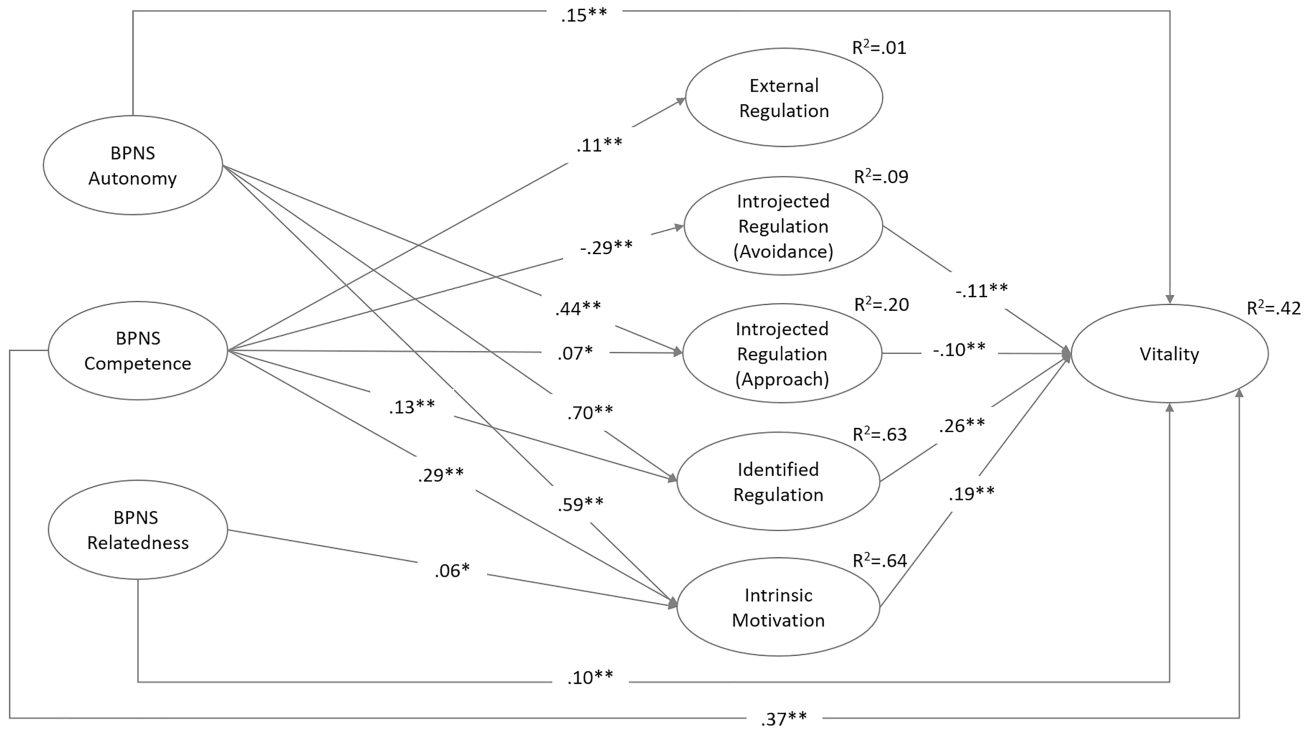

FIGURE 1 | Structural equation model with BPN-Satisfaction, motivational regulation, and vitality (during the forced distance learning period). $\chi^2(488) = 1667.328$, $p < 0.01$, $CFI = 0.965$, $RMSEA = 0.026$. Variables are modelled latently; measurement models are not shown; $^*p < 0.05$, $^{**}p < 0.01$; non-significant paths are not shown. A model in which social relatedness was differentiated according to peers and faculty did not yield any additional explanatory value for motivational regulation and vitality. In addition, the fit indices were slightly worse [$\chi^2(360) = 1440.024$, $p < 0.01$, $CFI = 0.959$, $RMSEA = 0.029$].

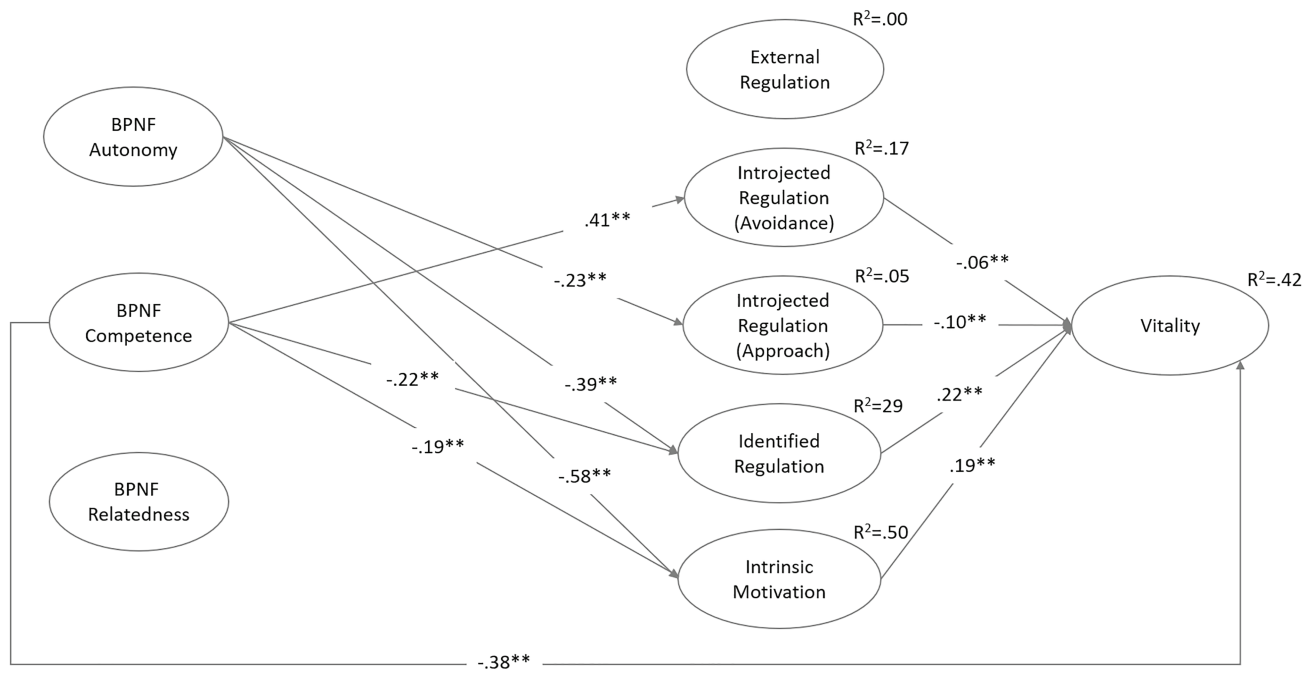

FIGURE 2 | Structural equation model with BPN-Frustration, motivational regulation and vitality (during the forced distance learning period). $\chi^2(494) = 1626.855$, $p < 0.01$, $CFI = 0.965$, $RMSEA = 0.027$. Variables are modelled latently; measurement models are not shown; $^*p < 0.05$, $^{**}p < 0.01$; non-significant paths are not shown.

with peers was significantly lower during the forced distance learning phase ($d = 2.11$). The results also show that in the field of education, a distinction between relatedness with peers and faculty is needed, as the mean scores of the two scales differed significantly (see also Müller and Thomas, 2018). The study shows only a small difference in relatedness frustration ($d = 0.21$) between the pre-pandemic and forced distance learning periods. As contact was restricted during the pandemic, relatedness was not actively frustrated by both the peers and teachers in the first semester of forced distance learning. On the other hand, virtual online communications and lockdown restrictions may have severely limited the satisfaction of social contacts and thus led to attenuated social relatedness. This may explain why the satisfaction of relatedness was considerably lower during forced distance learning than during regular face-to-face learning period, whereas the frustration of this need was only marginally higher.

The slightly higher subjective vitality of the students during the forced distance learning period was perhaps the most surprising finding. Thus, hypothesis 4 could not be confirmed. However, a detailed look at the data shows that vitality was significantly lower for the first-semester students during forced distance learning period than for students in higher semesters. This was probably due to the fact that these students were confronted with two challenges: the beginning of a new stage of life and the restrictions because of the pandemic. This is also reflected, for example, in the significantly lower scores of the first-semester students' intrinsic motivation and the satisfaction of their needs for competence and relatedness. Starting their studies under these conditions appears to be suboptimal from the students' perspective. This emphasizes the importance of providing special support for this group of students as well as the need to further investigate the motivational development of students who began their studies during the pandemic.

We also investigated whether vitality during the forced distance learning period can be explained by BPNS and BPNF as well as the extent to which the regulatory motivational types are appropriate mediators in this relationship (hypotheses 5 and 6; see also Núñez and León, 2016 or Martinek et al., 2021). In line with our expectations, the results show that the satisfaction of autonomy and competence are strong predictors of self-determined types of motivation (cf. e.g. Hsu et al., 2019; Vansteenkiste et al., 2020). Associations for introjected approach regulation were similar to those of other autonomous motivational regulations, being positively associated with the satisfaction of autonomy and competence and negatively associated with autonomy frustration. As a less self-determined form of extrinsic motivation, introjected avoidance regulation was negatively correlated with competence satisfaction and is explained by competence frustration. These findings correspond with results from studies conducted before the pandemic that showed associations between BPNS and introjected approach regulation and between BPNF and introjected avoidance regulation (Gagné et al., 2014; Cheon et al., 2019). The finding that satisfaction of relatedness only marginally predicted motivational regulation in the forced distance learning setting during COVID-19 was somewhat surprising. Even differentiating between relatedness with students and faculty did not change this small effect. An explanation for this unexpected result may be that satisfaction of the three basic needs was intercorrelated (see **Table 4**). Thus, the structural equation model could also underestimate the relevance of the support of relatedness because there are significant moderate correlations between BPNS for relatedness and autonomous types of regulation ($r = 0.23$ and 0.37, both $p < 0.01$; see also **Table 4** for the correlations between all basic needs). Our results corroborate the findings of Holzer et al. (2021), who also found little or no effects of relatedness on intrinsic motivation among university students during the forced distance learning period. They argued that social withdrawal in the sense of "cocooning" did not necessarily have a negative effect on internal psychological regulations and well-being. Online situations with no direct social interactions may well be experienced as highly self-determined (e.g., Ryan et al., 2006, 2010). If the other two basic psychological needs for autonomy and competence are reasonably satisfied, students may still be "well aligned with their inner selves" (Martinek, et al., 2021) and the need for relatedness may play a subordinate role. Another reason could be that the basic need for relatedness is not predominantly satisfied in the study context, but by family and/or friends (Legault et al., 2006; Tezci et al., 2017). Accordingly, the social connection to fellow students or the teaching staff would be less important for one's internal psychological regulation and well-being. These explanations are tentative and future research should examine the role of relatedness for motivational regulation and well-being over longer periods of distance learning.

Our study shows that BPNS and BPNF are hardly able to explain external regulations. The phenomenon that autonomous forms of motivation are better explained by perceived needs satisfaction or frustration is well known (e.g., Vandenkerckhove et al., 2019; Kaiser et al., 2020). In both structural equation models, BPNS and BPNF explain 42% of vitality, either directly or indirectly (mediated by motivational regulations). As assumed in hypothesis 6 and in line with previous findings (McDonoug and Crocker, 2007), autonomous forms of motivation (intrinsic and identified) positively predict vitality in both models. Competence satisfaction and frustration contribute substantially to student vitality. This is consistent with other findings in the context of higher education (e.g., Levesque et al., 2004.). Although introjected approach regulation is positively related to autonomy satisfaction and negatively related to frustration, thus suggesting a relatively high level of self-determination, its association with vitality is a negative one. From our perspective, this finding highlights the position of introjected approach regulation at the edge of autonomous versus controlled motivation. In contrast, introjected avoidance regulation is a controlled type of motivation as it is negatively associated with both needs satisfaction and subjective vitality

(i.e., with predictors and outcomes; see also Sheldon et al., 2017). However, study-related BPNS, BPNF, and motivational regulations are not the only predictors of general vitality. For example, individual- and/or lifestyle-related variables such as individual time management or greater amount of free time can serve as additional predictors of vitality and should be considered in future research.

Our findings emphasize the importance of high BPNS and low BPNF in distance learning settings. As is the case during forced distance learning, the support of basic psychological needs and the avoidance of needs frustration may be particularly important in other situations involving a high degree of strain.

Limitations and Future Research

One limitation of this study is that the data are not longitudinal. As the two samples (students before and after the introduction of forced distance learning) are similar in terms of age, gender, and courses of study, the results are nevertheless meaningful. However, as the sample comprises mainly students of teacher education, the social sciences, and humanities, it is unclear whether the findings can be applied to other courses of study. The sample is largely self-selective, which affects its representativeness. As most of the data were collected in the context of (partly compulsory) courses in which most students competed surveys, the self-selection effects are probably small.

The data for sample 2 were collected in spring and summer of 2020. It is quite possible that a certain habituation effect had set in among the students or that coping strategies had been developed so that autonomous motivation or the perception of needs satisfaction became high again. On the other hand, because of the long duration of the restrictions, the students and teachers' needs may have been even less satisfied and their motivation may have therefore suffered even more as the distance learning period progressed (cf. e.g. Marx et al., 2021). Further research must be conducted to clarify this aspect, ideally using a longitudinal design. Research can also consider relatively stable personality traits, motivational orientations, personality, and self-control abilities, which—in terms of resilience—may explain motivation and outcomes such as vitality (e.g., Vansteenkiste and Ryan, 2013; Vansteenkiste et al., 2020). It can also be worthwhile to survey amotivation, as this motivational type can be higher in times of crisis and offer valuable insights into university dropouts. Finally, one of the bigger challenges that is not just specific to the distance education context in times of a pandemic seems to be the targeting of social relatedness. Here, new approaches must be tested and, if necessary, the limits of virtual learning environments with respect to the quality of social interaction must be accepted.

Educational Implications

Our results show that the satisfaction of basic psychological needs was significantly lower and the frustration thereof substantially higher during the forced distance learning phase than before the pandemic. This suggests that students' basic needs should to be taken into account in the design of digital learning environments. Various measures can be taken by lecturers for this purpose. Regarding the basic need for autonomy, choices and rationales that emphasize the relevance of topics or actions in the seminar or lecture can be provided (Reeve, 2015). With regard to the need for competence, tasks with varying levels of challenge might be offered so that each student can reach a balance between his/her abilities and a given task (see Reeve, 2015; Ryan & Deci, 2017). With respect to the need for relatedness, lecturers should facilitate social interactions and collaborative work processes during their seminars. If such measures are taken and the students perceive their needs to be satisfied as a result, the highly pronounced externally determined motivation and the low level of self-determined motivation that became apparent during the pandemic can be counteracted at the same time.

Conclusion

This study found that autonomous forms of motivation and BPNS were lower and controlled forms of motivation and BPNF were higher during the forced distance learning phase brought on by the worldwide COVID-19 pandemic than in regular face-to-face learning situations. As outlined above, it is important to support the satisfaction of students' autonomy and competence both within and beyond distance learning settings, as they directly affect learners' quality of motivation and are responsible for their well-being. The satisfaction of relatedness with peers and faculty was very low during the pandemic. Although it was not strongly associated with autonomous types of motivational regulation, there may be detrimental effects if the restrictions on social contact are long lasting.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

In Austria and Germany, it is not necessary for members of these institutions to obtain approval from the Ethics Committee for such surveys of adult persons at higher education institutions. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

FM, AT, MC, AE, NG, DM, MW, A-KD, and SB conceptualized and designed the study and agreed on the final submission of the study. All authors performed data collection. FM carried out the statistical calculations. FM, AT, and SB wrote the first draft of the manuscript. FM managed and oversaw the entire

project. All authors contributed to the article and approved the submitted version.

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BRIEF RESEARCH REPORT
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First and Second Graders' Reading Motivation and Reading Comprehension Were Not Adversely Affected by Distance Learning During COVID-19

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Many assume that school shutdowns in the wake of the COVID-19 pandemic have significantly impaired students' achievement and self-determined motivation. Of greatest concern given the sudden shift to distance learning are students with inadequate access to digital media and insufficient experience organizing learning processes independently—for example, first and second graders. This study used a quasi-experiment with 206 elementary students to investigate differences in reading comprehension and self-determined reading motivation of students who attended grades one and two during or before the pandemic. Surprisingly, the results revealed no differences in reading comprehension and reading motivation between the groups, contradicting the assumption that the pandemic-driven shift to distance learning would inevitably impair young students' achievements and self-determined motivation.

Keywords: reading comprehension, self-determination theory (SDT), COVID-19, elementary school, achievement

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INTRODUCTION

In many countries, the COVID-19 pandemic necessitated school shutdowns. Numerous reports followed these shutdowns that students had been severely affected by the shift to distance learning. It is important to gain an understanding of the impact the pandemic had on student learning, because such knowledge may help to initiate appropriate action to compensate for eventual COVID-related detriments in students' achievement. In Austria, elementary students switched to home-based learning in March 2020 and again in November 2020 (Federal Ministry - Education, Science and Research, 2021). Thus, in the 2019–2020 school year, elementary students had 8 weeks of distance learning, and in 2020–2021, with some regional differences, students stayed away from school for at least 14 weeks. However, the school shutdowns were at no time absolute. Students could attend school even during the shutdowns, and many did when there was no childcare option. Specifically, students with poor German language knowledge were invited to attend school even during school shutdown to ensure adequate learning progress of these students (Federal Ministry—Education, Science and Research, 2020). Nevertheless, for most students, the school shutdowns meant new restrictions and changes such as being unable to meet with friends and classmates and limited contact with their teachers. Younger students especially badly missed their peers and teachers (Ewing and Cooper, 2021; Flynn et al., 2021).

The teaching itself also changed as teachers sought new ways to get in touch with their students. When choosing methods for distance learning, they had to consider the students' access to technical equipment and skills in handling digital media. The younger students might have had limited access to digital devices and not yet acquired the necessary skills for self-organized learning in the home environment. Empirical data suggest that only about 20% of the schoolteachers provided regular online lessons at least once a week during the school shutdown, and nearly 70% did not use digital devices to provide online lessons (König et al., 2020). Most schoolteachers relied primarily on standard worksheets and lesson plans but maintained contact with students and parents via social media. Educators and parents alike worried that students' emotional well-being and achievement might have suffered because of the pedagogic changes during the pandemic (e.g., Aurini and Davies, 2021; Minkos and Gelbar, 2020), albeit with great interindividual variance (Tomasik et al., 2021).

Learning to read is an important goal for first and second graders. In Austria, students are not taught to read in kindergarten, only in elementary school. Therefore, most students enter grade one with little or no reading skills. The Austrian curriculum for elementary schools provides that students should acquire basic reading skills during their first 2 years of school (Federal Ministry—Education, Science and Research, 2012). Thus, the pandemic-related school shutdowns had the potential to significantly impede the reading progress of the first and second graders who started school in the fall of 2019. Many expected that the pandemic would dramatically impact those children's reading achievements. And indeed, first empirical data have suggested that the school shutdowns might have had an especially great impact on students' reading skills in the early grades (Wyse et al., 2020). This study examined whether this was the case.

Reading Skills and Distance Learning During COVID-19

In 2020, researchers conducted a survey in the German-speaking countries of Austria, Germany, and Switzerland soliciting the perspectives of various stakeholders, including parents, students, school staff (e.g., teachers, administrators, authorities, and support), policymakers, and educational institutes. The School Barometer found that many students spent less time engaged in formal learning during the first school shutdown in March 2020 than during regular on-site schooling (Huber and Helm, 2020; König et al., 2020). This would suggest that students spent less time reading—and learning to read. Because the time spent reading is an important predictor of students' reading comprehension (Allington, 2002), decreased time spent reading could negatively affect the students' reading comprehension. We are accustomed to thinking of the young as digital natives—they have grown up surrounded by and using myriad devices, applications, and forms of connectivity. However, not all students have easy access to technical equipment or internet connections. Furthermore, most first graders are unfamiliar with the use of communication technologies necessary for distance learning, such as videoconferencing applications (Drexler, 2018; Huber and Helm, 2020; König et al., 2020). Many younger students have found online learning challenging and need help from their parents, older siblings, or others (Ewing and Cooper, 2021). Indeed, empirical evidence suggests that only a small percentage of elementary teachers conducted live online lessons. Instead, most elementary teachers developed and distributed lesson plans for the students (Flynn et al., 2021; Huber and Helm, 2020). While evidence suggests that learning plans can effectively substitute for in-person learning (Tomasik et al., 2021), they cannot make up for small-group collaboration. Because collaboration in pairs or small groups positively affects reading comprehension (Guthrie et al., 2007; Taylor et al., 2000), the lack of social interactions during distance learning might also have negatively impacted young students' reading skills (Allington, 2002; Guthrie et al., 2007). Given teachers' self-reported disinclination to use online communication tools (Huber and Helm, 2020), we can assume that their direct instruction and guidance were severely restricted during distance learning. Direct teacher instruction also fosters students' reading comprehension (Allington, 2002; Rupley et al., 2009), and its decline during the school shutdowns might also have affected students' reading comprehension education.

Online distance learning can also hinder teachers' task individualization, which is more difficult during videoconferences involving whole classes or large groups than in on-site learning. Very young children typically have limited concentration spans, so most education videoconferences are shorter than an in-person lesson; the limited time must be focused on covering material and assigning tasks that apply to the whole class. Although teachers could deliver one-to-one sessions, the amount of time this would require makes this an unrealistic option. Evidence shows that online learning during COVID-19 has been less individualized than regular on-site learning (Ewing and Cooper, 2021). Some teachers have always routinely individualized work packages for each student. However, during the school lockdowns, teachers lacked the easy student access that would enable them to assess the tasks' adequacy readily, so days might elapse during which the students struggled with ineffectual assignments. Elementary children, especially first graders, benefit from individualized reading instruction (Connor et al., 2013; Förster et al., 2018). Thus, the hiatus in individualization might have affected their reading comprehension development. However, the children who attended school during the lockdown because their families could not spend education-focused time with them during the days probably enjoyed a favorable learning environment with more individual training than their pre-pandemic in-person schooling. Overall, research suggests that the quality of reading instruction for first and second graders decreased during distance learning, even though many parents tried to support their children's learning (Flynn et al., 2021).

More data are needed on the achievement-related outcomes of elementary students during COVID-19.

Self-Determined Reading Motivation and Distance Learning During COVID-19

To investigate how distance learning during COVID-19 might have affected reading motivation, we used the framework of self-determination theory (SDT). SDT holds that highly self-determined types of motivation, such as intrinsic motivation and identified regulation, predict desirable outcomes such as deep-level learning and psychological well-being. Intrinsically motivated behaviors are inherently satisfying and require no external incentives or rewards; we engage in them because we enjoy them. Identified regulation concerns behaviors that might not be inherently pleasant, but we recognize as having value (Ryan and Deci, 2020).

While intrinsic motivation is considered an optimal basis for learning, identified regulation can support learning in domains that are not inherently enjoyable. According to SDT, motivational regulations are enhanced by supports for student's basic psychological needs for autonomy, competence, and relatedness (Niemiec and Ryan, 2009; Ryan and Deci, 2020). However, some evidence suggests that the sudden shift to distance learning during the COVID-19 pandemic has affected basic psychological needs satisfaction. For example, one study found that it negatively affected university students' basic psychological needs satisfaction and self-determined motivation (Author, submitted). Similarly, a retrospective study by Zaccoletti et al. (2020) found lower academic motivation during the pandemic-related school closures for children in grades 1–9. Extrapolating from these findings, we could expect a decline in self-determined reading motivations among first and second graders related to the school shutdowns. However, as with reading comprehension, we have insufficient data on how the pandemic-related restrictions affected elementary students' motivational regulations.

Changes in General Conditions Between 2015 and 2019

As this research investigates the impact of the pandemic on the reading skills of first and second graders, it is important to consider changes in general conditions that might have affected student achievement. Beside the school lockdowns changes in general conditions such as educational expenditure or school reform might have affected students' academic achievements and learning motivation. In Austria expenditure on education has progressively increased since 2000 (Statistik Austria, 2021). However, according to the results of the Progress in Reading Literacy Study the improvement in financial resources has not led to a meaningful improvement in students' reading comprehension from 2006 to 2016 (M_{2006} = 538; M_{2016} = 542; Mullis et al., 2007; Mullis et al., 2017). It is therefore unlikely, that changes in financial resources affected students' reading comprehension between 2015 and 2019. Another change concerned the implementation of a preparatory program for students with poor German language knowledge. While the resources for language support did not change between 2015 and 2019, in the school year 2018–19 attending a preparatory program became mandatory for students with poor German language knowledge (Federal Ministry—Education, Science and Research, 2019). Before then teachers could decide whether a student should attend a preparatory program or an immersion program with systematic language support, and many schools used both types of language promotion (Author, 2021). Research on the effectiveness of these types of language support is still inconclusive and presumably the quality and the quantity of support matters more than the type of program (Stanat and Cristensen, 2006). Overall, there were some changes in the general conditions in the educational system, but it seems unlikely that they led to meaningful changes in student outcomes. If anything, many fear that the implementation of a compulsory preparatory program for students with poor German language knowledge may have reduced immersion and negatively affected German language acquisition (Thomas et al., in press).

Research Questions and Hypotheses

The tenuous findings regarding the impact of the COVID-related school shutdowns on students' achievement and self-determined learning motivation inspired the following research questions and hypotheses:

1) Did reading comprehension differ between the students whose first 2 years of school fell during the COVID-19 pandemic and students who had regular on-site lessons during their first 2 years in school?
2) Did self-determined reading motivations differ between students whose first 2 years of school fell during the COVID-19 pandemic and students who had regular on-site lessons during their first 2 years in school?

H1: Students who did (did not) experience pandemic-related shutdowns during their first 2 years of school differed in reading comprehension.

H2: Students who did (did not) experience pandemic-related shutdowns during their first 2 years of school differed in self-determined reading motivations.

To answer these research questions, reading comprehension and self-determined reading motivations of students who started school in fall 2019 and thus, experienced COVID-19 related school shutdowns during their first two school years, were compared with outcomes from students who attended elementary school before the pandemic.

MATERIALS AND METHODS

Participants and Procedures

A quasi-experiment was conducted to answer the research questions. The participants were 206 students from five schools: Sample 1 comprised 102 students who started school in the fall of 2015 and experienced no school shutdowns; Sample 2 comprised 104 students who started

TABLE 1 | Study participation in the total sample and in both subsamples.

	Sample 1			Sample 2			Total sample		
—	t1	t2	t1 and t2	t1	t2	t1 and t2	t1	t2	t1 and t2
Participating	102	94	94	96	98	91	198	193	186
Not participating	0	8	8	7	5	12	7	13	0

TABLE 2 | Means and standard deviations of the dependent variables at t1.

	—	Word comprehension		Sentence comprehension	
—	N	M	SD	M	SD
Sample 1	102	19.25	7.91	0.64	1.08
Sample 2	96	18.92	8.05	0.7	1.35

school in the fall of 2019 and experienced pandemic-related shutdowns in their first and second year of school. As teachers could apply to participate in this research these are convenience samples. Both samples were drawn from the same five schools and thus, students of both samples had comparable social backgrounds. Two schools (four classes, $n_{\text{sample2}} = 67$, $n_{\text{sample2}} = 68$) were located in cities, and the other three schools were from rural locations. None of the schools had a catchment area with students from a privileged socioeconomic background. Because student characteristics and teacher characteristics are the most influential predictors of student achievement (Hattie, 2003), it is of great importance for the comparability of the samples that the catchment area and the teachers are the same in both samples. In fall 2015 participating teachers had 16–34 years of teaching experience. This is important because teachers might have gained additional experience from fall 2015 to fall 2019. However, research suggests that increases in teaching experience are associated with additional gains in student achievement only in novice teachers (Burroughs et al., 2019). Therefore, it is unlikely that the additional teaching experience gathered between 2015 and 2019 affected student outcomes. Of the 206 students participating in this study, one child from Sample 2 was excluded from all the analyses because a diagnosis of learning disabilities meant there were confounding differences in reading comprehension development. Therefore, the final sample consisted of 205 students. However, because of school and class changes, COVID-related absences from school, and lack of parental consent, only 186 students participated in both assessments (**Table 1**). It is important to note that principals of participating schools and participating teachers reported that they contacted parents of children with poor German language knowledge as well as parents with challenging domestic circumstances to let their children attend school during the school shutdown in the 2020–2021 school year.

In Sample 1, 38.2% of the students were female, and 82.4% spoke German as their first language. In Sample 2, 48.5% of the students were female, and 78.6% spoke German as their first language. The differences in sex ($\chi^2 = 2.22$, $df = 1$, $p = 0.14$) and first language ($\chi^2 = 0.45$, $df = 1$, $p = 0.50$) were not significant, indicating that the two samples were comparable. At t1, the students' mean age was 7.02 years ($SD = 0.55$). In both samples, the students' reading comprehension and self-determined reading motivation were assessed at the end of grade one (t1) and the end of grade two (t2). Data collection was approved by the relevant school authorities and was conducted during regular classes by the author. Participating students had to provide their parents' written consent.

Measures

Reading Comprehension in grade one was measured with two subtests assessing word comprehension and sentence comprehension. Word comprehension was assessed with 63 word–picture assignment tasks in which the children chose one word out of four to correspond with the picture; sentence comprehension was assessed using a maze format with five response options for 17 items. For each subtest, we gave the students 3 minutes of working time. The second graders completed a standardized reading comprehension test called *Ein Leseverständnistest für Erst- bis Sechstklässler* (Reading Comprehension Test for First to Sixth Graders) (ELFE 1-6; Lenhard and Schneider, 2006), validated for use with students in grades 1–6. The ELFE 1–6 comprised three subtests to assess word comprehension, sentence comprehension, and text comprehension. All three subtests used a multiple-choice answer format. The children had 3 minutes (each) to complete the word-comprehension and sentence-comprehension subtests and 7 minutes to complete the text-comprehension subtest.

Reading Motivations were measured at the end of grade two with an adapted version of the Scales Assessing Motivational Regulation for Learning (SMR-L, Thomas and Müller, 2016). The SMR-L measures intrinsic, identified, introjected, and external motivational regulation with three items per scale answered on a four-point Likert scale ranging from "not true" (1) to "true" (4). The SMR-L was validated with children from grades three to eight and tested in various pilot studies with children from grade two (Thomas, 2015; Thomas and Müller, 2016). The present study used only the items assessing intrinsic motivation and identified regulation.

Statistical Analyses

Multivariate analysis of variance (MANOVA) was used to assess the differences in reading achievement and reading motivation between the students in Sample 1 and Sample 2. First, we tested the assumptions for all outcome variables. For outcome variables at t1, the Box's M test ($p = 0.18$) and the Levene test ($p_{\text{word comprehension}} = 0.57$; $p_{\text{sentence comprehension}} = 0.24$) indicated that the covariances and error variances did not differ significantly

TABLE 3 | Means and standard deviations of the dependent variables at t2 by sample.

	—	Word comprehension		Sentence comprehension		Text comprehension		Intrinsic motivation		Identified regulation	
—	N	M	SD	M	SD	M	SD	M	SD	M	SD
Sample 1	94	31.48	10.86	13.11	4.87	8.48	4.38	3.33	0.84	3.41	0.61
Sample 2	98	31.98	8.85	14.20	4.90	8.91	4.10	3.44	0.65	3.57	0.51

between groups. Thus, the application of the MANOVA was adequate for all the variables at t1 (Model 1). For the reading comprehension variables at t2, the Box's M test ($p = 0.18$) was not significant, indicating adequate congruence between the covariance matrices. Levene's tests yielded non-significant results for the variables assessing reading comprehension ($p_{\text{word comprehension}} = 0.07$; $p_{\text{sentence comprehension}} = 0.86$; $p_{\text{text comprehension}} = 0.50$). However, the Levene's test for motivational regulations was significant ($p_{\text{intrinsic motivation}} = 0.02$; $p_{\text{identified regulation}} = 0.04$). Therefore, a MANOVA was run only for the outcome variables assessing reading comprehension (Model 2) and a Welch's t-test was applied for intrinsic motivation and identified regulation (Model 3). Because empirical evidence suggests that second-language learners might have lower reading comprehension scores (Stanat and Cristensen, 2006), I extended Models 1 and 2 to include first language (German vs. other) as a covariate (Model 4, Model 5). Pillai trace was used to evaluate the significance because it has adequate power for similar group sample sizes (Mayers, 2013).

TABLE 4 | Results of Model 1, Model 2, Model 3

Outcome	df	*F*	*p*	95% CI
Model 1				
Word comprehension	1	0.32	0.57	–1.94, 2.56
Sentence comprehension	1	1.42	0.24	–1.31, 0.92
Model 2				
Word comprehension	1	0.12	0.73	–3.32, 2.31
Sentence comprehension	1	2.42	0.29	–2.49, 0.29
Text comprehension	1	0.49	0.48	–1.64, 0.78
Model 3				
Intrinsic motivation	1	0.94	0.33	–0.32, 0.11
Identified motivation	1	3.54	0.06	–0.31, 0.01

RESULTS

An inspection of the dependent variable descriptive statistics shows that means were very similar for both samples (**Tables 2**, **3**). Model 1 showed that the students' word comprehension and sentence comprehension at t1 did not differ between the two samples (Pillai trace = 0.00, F (2,194) = 0.43, $p = 0.65$). These findings were confirmed for both dependent variables. Likewise, reading competencies at t2 did not differ between the samples (Pillai trace = 0.03, F (3,188) = 1.62, $p = 0.19$; Model 2). One-on-one tests confirmed these results. In Model 3, a Welch's test also yielded non-significant results for the motivational outcomes at t2. Relevant coefficients for Models 1 to 3 are displayed in **Table 4**. Thus, neither at t1 nor t2 were there any differences in reading competencies and reading motivations between the students in Sample 1 and Sample 2. Even when first language was added as a covariate (Models 4 and 5), the findings were not affected (Model 4: Pillai trace = 0.01, F (2,193) = 0.48, $p = 0.62$; Model 5: Pillai trace = 0.03, F (3,187) = 0.03, $p = 0.16$).

DISCUSSION

This study investigated differences in reading comprehension and reading motivation among students who did or did not experience pandemic-related school shutdowns during their first 2 years of school. Theoretical considerations complemented by some empirical findings suggested that students who attended grades one and two during the pandemic would have lower reading competencies and lower self-determined reading motivations compared to students who attended elementary school before COVID-19. However, dissenting hypotheses H1 and H2, this study found no evidence that the pandemic-related shutdowns had adversely affected these students' reading competencies or self-determined reading motivations. Thus, the anticipated declines in first and second graders' reading skills did not manifest in this student population. Moreover, as the non-significant Levene's tests showed, the interindividual differences in reading comprehension did not increase during the pandemic.

We must, however, consider that none of the schools was located in a large city. While their students' socioeconomic and ethnic backgrounds were diverse, none of the schools had a catchment area with a very low socioeconomic background or a high percentage of immigrants. Therefore, these results should not be applied to those populations. However, the students in this study are drawn from low to medium socioeconomic backgrounds and findings can be generalized to these populations. Another limitation of this study is, that it cannot completely be ruled out that changes in general conditions might have affected changes in student achievement. As already discussed, an increase in general expenditure on Austria's education system was not associated with students reading comprehension between 2006 and 2016 (Mullis et al., 2007; Mullis et al., 2017`) and it is thus unlikely that it affected students' achievement between 2015 and 2019. The shift of resources for children with poor knowledge of the German language from school autonomous use to mandatory implementation of preparatory programs probably has no

impact on the findings because empirical evidence suggests that there is no difference in student achievement for immersion with systematic language support programs and preparatory programs (Stanat and Cristesen., 2006). Moreover, only one of the schools was affected by this reform. Before 2018 this school had both programs and dedicated about 50% of resources for language promotion to each of them (school principal, personal communication, October 11, 2021). The shift to compulsory preparatory programs is perceived as detrimental for the development of children with poor German language knowledge by experts and by teachers (Thomas et al., in press) and is therefore unlikely to have contributed to the surprisingly good performance of sample 2.

While the results of this study certainly are good news, this study cannot explain which factors contributed to these findings. One possibility is that because the school shutdowns meant that the students were not involved in non-academic classes (e.g., gym, art), the teachers had more time to focus on teaching reading. Another possibility is that the teachers used the advantage of smaller classes (those students who attended school even during school shutdown) to work intensively on their reading comprehension. The Austrian Ministry – Education, Science, and Research (2021) recommended that students with poor knowledge in the language of instruction should attend school during the school shutdown in the 2020–2021 school year, and according to statements of participating principals and teachers, this recommendation was implemented successfully. Thus, many students with underprivileged backgrounds attended school during the second school shutdown and probably received special attention during this time. A third possibility is that the teachers' specialized lesson plans for the shutdowns effectively substituted in-person learning (Tomasik et al., 2021). Parental involvement also likely played a role. While this study did not include such data, there is evidence that parental support increased meaningfully during school shutdowns (Flynn et al., 2021), which might have compensated for any shortcomings of the enforced distance learning.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the author, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

AT desiged this research, conducted the data collection, conducted the data analysis, and wrote the manuscript.

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Hong Kong Children's School Readiness in Times of COVID-19: The Contributions of Parent Perceived Social Support, Parent Competency, and Time Spent With Children

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School readiness is an important but challenging issue of child development, especially during COVID-19 when most of the traditional offline activities that could promote school readiness (e.g., on-site visit) have been canceled. There is a gap between the knowledge needed to promote children's school readiness in times of pandemic and the limited understanding of this topic so far. This gap could be particularly concerning in the social contexts where examinations are stressed and educational competition is high (e.g., Hong Kong). In this study, we examined how well children were ready for primary school, the extent to which parent perceived social support was related to children's school readiness, and whether parent competence and their time spent with children would moderate the said link. A cross-sectional design survey with total population sampling (supplemented with convenience sampling) was conducted. Massive e-mails were sent to all kindergartens in Hong Kong inviting them to join the study by distributing the survey link to the parents of their K3 students. A total of 643 Hong Kong parents whose children were about to transition to primary school (87.1% mother) participated, answering measures specifically designed for this study online about how well they thought their children were ready for school, their competence to help with children's school transition, and how much time they spent with children. Data were analyzed with PROCESS macro (model 3) in SPSS. The results found that most parents considered that their children were not fully ready for school, especially in terms of academic skills, self-management, and mental preparation. Furthermore, moderation analyses showed that after controlling for a number of demographic variables, parent perceived social support was positively related to better school readiness in children and this link was jointly moderated by parent competence and time spent with children. Specifically, children were rated most ready when parent perceived stronger social support, felt more competent, and spent more time with children. By contrast, the link between perceived social support and children's school readiness was insignificant for parent who felt more competent but spent less time with children. Implications of how to enhance children's school readiness are discussed.

Keywords: school transition, school readiness, parents, family, COVID-19, pandemic

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INTRODUCTION

The COVID-19 pandemic has considerably disrupted children's normal school lives around the globe due to school closure and reclosure (United Nations, 2020a, 2020b). Studies have documented the negative consequences of school closure and lasting online learning in children, such as adverse physical, mental, and social well-being, poor educational outcomes, and broadened educational inequalities (Hoffman and Miller, 2020; Masonbrink and Hurley, 2020; UNICEF, 2020; Van Lancker and Parolin, 2020). Although studies that have abundantly examined the effect of COVID-19 on children's education, a topic that has received comparatively much less attention is how the pandemic affects young children's school readiness for the transition from kindergartens to elementary school.

School readiness refers to "the state of child competencies at the time of school entry that are important for later success" (Snow, 2006, p. 9). Nurturing children to be ready for school is vital, as cumulative evidence has shown that a good school readiness for formal education is linked to both short-term and long-term consequences, including better academic achievements, better mental health, less substance use, and less criminality (Trentacosta and Izard, 2007; McClelland et al., 2014; Jones et al., 2015; Lynch et al., 2017; Pan et al., 2019). Given the importance of school readiness in childhood, scholars have designed a number of intervention programs to enhance children's school readiness (Sheridan et al., 2010; McClelland et al., 2019). However, promoting school readiness in children is not an easy task (Kagan and Neuman, 1997; Boivin and Bierman, 2014). This task has become even more challenging in the past year due to the outbreak of COVID-19, which has precluded a majority of offline activities that could have been originally arranged to promote school readiness (e.g., on-site visit). To our knowledge, little research has examined children's school readiness and the role of parents in getting their children ready for school in time of COVID-19. A timely understanding of this topic is crucial to shed light on ways to promote children's school readiness in this particular period.

HONG KONG CHILDREN'S LEARNING DURING COVID-19 OUTBREAK

In Hong Kong, the formal education starts with primary school and kindergarten is not compulsory. Nevertheless, most children are enrolled in kindergarten because the educational system is competitive and parents have high expectations on their children's early preparation for formal schooling (Lau, 2014; Wong and Rao, 2015; Lau and Ng, 2019). During 2020 and 2021, the Education Bureau of Hong Kong announced school suspension from time to time and advised to switch face-to-face learning activities to distance learning in response to the irregular outbreak of COVID-19. According to a large-scale survey (Lau and Lee, 2021), although most kindergartens and primary schools in Hong Kong responded rapidly by offering online courses, a number of concerning issues also emerged. First, the sudden change to distance learning increased teachers' burden of making relevant materials. Worse still, most of the distance learning was not interactive and did not sufficiently meet parents' expectations. Second, parents were required to help their kids with distance learning, especially for lower grade children. However, many parents did not have sufficient time and they lacked relevant knowledge to assist their kids' learning. Third, a significant proportion of parents were dissatisfied with schools' arrangements no matter whether distance learning was offered to their children, and the top reason of dissatisfaction was lack of support. These findings not only suggested that children's learning and academic activities that are essential for school readiness had been largely disrupted, but also implied that parents' perceived social support, their competence to help with their kids' learning, and whether they had sufficient time with their children emerged as crucial factors associated with Hong Kong children's learning as well as school readiness in times of COVID-19. Using survey data collected from Hong Kong parents, this research aims to understand Hong Kong children's school readiness during the new normal period and the role of parent perceived social support, their competence, and time spent with children.

CHILDREN'S SCHOOL READINESS

Research on school readiness has generated a number of theoretical accounts in the last 50 years. Early maturational perspective suggests that children's development is preprogramed by their biological time clock and therefore children's readiness to learn relies on their cognitive maturity level (cf. Kagan, 1992). In light of this view, deficits in school readiness lie within the child and the development of children cannot be pushed beyond their biological development level by teaching (Winter and Kelley, 2008). More recently, the holistic account suggests that both children's skills (e.g., emotional and social skills) and the roles of ecological systems (e.g., family) should be emphasized (Diamond, 2010). Prior research found that teachers and parents typically defined school readiness in terms of children's cognitive, self-care, psychomotor, language, and social–emotional skills and abilities (Altun, 2018). Besides, Blair, and colleagues (Blair, 2002; Blair and Raver, 2015) further considered that self-regulation should also be included as an additional component of school readiness, as it addresses children's ability to attend to information, use it appropriately, and inhibit behavior that interferes with learning (Pan et al., 2019). Of note, the holistic perspective not only suggests that children's school readiness can be measured in terms of various skills and abilities at the time of school entry (Snow, 2006), but it also informs that children's school readiness can be improved both by strengthening children's skills and abilities (e.g., McClelland et al., 2019) and by building an engaging environment that supports children's learning and growth (e.g., Sheridan et al., 2010). Inspired by the holistic account, we measured children's school readiness by asking parents to rate the extent to which their children were ready for primary school in terms of various skills and abilities (e.g., self-care, social, emotional, etc.).

THE ASSOCIATION BETWEEN PARENT PERCEIVED SOCIAL SUPPORT, PARENT COMPETENCY, TIME SPENT WITH CHILDREN, AND SCHOOL READINESS

Parent perceived social support refers to parent's overall perception of the tangible (e.g., money) and intangible (e.g., knowledge) resources for stress management within their social network (French et al., 2018). The social support parents receive is typically considered a distal predictor of child outcomes through parenting processes (Bronfenbrenner, 1979). Several studies have found that parent perceived social support is related to higher quality parenting practices in mothers (Shin et al., 2006; Wallace, 2013). Prior research also found a positive association between parent perceived social support and better cognitive and behavioral outcomes in children (Carothers et al., 2006). Using longitudinal data, Bono et al. (2016) found that parent perceived social support was both directly and indirectly (through depression and parenting behavior) related to children's school readiness (measured as cognitive, language, and social–behavioral skills). In addition, parent perceived social support has been viewed as a protective factor that strengthens parents' and children's resilience in response to various stressors (Armstrong et al., 2005; Algood et al., 2013). This perspective aligns with the family stress model which suggests that protective factors may mitigate the negative impacts of parental stress and disrupted parenting on child adjustment outcomes (Masarik and Conger, 2017). However, a recent study employed latent profile analysis to examine the extent to which parent perceived social support was related to different school readiness profiles in black girls, but no significant findings were achieved (Iruka et al., 2020). Taken together, only a small number of studies have so far directly examined the association between parent perceived social support and children's school readiness, and these limited studies were conducted in a non-pandemic period. Although a research discussed that parents perceived social support would be important to children's home learning and mental health during the COVID-19 pandemic, it did not directly examine the association between parent perceived social support and children's learning (Ren et al., 2020). In sum, little is known whether the existing findings could be generalized to this new normal period. Moreover, the mixed findings in the literature suggest that there might be certain factors moderating the said link, but scant research has examined this possibility. Hence, it is necessary to further reveal under which conditions social support parents perceive would have a larger effect on children's school readiness. In this study, we examined whether parent competence and the quantity of time spent with the child might serve as potential moderators.

In this study, parent competence refers to the extent to which parent possess relevant knowledge, skills, and a positive attitude in helping with their children's school transition. This definition well aligns with the building blocks of the Triple-P program (Sanders et al., 2003). With high competence, parents are more likely to have positive parent–child interactions (Moon et al., 2020). For instance, competent parents are able to provide clear expectations for child behavior, give positive reinforcement to consolidate desirable behavior, and engage their children in an interactive and developmentally appropriate interactions, all of which offering a facilitative environment for the development of school readiness skills, such as language, cognitive, and social–emotional skills (Burchinal et al., 2002). The role of parent competence in the association between parent perceived social support and children's school readiness may be nuanced. On the one hand, according to the risk–resilience model (Masten, 2001), social support can be seen as the external resource that mitigates the effect of family risk (e.g., low parent competence) on child developmental outcomes (e.g., school readiness). In this sense, parent perceived social support could be positively related to children's better school readiness when parents have low competence in scaffolding their children. On the other hand, parents with high competence are more likely to maximize the support services provided to them and better address their needs with the support (Scheel and Rieckmann, 1998; Harty et al., 2007; Lee et al., 2020). The nuanced role of parent competence may further depend on whether parents spend enough time with their children. In a recent study conducted among highly educated Korean parents (a proxy of parent competence), it found that main caregivers' (usually mothers) positive parenting behavior was related to children's school readiness only for those who had more time with their children (Suh, 2021). Although this study did not directly measure parent competence, it implies that when parents have sufficient time with their children, they might have more opportunities to apply their parenting practices as well as the social support in fostering children's school readiness. Taken together, we consider that when parents have enough time with their children, social support may be useful in facilitating children's school readiness for parents with both high and low competence, because they have more time to utilize the social support. Furthermore, the effectiveness of social support might be even larger for parents with high competence because they are more likely to know how to maximize the social support. For parents who do not have enough time with their children, they might have less time applying the social support and thus less likely help with children's school readiness. In other words, both parent competence and time spent with the child may jointly moderate the association between parent perceived social support and children's school readiness.

THE CURRENT STUDY

As mentioned, only a limited number of studies have examined the association between parent perceived social support and children's school readiness and little is known about the boundary variables that moderate the effectiveness of social support, especially in times of COVID-19. To address these gaps, this study examined two questions: (1) the extent to which social support would be related to children's school readiness and (2) the extent to which parent competence and time spent with the child would jointly moderate the "parent perceived

social support – children's school readiness" link. Based on the literature reviewed above, we hypothesize that parent perceived social support would be related to better school readiness in children and that this link would be more pronounced for parents who have high competence and more time with children. In addition, we controlled for a range of demographic characteristics (e.g., child gender, family SES, parent marital status, parent age, etc.) to rule out their potential confounding effects on children's school readiness.

MATERIALS AND METHODS

Research Design

Data of this study were part of an online survey on parenting and school transition during COVID-19 in Hong Kong. After obtaining the approval from the Human Research Ethics Committee at the authors' affiliated university, an online survey was conducted between May and June 2021, approximate 3 months before children entered primary school. Two sampling strategies were employed in this study. First, a total population sampling strategy was utilized, in which all parents from Hong Kong kindergartens are eligible to participate. Specifically, school invitation email was sent to all kindergartens (around 1,000 kindergartens in total) in Hong Kong explaining the aim of the study. Kindergartens were invited to provide information of the contact person by completing a form in Qualtrics. A total of 58 kindergartens agreed to help disseminate the research invitation to families of their students. Parents who were interested to participate were invited to complete the consent form and survey through the link provided on the invitation letter. Second, the study recruited a convenience sample *via* a Facebook page with parents as the target audience. The parent invitation letter, consent form, and online survey were provided to all participants through a hyperlink in the Facebook post. All participating parents completed the online parent survey *via* Qualtrics. Data obtained were exported from Qualtrics to SPSS for data analysis.

Participants

A total of 825 parents consented to participate in this study. However, 106 parents who failed to complete the whole survey and 76 parents who reported their children as diagnosed with a special need were excluded from the analyses. Therefore, participants of the final sample were 643 parents recruited through 58 kindergartens (69.7%) and the Facebook (30.3%). These parents had children (M_{age} = 72.11 months, SD = 5.16 months; 46.3% boys) who were in the final year of kindergarten (**Table 1**). Most of the respondents were mothers (87.1%), married (91.8%), and reported an age range of 36–40 years old (33.3%). Most of the participating parents had a child transitioning to primary school for the first time (68.7%) and attending half-day kindergarten program (85.2%) at the time of the survey. The median range of monthly household income was HK$20,001–40,000 (US$1 = HK$7.78; the median income of all Hong Kong families: HK$26,600, Census and Statistics Department, 2021).

TABLE 1 | Demographic Variables of Study Population.

Variables	*n*	%
Gender of child		
Male	298	46.3
Female	345	53.7
Gender of parent		
Male	83	12.9
Female	560	87.1
Marital status		
Married	590	91.8
Other	53	8.2
Age of parent		
≤30	52	8.1
31–35	200	31.1
36–40	214	33.3
41–45	134	20.8
≥46	43	6.7
First primary school transition of the child		
Yes	442	68.7
No	201	31.3
Type of class mode attended		
Full day	95	14.8
Half day	548	85.2
Monthly household income (in Hong Kong dollar)		
<$10,001	42	6.5
$10,001–$20,000	183	28.5
$20,001–$40,000	206	32.0
$40,001–$60,000	99	15.4
$60,001–$80,000	52	8.1
$80,001–$100,000	28	4.4
>$100,000	33	5.1

Instrumentation

The online survey was co-created by the authors based on their research expertise and research questions, as well as a careful review of relevant literature. The items related to "perceived support" and "time spent" with children were designed to directly address the constructs using a single item. On the other hand, multiple items were developed to assess the multidimensional nature of "parent competence" and "school readiness." A pilot study was conducted with a total of 10 parents. The feedback received were related to the enhancement of the clarity and structure of the survey. Based on the feedback, relevant changes were made before the survey was finalized and used in the actual study. The online survey included questions in three main sessions: (1) parent–child relationships, (2) parents' involvement and support for school transition, and (3) children's school readiness outcomes. In this study, the following items were selected to address the research questions.

Perceived support (1 item): "Do you have enough support to help you with your child's transition to primary school?" This item was rated on a four-point scale (1 = *completely not enough*, 2 = *a little bit enough*, 3 = *moderately enough*, 4 = *completely enough*).

Parent competence (three items): "Are you confident in helping your child's primary school adaptation?" "Do you have the relevant skills to help your child adapt to primary school life?" and "Do you have the relevant knowledge to help your child adapt to primary school life?" on a four-point scale (i.e., 1 = Completely not confident/knowledgeable/enough, Completely not confident/knowledgeable/enough 2 = *a little bit confident/knowledgeable/enough*, 3 = *moderately confident/knowledgeable/enough*, and 4 = *very confident/knowledgeable/enough*). The three items assessed the parents' efficacy, knowledge, and skill related to their competence in helping children's primary school adaptation. These items were developed based on the parenting behaviors/practices scientifically demonstrated to be crucial for child developmental outcomes (Sanders et al., 2003; Dix and Meunier, 2009). The three items were averaged and the mean score was used as an indicator of parent competence. The internal consistency for the three items was 0.79.

Time spent with the child (one item): "Compared to the time before the pandemic, is there a change in the quantity of time spent with your child?." This item was rated on a five-point scale (1 = *a lot less*, 2 = *a little bit less*, 3 = *not much change*, 4 = *a little bit more*, 5 = *a lot more*).

School readiness (10 items): "How prepared is your child in the following skills for transition to primary school? (1) Self-care ability, (2) Social skills, (3) Emotion skills, (4) Motor ability, (5) Language ability, (6) Cognitive ability, (7) Mental preparation, (8) Academic knowledge, (9) Self-management, (10) Routine behavior." These school readiness items were developed based on the skills considered important for school in both international and local contexts (e.g., Lau et al., 2011; Ip et al., 2016; Lau and Power, 2018). These items were rated on a four-point scale (1 = *completely not prepared*, 2 = *not prepared*, 3 = *prepared*, and 4 = *completely prepared*). The internal consistency for the ten items was 0.89.

Data Analysis

We analyzed the data in SPSS 26.0 (IBM Corp, 2019) in several steps, with 0.05 as the level of significance. First, we examined the mean levels of each school readiness indicator to understand the extent to which Hong Kong parents perceived their child was ready for transition to primary school. Repeated measure ANOVA was carried out to examine whether parents' ratings on each school readiness indicator were significantly different among each other. Pairwise comparisons were followed and corrected level of significance (i.e., 0.05/10 = 0.005) was applied to determine the significant differences between each pair of indicators to control for Type I error. Second, we conducted descriptive statistics (e.g., means, standard deviations, and skewness) to capture the centralities of the main variables. Third, we performed bivariate correlations between parent perceived support, parent competence, time spent with the child, and children's school readiness. The correlation coefficients were also interpreted in terms of effect sizes, with 0.10, 0.30, and 0.50 representing small, medium, and large effect sizes (Cohen, 1992). Fourth, we utilized Hayes' (2017) PROCESS macro (version 3.15, Model, 3) to conduct a regression-based moderation model to examine the association between parent perceived support and children's school readiness as well as the joint moderation effects of parent competence and time spent with the child. In this model, we tested three main effects (i.e., parent perceived support, parent competence, and time spent with child), three two-way interaction effects (i.e., parent perceived support * parent competence; parent perceived support * time spent with child, and parent competence * time spent with child), and one three-way interaction effect (i.e., parent perceived support * parent competence * time spent with child). Of note, the independent variable and the two moderators were centered and bootstrapping technique ($N = 5{,}000$) was used. In the final step, we performed simple slope tests to examine the associations between parent perceived support and children's school readiness by various combinations of the two moderators (i.e., low parent competence + less time with the child, low parent competence + more time with the child, high parent competence + less time with the child, and high parent competence + more time with the child).

RESULTS

Levels of Children's School Readiness

As shown in **Figure 1**, Hong Kong parents had different ratings on various school readiness indicators. Specifically, parents considered that their children were quite ready in terms of motor ability (3.11 out of 4), language ability (2.99 out of 4), cognitive ability (2.91 out of 4), routine behavior (2.89 out of 4), and social skills (2.88 out of 4), whereas they perceived that their children were less prepared for primary school in terms of academic knowledge (2.47 out of 4), self-management (2.67 out of 4), and mental preparation (2.68 out of 4).

We conducted a repeated measures ANOVA to examine whether parents' ratings on each school readiness indicators were different. The results of multivariate tests were significant, Wilk's *Lambda* = 0.476, $F(9, 729) = 73.61$, $p < 0.001$, *partial eta squared* = 0.48, suggesting that significant differences were found for parent ratings on different school readiness indicators. The results of further pairwise comparisons are summarized in **Table 2**. In general, parent postulated that their children were most ready in terms of motor ability and that their children were least ready in terms of academic knowledge.

Means, Standard Deviation, and Bivariate Correlations Among the Main Study Variables

In general, parents perceived inadequate support for their child's transition to primary school (2.02 out of 4), and they also felt that they were not sufficiently competent of assisting their child (2.11 out of 4). In the meanwhile, they spent as much time with their child in times of COVID-19 as the days before the outbreak. In addition, they perceived that their child was moderately ready for primary school overall (2.81 out of 4). Regarding the bivariate correlations, the results showed that high levels of perceived support, parent competence, and time

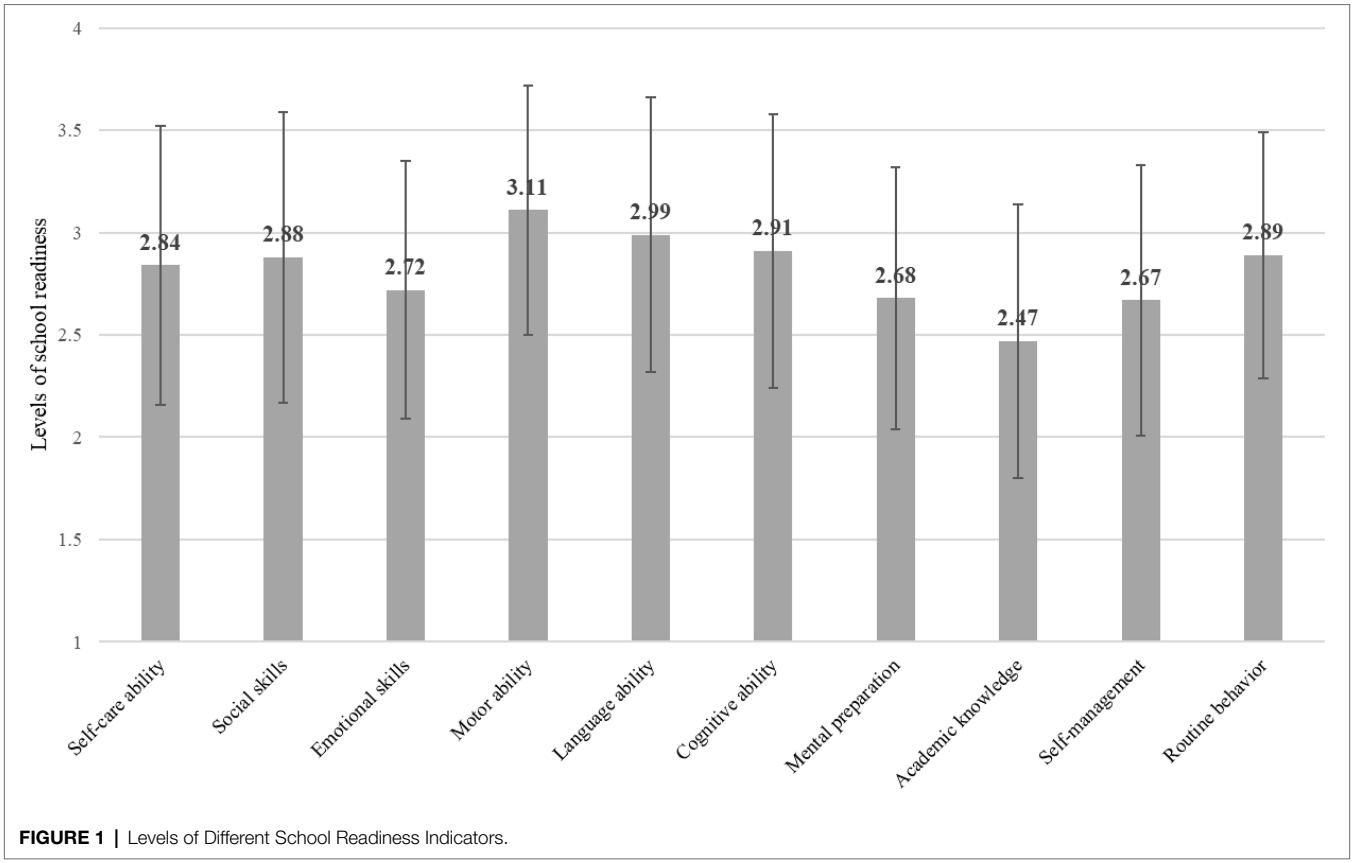

FIGURE 1 | Levels of Different School Readiness Indicators.

TABLE 2 | Pairwise Comparisons of School Readiness Indicators.

School readiness indicators	Pairwise Comparison (I-J Difference)
1. Self-care ability	1–2 (−0.02); **1–3 (0.11)**, **1–4 (−0.29)**, **1–5 (−0.13)**, 1–6 (−0.07), **1–7 (0.15)**, **1–8 (0.34)**, **1–9 (0.17)**, 1–10 (−0.05)
2. Social skills	**2–3 (0.13)**, **2–4 (−0.27)**, 2–5 (−0.10), 2–6 (−0.05), **2–7 (0.17)**, **2–8 (0.36)**, **2–9 (0.19)**, 2–10 (−0.02)
3. Emotional skills	**3–4 (−0.40)**, **3–5 (−0.23)**, **3–6 (−0.18)**, 3–7 (0.04), **3–8 (0.23)**, 3–9 (0.06), **3–10 (−0.15)**
4. Motor ability	**4–5 (0.16)**, **4–6 (0.22)**, **4–7 (0.44)**, **4–8 (0.63)**, **4–9 (0.45)**, **4–10 (0.24)**
5. Language ability	5–6 (0.05), **5–7 (0.27)**, **5–8 (0.47)**, **5–9 (0.29)**, 5–10 (0.08)
6. Cognitive ability	**6–7 (0.22)**, **6–8 (0.41)**, **6–9 (0.24)**, 6–10 (0.03)
7. Mental preparation	7**–8 (0.19)**, 7–9 (0.02), **7–10 (−0.19)**
8. Academic knowledge	**8–9 (−0.18)**, **8–10 (−0.39)**
9. Self-management	**9–10 (−0.21, p <0.001)**
10. Routine behavior	-

Pairwise comparisons that are significant at the corrected level of significance (i.e., p <0.005) are bolded. Positive and negative values of the I-J difference indicates that the value of I is significantly larger and smaller than the value of J, respectively.

spent with the child were positively related to children's school readiness at about medium, medium-to-large, and small effect sizes, respectively (**Table 3**).

The Moderation Analysis of the Association Between Parent Perceived Support and Children's School Readiness by Parent Competence and Time Spent With the Child

The overall model accounted for 27.0% variance of children's school readiness, and the results are summarized in **Table 4**. As shown, child gender and whether the target child was the first one at home for school transition were significantly related to children's school readiness, with girls and the target child being the first one for school transition reported to be more ready.

After controlling for demographic covariates, the main effect of parent perceived support ($B = 0.10$, $p = 0.001$) and parent competence ($B = 0.31$, $p < 0.001$) was significant, but the main effect of time spent with the child was not ($B = 0.03$, $p = 0.191$). The two-way interaction effect between parent perceived support and parent competence ($B = -0.05$, $p = 0.102$) and the one between parent perceived support and time spent with the child ($B = 0.03$, $p = 0.282$) was not significant, but the two-way interaction effect between parent competence and time spent with child was ($B = -0.11$, $p = 0.003$). More importantly, the three-way interaction was also found significant ($B = 0.06$, $p = 0.038$).

Breaking down the three-way interaction effect, we found that the interaction between parent perceived support and parent competence was only significant when parents spent less time (−1 SD) with their children ($B = -0.10$, $p = 0.017$)

TABLE 3 | Means, Standard Deviations (SD), and Bivariate Correlations among the Main Study Variables.

Variables	1	2	3	4
1. Parent perceived support	-			
2. Parent competence	0.63***	-		
3. Time spent with the child	0.02	0.11**	-	
4. Child school readiness	0.37***	0.46***	0.13**	-
Range	1–4	1–4	1–5	1–4
M	2.02	2.11	3.61	2.81
SD	0.75	0.62	0.90	0.47
Skewness	0.58	0.57	0.04	−0.22

$^{**}p < 0.01$; $^{***}p < 0.001$.

but not when they spent more time (+1 SD) with their children ($B = 0.08$, $p = 0.820$).

We further broke down the two-way interaction effect between parent perceived support and parent competence and examined the simple slopes for the association between parent perceived support and children's school readiness by the four combinations of the two moderators. The results are summarized in **Figure 2**. For parents who reported lower competence and spent less time with the child, higher levels of perceived support were related to stronger children's school readiness ($B = 0.13$, $p = 0.010$, 95% CI = [0.03, 0.23]). For parents who reported lower competence and spent more time with the child, higher levels of perceived support were also related to child stronger school readiness ($B = 0.12$, $p = 0.015$, 95% CI = [0.02, 0.22]). For parents who reported higher competence and spent less time with the child, higher levels of perceived support were *not* related to children's school readiness ($B = 0.02$, $p = 0.960$, 95% CI = [−0.09, 0.10]). For parents who reported higher competence and spent more time with the child, higher levels of perceived support were related to stronger children's school readiness ($B = 0.13$, $p = 0.001$, 95% CI = [0.05, 0.21]). Taken together, these findings suggested that children's school readiness was the joint function of perceived support, parent competence and how much time parents spent with the child.

DISCUSSION

The existing studies have widely examined the effect of COVID-19 on children's developmental outcomes, such as well-being, educational achievements, and educational inequalities (Hoffman and Miller, 2020; Masonbrink and Hurley, 2020; UNICEF, 2020; Van Lancker and Parolin, 2020), but little is known how well preschoolers are ready for school in time of COVID-19 and the role of parents in promoting children's school readiness. Given the importance of children's school readiness to their short-term and long-term developmental outcomes, nurturing children to be ready for formal schooling is highly necessary and significant. During COVID-19, many offline activities that could have been carried out to foster children's school readiness have to be canceled. At the time of writing, several organizations have provided various forms of support to facilitate Hong Kong children to transition to primary school (e.g., The Education University of Hong Kong, 2021). However, little research has examined the extent to which parent perceived social support is linked to children's school readiness and what factors moderate the effectiveness of the social support. In this study, we examined the association between parent perceived social support and children's school readiness and the moderation of parent competence and time spent with the child. The current findings largely confirm our hypotheses, suggesting that Hong Kong children's school readiness in times of COVID-19 is a function of parent perceived social support, parent competence, and the quantity of parent–child time.

Descriptive findings indicated that Hong Kong parents did not receive adequate social support. This result is consistent with Lau and Lee's (2021) research findings that Hong Kong parents were not satisfied with school's distance learning arrangement and would like to have more support for their children's learning during the outbreak of COVID-19 in 2020. In particular, parents rated their children to be least ready in terms of academic knowledge. This finding may reflect Hong Kong parents' high expectations on their children's preparedness for formal schooling in order to fit in the school soon and achieve good academic accomplishment (Wong and Rao, 2015; Lau and Ng, 2019).

Consistent with prior research (Bono et al., 2016) and discussion (Ren et al., 2020), our findings indicate that parent perceived social support is positively related to better school readiness in children even in times of COVID-19. The current results support the view that the parent perceived social support parents is a crucial resource for them to deal with the stressors (Armstrong et al., 2005; Algood et al., 2013), such as promoting children's learning activities even in times of COVID-19 (Oppermann et al., 2021).

Going beyond and above, the significant findings of moderation analyses suggest very nuanced association between parent perceived social support and children's school readiness. For parents who have more time with their children, the "parent perceived social support – school readiness" link is significant both for parents with higher and lower competence, but perhaps due to *different underlying mechanisms*. For parents with higher competence, the reason why perceived social support is useful in facilitating children's school readiness might be because these parents know better how to maximize the utility of the social support (Scheel and Rieckmann, 1998; Harty et al., 2007; Lee et al., 2020). For parents with lower competence, perceived social support is useful because it may compensate the family inadequacies, which is consistent with the risk-resilience model (Masten, 2001) and prior research which discloses that using intervention to enhance the family environment can benefit children's school readiness (Sheridan et al., 2010). Of note, although these explanations appear plausible, we did not carry out direct examination and it would be promising for future research to investigate these potential mechanisms more closely.

Under the condition that parents have less time with their children, parent perceived social support is only effective for parents with lower rather than higher competence. This result is somewhat consistent with Suh's (2021) study which found

TABLE 4 | Moderation Analysis of the Association between Parent Perceived Support and Child School Readiness by Parent Competence and Time Spent with the Child.

Predictors	*B*	*SE*	*p*	95% CI
Report informant (1 = mother, 2 = father)	0.07	0.05	0.187	[−0.03, 0.17]
Child gender (1 = boy, 2 = girl)	**0.08**	**0.03**	**0.009**	**[0.02, 0.15]**
Class mode (1 = full day, 2 = half day)	−0.03	0.05	0.491	[−0.12, 0.06]
First child in transition (1 = yes, 2 = no)	**−0.10**	**0.04**	**0.005**	**[−0.18, −0.03]**
Marital status (1 = married, 2 = other)	0.07	0.06	0.228	[−0.05, 0.19]
Parent age	−0.01	0.02	0.598	[−0.05, 0.03]
Family monthly income	−0.01	0.01	0.351	[−0.03, 0.01]
Parent perceived support	**0.10**	**0.03**	**0.001**	**[0.04, 0.15]**
Parent competence	**0.31**	**0.04**	**< 0.001**	**[0.24, 0.38]**
Time spent with the child	0.03	0.02	0.191	[−0.01, 0.07]
Parent perceived support * parent competence	−0.05	0.03	0.102	[−0.10, 0.01]
Parent perceived support * time spent with the child	0.03	0.03	0.282	[−0.03, 0.10]
Parent competence * time spent with child	**−0.11**	**0.04**	**0.003**	**[−0.18, −0.04]**
Parent perceived support * parent competence * time spent with the child	**0.06**	**0.03**	**0.038**	**[0.003, 0.12]**

Bold values are the significant effects.

that competent mothers' positive parenting behavior was positively related to their children's school readiness for those who could spend more time with children. One plausible explanation for these findings is that when parents do not feel competent, they might be more likely to just follow the instructions of the social support. By contrast, for competent parents, they might not be content of just utilizing the social support but might also be prone to figure out the rationale of the social support and how to use the social support better. Without enough time to go through the deliberative processes, competent parents might possibly feel social support is not empowering enough and might be reluctant to fully utilize the support, thus rendering the perceived social support much less effective. This explanation somewhat concurs with a recent study which found that parents who felt competent to help with their kids' difficulties were less likely to simply utilize social support because it might be a sign of inability to competent parents (Benatov, 2019). Given the scarce volume of this line of research, it would be promising for future studies to examine how parents with high and low competence select and utilize social support differently to promote their children's school readiness.

IMPLICATIONS

This study offers important insight into children's school readiness in times of COVID-19. Specifically, the findings that parents did not receive adequate support and that parents' perceived social support is associated with better children's school readiness call for more support for parents during the pandemic to foster their children's school readiness. Importantly, the findings that perceived social support is associated with children's school readiness among the groups of parents who can spend more time with their children, regardless of their perceived competence, and parents who had lower competence and spent less time with children suggested that universal support should be provided to parents regardless of whether they are able to spend more time with their children and their perceived competence.

Specifically, traditional school transition support practices for families, including providing information about primary schools and expectations for children's behavior, suggested activities for parent–child interaction that promotes children's school readiness skills, and advice on parenting strategies that would promote children's adjustment during school transition should continue to be implemented during the pandemic. Although school closures and the use of distance learning may be necessary during the pandemic in different countries, appropriate and adequate support must be provided to parents to prepare their children for the transition to primary schools as far as practical in a safe manner during the pandemic (e.g., conducting parent education online, implementing school transition support programs in small groups, and providing detailed guidelines for preparing children).

On the other hand, the finding that social support was not associated with children's readiness for school among parents who spent less time with their children but have high competence suggested that tailored support should be provided to this group of parents. This group of parents are likely to be busy parents with high parental efficacy. As a result, they may not have time to involve or may not see the need of learning new parenting skills from their social support, even if social support is adequately available. To address their needs, developing tailored, easy-to-follow steps and involvement strategies that are evidence-based may be useful to encourage parental involvement and the use of effective strategies to help children get ready for primary school. As such, efforts are needed to improve schools' and community's ability to support parents and students, in which professional development training should be provided to teachers and different family service providers to increase their capacity in supporting parents and respond rapidly to challenges related to school transition during the pandemic in a sensitive way.

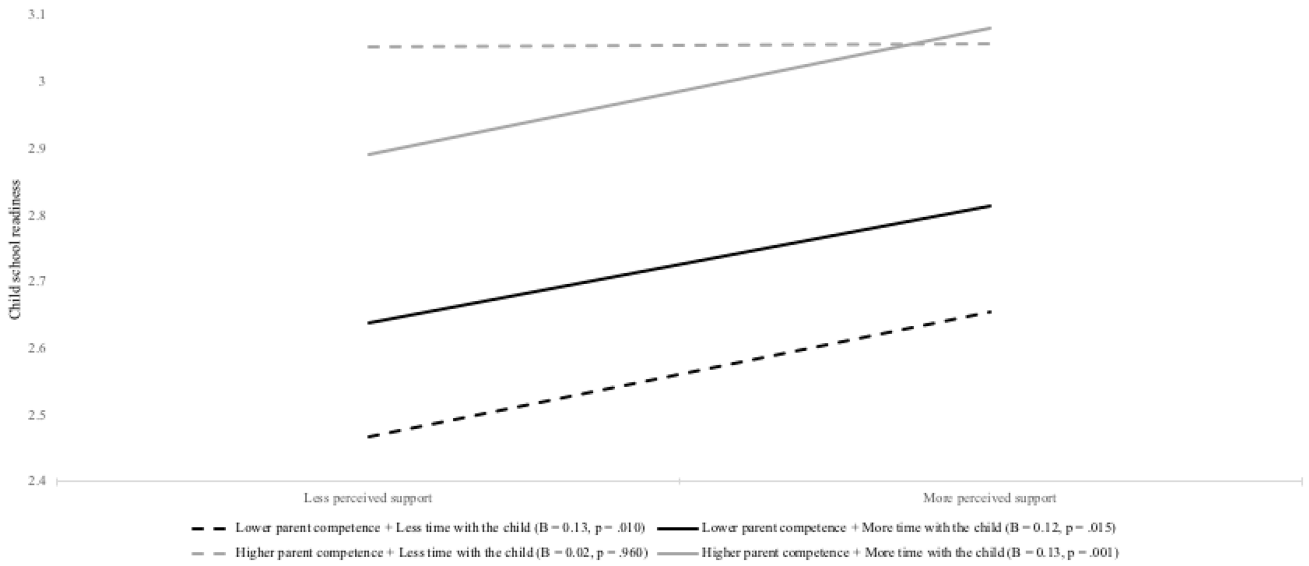

FIGURE 2 | Simple Slope Tests for the Association between Parent Perceived Support and Child School Readiness by Parent Competence and Time Spent with the Child. Lower/less and high/more level refers to 1 SD below and above the mean of the variable, respectively.

LIMITATIONS AND FUTURE DIRECTIONS

The present study has the following limitations. Most notably, this study only collected data at one time point, and thus, longitudinal and causal relations between parent perceived social support and child school readiness cannot be ascertained. Future studies should collect data across multiple time points to confirm the influence of social support on children's readiness outcomes over time. Second, the data were only collected in Hong Kong where the early education systems are quite unique with high parental expectation for academic performance and high parental involvement in children's learning. Thus, the findings and implications may be culturally specific and cannot be generalized to other cultural contexts. Future studies should examine the issue using a non-Hong Kong sample in different cultural contexts to inform the design of support for parents for promoting children's school readiness during the pandemic. Finally, the present study utilized parent reports for assessment of all main variables and the findings may be biased as a result of the informant bias. Future research should consider utilizing multi-informants (e.g., child and spouse reports, observation), more standardized measures, and objective methods (e.g., child tests) in their assessments.

CONCLUSION

To our knowledge, this study is among the first to explore the association between parent perceived social support and children's school readiness, as well as the moderating effects of parent competence and time spent with children in such relation. Findings suggested that the support parents receive for preparing their child for primary school is inadequate during the COVID-19 pandemic and that children are not completely ready for school. Findings from moderation analyses also suggested that parent perceived social support is positively related to children's school readiness, except for the group of children whose parents have less time with them and have higher competence. Together, the results call for more general support for parents so that they can better prepare their children for primary school during the pandemic. The results also suggested the importance of providing tailored support to parents who have less time with their children and have higher competence to promote their child's school readiness.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Education University of Hong Kong. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

EL and J-BL contributed to conception and design of the study. EL organized the database. J-BL performed the statistical analysis. EL and J-BL wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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BRIEF RESEARCH REPORT
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Push-Pull-Mooring Analysis of Massive Open Online Courses and College Students During the COVID-19 Pandemic

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The partial least squares structural equation modeling (PLS-SEM) provides researchers with an analysis tool for prediction theory. As the coronavirus disease 2019 (COVID-19) brings risks to teaching and learning, students have been forced to switch from classroom learning to online learning and most subjects have chosen massive open online courses (MOOCs) for online learning in China. This study examines whether MOOCs can replace traditional classroom education and explores the factors that influence the intentions of switching of the students from offline to online. We sequenced the PLS-SEM analysis of data with 397 students from a university in Zhejiang province of China, testing the model parameters, and discussing the push-pull-mooring (PPM) theory. Our data demonstrate that security risk is a push factor, switching costs are a mooring factor, and perceived usefulness and task–technology fit are pull factors that pull students from traditional, offline learning to MOOCs. In addition, the PPM model of the analysis results provides a more specific understanding of the importance–performance analysis of each factor. Our findings suggest that to constantly improve the switching intention to address unexpected challenges in the future, teachers should establish an effective emergency management measures, including curriculum design, to be consistent with their needs.

Keywords: MOOCs, COVID-19, push pull mooring, PLS-SEM, task-technology fit

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INTRODUCTION

Massive open online courses (MOOCs) represent essential technological advances that have taken place in higher education over the past 10 years. Smart devices and the Internet can be used to participate anytime and anywhere in open and massive online courses designed and provided by accredited higher education institutions and organizations, resolving the educational inequality in traditional teaching. Moreover, the massive online learning resources of such courses help to diverse groups, including elementary and middle school students, college graduates, and professionals, to discover and develop their technological potential, thereby enabling them to respond more

favorably to market needs (De Notaris et al., 2021). Educators can upload prerecorded courses on MOOC platforms (and materials, text, audio, and video) and the participatory and interactive experience can be enhanced by combining other social media applications for experience sharing (Alhazzani, 2020; Lee et al., 2021; Su and Lai, 2021). E-learning and digital cultures have increased following the rapid expansion and scale of global campus education. Such interactivity allows learners to undergo interactive learning in a digital environment, even without a specific school or educational institution. Godwin-Jones (2014) proposed that MOOCs enable individuals to learn any course from the best universities through the Internet. In addition, the individuals can learn on MOOC platforms without spatial and temporal limitations (Waldrop, 2013; Shah, 2015).

Moreover, the adoption of the online teaching model has increased due to the coronavirus disease 2019 (COVID-19) pandemic, which has led to the shutdown of educational institutions worldwide. In response to rapid spread of the COVID-19, the Ministry of Education (MOE) of China announced the launch of online teaching in colleges and universities as a measure to reduce infections by reducing contact. The ministry also implemented the policy of "stopping class without stopping learning" to shift the teaching mode from traditional classroom education to online teaching (Zhou, 2021). With the increased popularity of online teaching modes, MOOCs have emerged as one of the online teaching models in China with a high usage rate.

However, the implementation of MOOCs in online teaching in China is not optimal. Castillo et al. (2015) indicated that technology access is the central barrier to MOOC use in developing countries. Insufficient technology access to information and communication technology (ICT) equipment and the limited Internet penetration rate and connection speed have led to challenges in the sustainability of MOOC learning in the long term. MOOC learning in China, as a developing country, is affected by these factors. In addition, considering the factors of knowledge access and education and technological systems, resource distributions in different regions are unequal, which inevitably affect the usage rate of MOOCs to a certain extent. Deng et al. (2019) focused on the design of MOOCs to determine how to optimize the MOOC teaching environment to reduce the pedagogic imbalance caused by social inequality resulting from differences in age, gender, education level, and cultural background. Moreover, Cheng (2019) pointed out that MOOCs can provide a better learning effect than other online learning modes. However, whether it is better than the traditional teaching mode has not yet been discussed.

Massive open online courses can replace traditional teaching styles that have become a matter of controversy, particularly during the pandemic when individuals have had to adjust previous teaching forms owing to the COVID-19. Specifically, many studies conducted during this period examined whether a positive attitude toward continuous learning (and considering it conducive to user development in the face of the pandemic) also plays an important role in the continuous promotion of the online learning mode (Daumiller et al., 2021). The rapid shift from offline teaching to MOOCs as an emergency response to the COVID-19 prompted teachers to focus on solutions for the lack of information technology (IT) ability when responding to the teaching emergency. Finally, they found an appropriate online mode in MOOCs. As a result of the COVID-19, the MOE of China. (2020) stated that China ranks first globally in terms of the number of MOOCs and viewers. Furthermore, MOOCs have become a key factor in promoting higher education reform in China. They not only help Chinese universities to successfully cope with the teaching difficulties under the COVID-19, but also provide valuable experiences in building a high-quality national lifelong learning model. In the future, the MOE of the People's Republic of China (PRC) will continue to increase investment in the resource construction of MOOCs. As MOOCs have been frequently used during the COVID-19 pandemic, it appears to have replaced the traditional learning mode of college students. During the initial spread of the COVID-19, MOOCs were used very often and appear to have been used instead of the traditional learning mode principally in college students. Giving up an original behavioral habit for a particular reason, referred to as the push-pull-mooring (PPM) theory, was mainly adopted in previous studies to explore changes in behavior modes (Moon, 1995). The essence of the theory is to probe into the modes of user migration behavior. Before the outbreak, students who used MOOCs did not have perfect conditions in terms of technology requirements; however, the reverse applies during the epidemic period. The push of negative influences such as environmental factors, the pull force of the benefits to the positive behaviors of the individuals, and the mooring force of individuals themselves could be seen (Hou et al., 2011; Lai and Chou, 2017). In this process, the environmental safety of MOOCs by students was the push and Chen and Keng (2019) exemplified this by the intentions of the students to transition from face-to-face English classes to online learning platforms. Furthermore, they proposed that to improve the learning efficiency of the students, greater emphasis should be placed on the demands of learners in online learning. Therefore, in this study, we examined motivation of the college students, perceived usefulness, and increased MOOC utilization. Due to the impact of the COVID-19 pandemic, intentions of the students to migrate from offline to online learning have become a crucial challenge in explaining migration behavior under emergency management. According to the debate, this study provided a mode to explain the transition to MOOCs based on the PPM theory, bringing fresh insight for future MOOC advocacy.

Based on the above background, the following speculation can be obtained: Environment, technology, and learning intentions of the students might be the motivating factors for people to suddenly use MOOCs on a large scale. The effects of these factors were explored by PPM to obtain the conclusion that, if there is no pandemic in the future, information technology is not improved as in the past, and offline learning motivation of the students is greater than the online learning motivation, the users of MOOCs may be greatly reduced. Subsequently, the previous large-scale promotion and investment of our country may be wasted.

THEORETICAL FRAMEWORK

The partial least squares structural equation modeling (PLS-SEM) helps researchers to understand the factors that predict the intention of the students to use MOOCs. Moon (1995) discussed the push-pull model, added the mooring factor, and integrated them into the PPM theory. As Moon explained, the push, pull, and mooring factors directly affect the migration factors of the individuals. Moreover, among the factors affecting migration, the concept of mooring probably served as a factor in promoting or hindering migration. Subsequently, the theory was adopted by scholars in different fields from various perspectives and the concept of PPM was explained as consumption cost of the users to explain the impact of their behavior migration (Chen and Keng, 2019). However, PPM differs from the established research constructs of the past in that the theory can efficiently explain various characteristics under various environmental influences according to disparate research situations (Chen and Keng, 2019). Previous studies employed the Technology Acceptance Model (TAM) (Ashrafi et al., 2020; Eksail and Afari, 2020) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Tseng et al., 2019) to explain the online learning of the students. However, these studies tend to explain the reasons of use of the users at the technical level. Through PPM, the influencing factors for use of the users under different topics can be determined only by considering the uniqueness of backgrounds of the users at that time (Lin et al., 2021).

This study extends the concept of population migration and investigates the factors affecting switching intention of the students (i.e., feelings of the students as they shift from the traditional, offline mode of classroom learning to MOOCs platforms). By switching learning modes, variables such as perceived usefulness and switching cost proposed by Chen and Keng (2019), and the security risk put forward by Cheng et al. (2019), are incorporated into the model. In addition, task–technology fit (TTF) was extended as an independent variable in this study. Accordingly, a research model was built that can influence the switching behavior of the students as the learning modes change under the impact of the COVID-19 in Chinese colleges and universities. The three factors of "push, pull, and mooring" were defined in accordance with an online learning environment mode to better analyze the reasons for the change of learning modes of the students. **Figure 1** illustrates the relationship between the three variables according to the concept of PPM and individual willingness.

Push Factors

Push factors are factors that push individuals away from their original positions. Security risk was characterized by Cheng et al. (2019) as consumers migrating to alternatives with lower safety risks because of their impression of high security risk with the services they previously used.

Bozkurt and Sharma (2020) proposed that other unpredictable changes such as wars, regional conflicts, natural disasters, and other catastrophes (including the COVID-19 pandemic) affect the learning of the students; thus, remote learning systems are necessary to implement distance education. The benefits of MOOCs, which enable distance education, have been demonstrated for coping with natural disasters. For example, in the COVID-19 pandemic, learning environments of the students have shifted from outdoors to their homes on their personal laptops. Song and Song (2021) found that in South Korean universities with distance education implementation, a comfortable educational environment is one of the reasons for intention of the students to adopt the online learning model; to a certain extent, learning in the home environment can provide personalized space. In a previous study, Earthman (2002) investigated traditional face-to-face classrooms in schools or training institutions of the past; overly complex learning environments or crowded schools or classrooms produced various problems and, thus, affected academic performance of the students. It is evident that students would choose to stay away from traditional, offline courses to avoid security risks during the COVID-19 pandemic when they realize that such risks stem from the external environment. Thus, a push for MOOCs can be created. Therefore, this study proposed the following hypothesis:

> H1: The higher the perception of the impact of the university students on safety risks, the lower their acceptance of learning in physical courses and the higher their intention to switch to MOOCs.

Pull Factors

Pull factors attract individuals to a new role. For example, factors promoting students to switch from the traditional learning model to the model based on MOOC learning platforms are considered as pull factors. Zhenghao et al. (2015) indicated that MOOCs enable users to gain professional benefits in specific forms such as practical skills for earning a promotion, seeking a job, or starting a business. MOOCs can also help to realize self-development-oriented education or educational benefits. Kasch et al. (2021) stated that reasons for the increasing adoption of MOOCs included the immediate availability of the materials, free selection of the students, and continuous learning enabled by the course arrangement. These factors were related to the perceptions of the students of MOOC usability, which also indirectly affected the feedback between students and their peers (Julia and Marco, 2021). This demonstrates that MOOC usability could be a reason for increased user adoption.

This study focused on the TTF model proposed by Goodhue and Thompson (1995). This model explained the capabilities of IT in supporting job tasks and determined the effects of IT on individual task performance by describing cognitive psychology and cognition behavior, thereby reflecting the logical relation between IT and task requirements (Goodhue and Thompson, 1995). Relevant research has focused on how attributes of IT, such as quality, ease of use, and usefulness, affect the attitude of the users, emotions, beliefs, motivation, and self-efficacy regarding the information system (Tao and Xu, 2012). In previous studies, TTF was not mentioned in the push-pull theory (Khan et al., 2018). Wu and Chen (2017) indicated that TTF was rarely applied in online learning; in particular, no specific investigation has been conducted regarding whether MOOC usage of the students

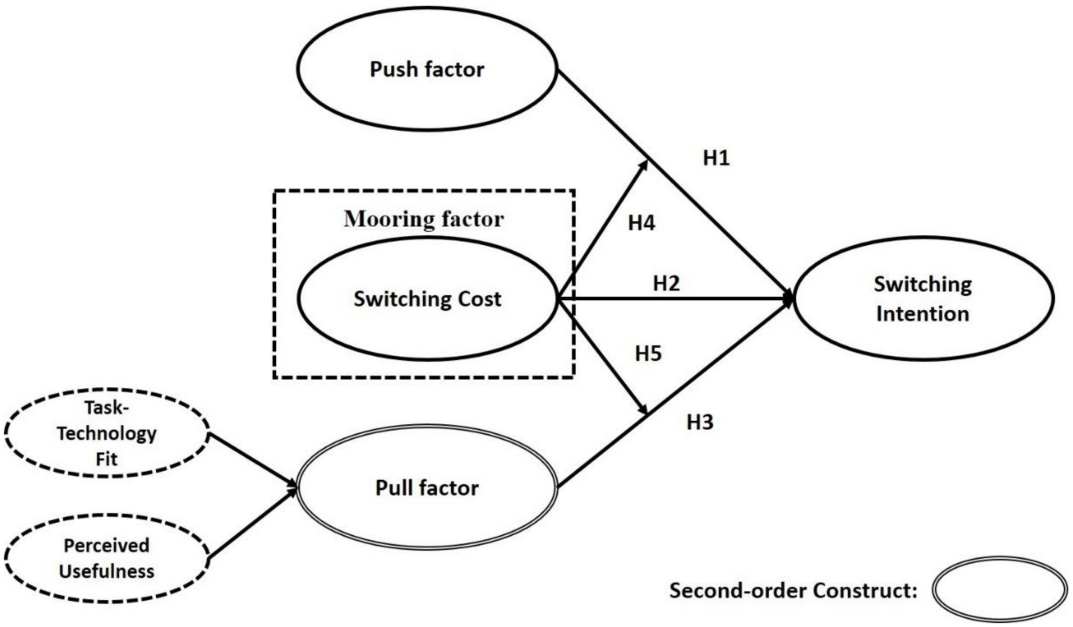

FIGURE 1 | Research model.

has positive effects on their learning outcomes. However, Khan et al. (2018) used TTF as a theoretical framework to predict the acceptance of MOOCs by students in developing countries. They concluded that TTF had positive effects on behavioral intention. Goodhue and Thompson (1995) showed that users could perceive their daily tasks such as learning as simple and effective through TTF. Therefore, if MOOC technology fits the tasks of the individuals, the acceptance and adoption rates of MOOCs would inevitably increase. This study suggests that during the COVID-19 pandemic, learners identified the usefulness and TTF of online MOOC platforms. Therefore, students are more willing to accept the change from traditional offline mode to MOOC platforms. Overall, the main factors that influence the pull force proposed in this study include usefulness and TTF, which serve as positive factors that drive the change. Based on the discussion above, this study proposes a second hypothesis:

H2. The higher the perceived switching costs of university students, the lower their intention to switch from physical courses to MOOC learning.

Mooring Factors

The mooring factors in this study referred to the negative factors that hindered individuals from switching from the traditional environment to the online environment. Switching costs are regarded as a crucial mooring factor; they are important explanatory variables for switching behavior regarding platforms (Xu et al., 2014; Chang et al., 2017; Jung et al., 2017; Cheng et al., 2019) and a decisive factor that determines and regulates customer satisfaction (Burnham et al., 2003). Switching costs are the costs incurred by a user as a direct result of switching from the *status quo* to a new situation (Cronin et al., 2000). Moreover, the concept of switching costs varies among different situations. Klemperer (1995) indicated that such costs not only affect switching behavior of the customers, but also provide a competitive advantage. Nilssen (1992) divided switching costs of the users into transaction costs and learning costs. Fornell (1992) indicated that such costs implied costs for searching materials, discounts of the customers, financial conditions, habits of the customers, emotional costs, cognitive effort, and psychosocial risks. Therefore, in the service industry, perceptions of the customers of switching costs should be considered from the perspective of highly customized and personalized services and geographical distribution (Jones et al., 2007).

Accordingly, given the current popular trend of online learning in China, relevant switching costs for MOOCs should be considered to maintain long-term satisfaction of the students and to prevent their switching to other learning modes because of past habits and emotional costs. Given personalized services and associated discounts of MOOCs for learners, MOOCs provide, in terms of cost, a practical alternative to expensive face-to-face training courses (Young et al., 2017). However, according to Porter (2015), the investment cost for MOOCs differs among universities and depends on a series of factors including the subject area, mode of learning, type of materials used, and level of experience of the development team. Moreover, additional fees are required in courses involving specific learning designs; therefore, the budget should be increased if open educational resources (OERs) do not apply. In other words, students did not need to pay additional costly fees if the instruction material in MOOCs was paid by the school or if OERs were sufficient for MOOCs to meet the needs of the students. Thus, in this study, the third hypothesis is proposed:

H3. The greater the impact of perceived usefulness and TTF perceived by university students, the higher the intention to switch to MOOC learning.

With respect to switching costs, such learning costs also involve the pattern of habitual behavior and emotional cost of an individual. Ma and Lee (2020) examined customers who used MOOCs in the least developed countries in Asia and found that traditional teaching and peer influence were the main obstacles to MOOC usage. Thus, the drive for customers, or "residents", to stay in, or leave, their original place of residence can be summarized as mooring, an influential concept on migration behavior (Moon, 1995). Thus, among factors that hinder the adoption of MOOCs, the traditional teaching mode is a reason affecting MOOC usage of the students. Krauth (2015) indicated that, ultimately, MOOCs do not facilitate one-on-one and face-to-face relational services between teachers and students. In addition, the cost of learning during the transition from traditional, offline learning to online learning environments is considered as a key factor affecting learning efficiency of the students (Chen and Keng, 2019).

Given their own habits and preferences, individuals may be unwilling to switch to new and more favorable services (Gefen et al., 2003; Grewal et al., 2003). In the past, students in China used to learn exclusively in offline classrooms. However, during the COVID-19 pandemic, learning through MOOCs at home prevents risk to the COVID-19 exposure outdoors. Thus, during the COVID-19 pandemic, the most important consideration in MOOCs is safety. Polites and Karahanna (2012) showed that switching behavior occurs when alternative services provide greater benefits than those of the original services. Therefore, during the COVID-19 pandemic, students switched to MOOCs if these provided greater benefits than traditional teaching. Lin et al. (2021) regarded this learning efficiency produced from switching learning platforms of the students during the COVID-19 pandemic as a mooring factor for their continual use of online teaching and relevant personal habituation was also considered. Thus, considering the learning cost involved in switching from traditional learning to MOOCs as the impact of mooring on driving factors, the fourth hypothesis is proposed as:

H4. The poorer the relationship between the push factors and the switching intentions of the students, the higher the switching cost.

In addition to the factors involved in learning costs, the cost of searching for materials plays a crucial role. Covach (2013) indicated that although MOOCs may not replace traditional university education, much effort has been made to provide MOOCs as free courses for knowledge dissemination to a wide range of individuals. This implies that MOOCs with free, rich, and diverse materials would ensure continuous usage of the students of MOOCs. Thus, the fifth hypothesis is proposed:

H5. The weaker the relationship between the pull factors and the switching intentions of the students, the higher the switching cost.

METHODOLOGY

Construct Operationalization

The perceived security risk arose from the three questions raised (Grewal et al., 2003). In terms of operational definition, the perceived security risk is defined as a safety problem that affects the offline courses during the COVID-19 pandemic, which prompts college students to turn to the online learning platform with a lower security risk (Lin et al., 2021). Second, the pull factor consists of two subconstructs of usefulness and TTF. Gefen et al. (2003) suggested that the variables of perceived usefulness were evaluated by using two scales. In terms of operational definition, perceived usefulness is defined as the feeling that the online platform helps them to learn and use. The four tasks technology adaptation was taken as the research object (Isaac et al., 2019). In terms of the operability of questionnaire design, whether the learning objectives and online platform meet the needs of learning of the students were mainly explored. To ensure the accuracy of the analysis of measurement items, in this study, based on the operational definition of the pull factor by existing studies, the construct is defined as the formative indicator of a two-stage model consisting of two subconstructs including TTF and usefulness (Chen and Keng, 2019; Lin et al., 2021). The switching cost and switching intention were designed with the scale introduced by Chen and Keng (2019) and Jin et al. (2021). In terms of operational definition, the switching cost refers to the loss of learning efficiency of the students when they switch from the offline to online learning platform during the COVID-19 pandemic. Meanwhile, the switching intention refers to the willingness to switch from the offline to the online learning. All the items were measured by the Likert 7 subscale. The questionnaire was designed mainly based on the original English scale. Since the main subjects of this study were Chinese university students, the questions of the questionnaire were translated into Chinese by the three university professors and then through reverse translation, the concepts of the translated questions were confirmed to be no different from those of the previous ones.

Data Collection

In this study, before the formal questionnaire survey was conducted, preliminary pretesting of the questionnaire was performed and relevant scales in the literature were compiled. This was followed by a simple trial test with participants from the university where the researcher worked with the total sample comprising 32 students from a class. Through a trial test, the design of the research questions was verified. With respect to the distribution of the questionnaires, the survey was conducted exclusively online, as the COVID-19 pandemic was still at its peak. The main reasons for selecting online questionnaires include the following: First, numerous universities have adopted online courses due to the COVID-19 pandemic; thus, a large number of university students are studying at home. Therefore, survey samples can be collected effectively by adopting online questionnaires. Second, online questionnaire collection could reduce the cost of questionnaire recovery, shorten the time for

questionnaire responses, and questionnaires could be provided to appropriate users (Bhattacherjee, 2002; Su et al., 2021).

Therefore, data from the formal questionnaire were gathered through Wenjuanxing.[1] The survey period was from late May to mid-June 2020 (when courses of the students were about to end) following a semester-long experience of using MOOCs. As the researcher adopted convenience sampling to ensure the effective distribution of the questionnaire, respondents were mainly students from a university in Zhejiang province. The questionnaire was distributed to a teacher group on WeChat and group members were asked to help forward the questionnaire to students participating in MOOCs and to encourage the students to answer voluntarily. The main objective of the research questions was to examine the switching behavior of university students from courses in traditional physical classrooms to MOOCs due to the COVID-19 pandemic. A total of 403 valid questionnaires were returned and 6 invalid questionnaires were excluded by removing invalid samples (the criteria for judging invalid questionnaires included excessively extreme responses [(such as 1 and 7) or uniform responses for all the items]; the number of valid questionnaires was 397.

The study population comprised 111 male (27.96%) university students and 286 female (72.04%) university students. Students who had never used MOOCs before the COVID-19 pandemic accounted for 57.49%, whereas those who had used MOOCs to study before the COVID-19 pandemic accounted for 42.51%. Finally, in terms of the distribution of respondents by colleges, 173 respondents were from the school of business/school of management, accounting for 43.56% of all the respondents, followed by 91 (22.37%) respondents from the school of humanities and the school of law, 81 (20.84%) respondents from the school of science and engineering, and 53 (13.23%) respondents from the school of education.

RESULTS

First, the measurement model analysis included the Cronbach's alpha validity, convergence validity, and discriminant validity, which verified the reliability and validity of the scale measurement. Second, the PLS was used to evaluate the model. The PLS-SEM was chosen for analysis, as it was more suitable than SEM based on covariance and was mainly adopted to conduct an exploratory study of theoretical development and the potential variable scores were required for subsequent analysis in this study (Balakrishnan et al., 2017). In addition, a second-order model with a reflective form was adopted. The pull factor is a second-order forming entity in this study with pull factors including a reflective construct dimension-perceived usefulness and TTF. However, because SEM based on covariance cannot test the second-order formative construct, the PLS-SEM is the best option for testing the second-order formative construct (Balakrishnan et al., 2017). As a result, the PLS approach was appropriate for model analysis in this study.

[1] www.wjx.cn

The common method variance (CMV) has two solutions. First, in the questionnaire design, the questionnaire items were paged to reduce the weariness of the respondents caused by long content when answering the questionnaire and to reduce the influence of CMV by continuous answering. Second, the Harman single factor test was used to check whether CMV was available. Principal component analysis (PCA) was adopted in the experiment and through the test results. It could be determined that there was no single factor accounting for more than 50% of the impact and the factor explained shows that the value is 0.385. Based on the test results, no CMV occurred in this study and all the results were in line with the values recommended in a previous study (Balakrishnan et al., 2017). Finally, Hair et al. (2017) suggested that the variance inflation factor (VIF) should be below 5 for this study. The research results showed that all the index values ranged from 1.573 to 3.685; therefore, it is expected to be in line with good results as shown in **Table 1**.

Measurement Model

In terms of the results from measuring convergence value, Hair et al. (1998) proposed that convergence value was mainly used to measure the composite reliability (CR) and average variance extraction (AVE) among various constructs. According to the sample results recovered by respondents, component reliability, the Cronbach's alpha, and AVE results listed in **Table 1**, the CR values between the measurement constructs in this study ranged from 0.864 to 0.957, all higher than the recommended values (CR value was higher than 0.7) proposed by Hair et al. (2017). As such, these constructs are internally consistent. Moreover, the AVE of the construct itself is also higher than previously suggested values by more than 0.5 (Yuan and Powell, 2013), indicating that this result has good convergence value. The AVE of the construct ranged from 0.785 to 0.931, which is consistent with the recommendations in previous studies. Finally, the second-order formative indicator is assessed according to whether its weight is significant ($p < 0.05$) (Wang and Haggerty, 2011; Lin et al., 2021). Based on the results in **Table 1** below, the weight values of the two dimensions, perceived usefulness and TTF, of the pull factor show a significant influence, so that these two indicators can form the concept of the pull factor.

Discriminant validity refers to the degree to which an indicator of a potential variable differs from other indicators of potential variables that form part of the model (Balakrishnan et al., 2017). Two criteria were used to evaluate the discriminant validity. Traditional, discriminative validity measures include the observation of cross-loading, as it requires that the variance of an underlying variable with its related indicators be greater than that of other potential variables in the model (Yuan and Powell, 2013). In addition, traditionally, the existence of discriminant validity is confirmed when the square root of the AVE of each construct is greater than the correlation between the related construct and all other constructs (Yuan and Powell, 2013), as shown in **Table 2**. However, recent studies have proposed replacing traditional measures with the heterotrait-monotrait correlation ratio (HTMT) as an alternative method for assessing discriminant validity (Henseler et al., 2014). Henseler et al. (2014) suggested 0.90 as a threshold value for structural models with constructs. In

TABLE 1 | Research topics on the push-pull-mooring (PPM) theory.

Construct	Items	Factor loading	α	CR	AVE	VIF
Perceived security risk (SER)	SER1SER2SER3	0.966***0.960***0.943***	0.954	0.970	0.915	1.573
Perceived usefulness (PU)	PU1PU2	0.964***0.965***	0.925	0.964	0.931	3.685
Task-technology Fit (TTF)	TTF1TTF2TTF3TTF4	0.956***0.959***0.946***0.901***	0.957	0.969	0.885	3.685
Switching Cost (SwiCo)	SwiCo1SwiCo2SwiCo3	0.904***0.880***0.873***	0.864	0.916	0.785	1.951
Switching intention (SW)	SW1SW2SW3SW4	0.917***0.946***0.898***0.932***	0.942	0.959	0.853	DV

$^{***}p < 0.05$.

TABLE 2 | Analysis of discriminant validity (Fornell–Larcker Criterion).

	TTF	SER	PU	SW	SwiCo
TTF	**0.941**				
SER	–0.470	**0.957**			
PU	0.804	–0.492	**0.965**		
SW	0.776	–0.558	0.766	**0.924**	
SwiCo	–0.559	0.625	–0.562	–0.676	**0.886**

SER, perceived security risk; SwiCo, switching cost; TTF, task–technology Fit; SW, switching intention; PU, perceived usefulness. The bold values indicate average variance extraction (AVE) square root.

TABLE 3 | Analysis of heterotrait-monotrait.

	TTF	SER	PU	SW	SwiCo
TTF					
SER	0.492				
PU	0.856	0.524			
SW	0.817	0.589	0.820		
SwiCo	0.614	0.684	0.626	0.745	

SER, perceived security risk; SwiCo, switching cost; TTF, task–technology Fit; SW, switching intention; PU, perceived usefulness.

this study, the values ranged from 0.492 to 0.856, indicating that discriminant validity was established for all the constructs of the model, as shown in **Table 3**.

Structural Model

The H1–H5 parts were mainly analyzed in this study based on the results. According to the statistical analysis results, the overall explanatory value of this study was as high as 0.63, which implies a high overall explanatory value in this study. Based on H1 results, perceived security risk ($\beta = -0.094$, $p < 0.05$, $t = 2.040$) had a negative influence on switching intention. Second, based on the H3 result, the pull factor ($\beta = 0.594$, $p < 0.05$, $t = 10.047$) had a significant positive impact on switching intention. Third, the switching cost of H2 ($\beta = -0.273$, $p < 0.05$, $t = 4.520$) also had a significantly negative relationship with the switching intention. Finally, in terms of the influence of the adjustment effect, the results showed that neither H4 ($\beta = 0.053$, $p > 0.05$, $t = 1.334$) nor H5 ($\beta = -0.054$, $p > 0.05$, $t = 1.812$) habits have an adjustment effect on the push/pull factors. The results of this research model are summarized in **Figure 2**.

CONCLUSION AND DISCUSSION

Conclusion

The empirical results revealed that security risk was the push factor that transferred students from traditional, physical classrooms to MOOC platforms. During the COVID-19 pandemic, students felt insecure and preferred not to attend classes in physical classrooms, which corresponded with the switching intention demonstrated by previous PPM research (Cheng et al., 2019; Chen and Keng, 2019). In terms of the push factor, security was a key indicator that drove students out of physical classrooms (Cheng et al., 2019). Because of the COVID-19 pandemic, students were concerned about the lack of security measures in traditional, physical classrooms and preferred to take courses on MOOC platforms. Considering the difficulties of conducting traditional, in-person courses during the COVID-19 pandemic, teachers should establish effective emergency management measures (e.g., an emergency security mechanism and a valid approach to efficiently implement online courses and establish new ones) to address unexpected challenges in the future. However, when the threat of COVID-19 is over and students feel safer outside, their learning habits may switch from online to offline because of reduced security risks.

In terms of pull factors, the use of MOOC platforms during the pandemic was affected by two essential subdimensions, namely perceived usefulness and TTF. Studies have indicated that TTF is the key dimension influencing intention of the students to engage in online learning (Khan et al., 2018; Isaac et al., 2019). Students might complete their education and learning tasks through MOOCs during the COVID-19 pandemic. Thus, the key to increasing goodness of fit of the students is the selection of teachers and schools on MOOC platforms and compatible teaching materials. Students are more likely to accomplish their learning tasks and engage in MOOC learning when the design of an online course is consistent with their needs. In addition, perceived usefulness affects the intention of the students to transfer to MOOC learning. This factor is consistent with the findings on online learning switching intentions in the literature (Balakrishnan et al., 2017; Cheng et al., 2019). After the COVID-19 pandemic, universities are advised to provide more diverse MOOC content and develop personalized materials to attract students to MOOC platforms such as enabling students to make their selections on teachers and instructional resources for MOOC platforms. For instance, when establishing a new course, a teacher can record relevant MOOCs and incorporate regional instances into lessons. The course can

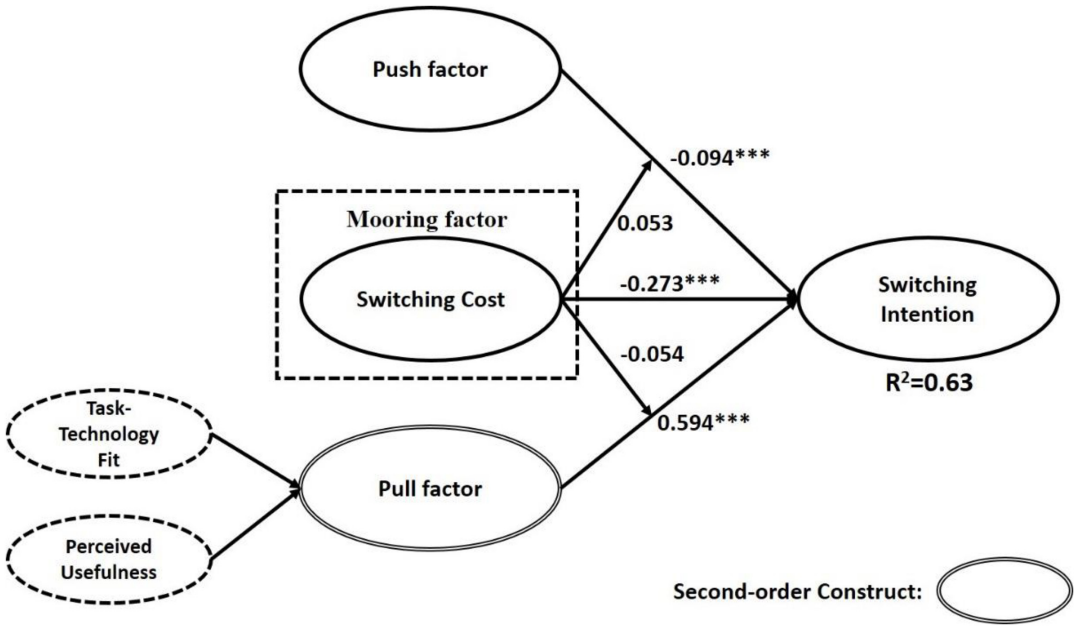

FIGURE 2 | Research analysis result. ***$p < 0.05$.

thus become more aligned with local needs and enable students to provide feedback on the course content during online face-to-face interactions. Furthermore, MOOCs offer many out-of-school curriculum resources, and to a certain degree, supplement the study of resource distributions across the different regions that may be unequal.

According to the research results, the cost of switching traditional, physical courses into MOOCs is low, which is consistent with the conclusions of previous studies (Cheng et al., 2019). During the COVID-19 pandemic, students in Chinese universities showed an increased willingness to switch to MOOCs due to their lower cost. Therefore, this study suggests that to constantly improve switching intention, the focus should be on curriculum design, especially the establishment of specific courses in different regions. Local higher schools need to design courses in combination with local industries, where the course content may be added through the integration of industry and learning. The cost and time of MOOC course construction would be effectively reduced as well.

Implications for Research

This study makes several significant contributions. First, efforts have been made to build barrier-free and high-quality education for MOOCs, which differs from other e-learning courses in universities (Yuan and Powell, 2013). When universities in China adopted emergency response strategies under the COVID-19 pandemic, students switched from the traditional learning mode to online MOOCs. This study determined the factors influencing migration behavior, which differed from the factors influencing daily use of the students of MOOCs in the past. In particular, this study examined the effects of security risks, TTF, and switching costs on PPM switching behavior. The study results enrich the expectations and experiences of MOOCs across different environmental backgrounds (Bagozzi, 2007). The interaction of these three factors also indirectly influenced motivation of the users to use MOOCs and their preferences. Our findings suggest that to constantly improve the switching intention to address unexpected challenges in the future, teachers should establish effective emergency management measures, including curriculum design, to be consistent with needs of the students to adapt to different environments.

Limitations and Future Research

This study had some limitations. First, it used a questionnaire survey and the number of recovered samples was limited. In particular, the samples were not obtained from universities in all the provinces in China and a single, specific university was surveyed. Therefore, subsequent studies should examine whether, given various regional characteristics, the COVID-19 pandemic affected the promotion of MOOC-based learning and the switching intentions of the students. Second, this was a cross-sectional study. However, under the continuous evolution of the COVID-19 pandemic, longitudinal studies should be conducted to explore and observe the factors of interest at different time points, which can further clarify whether the learning mode that emerged during the COVID-19 pandemic accelerated the subsequent promotion of MOOC platforms in universities. This study also did not discuss whether the basic information data had an adjustment effect on the structure of this study, which remains for further analysis in the future. Finally, this study is still in its initial stage and is unable to obtain a date for a normal environment. However, when possible, we suggest extracting data in a non-epidemic environment in the future.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

All authors contributed equally to the conception of the idea, implementing, analyzing the experimental results, writing the manuscript, read, and approved the final manuscript.

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Two Waves of COVID-19 in University Setting: Mental Health and Underlying Risk Factors

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The aim of the paper was to assess the differences in the mental distress of university students in the first and second waves of COVID-19, to compare these levels with that of the general population as well as to identify the risk factors associated with the changes in mental health. A total of 2,025 university students in core psychology courses in all years of study at the Faculty of Education at Palacký University Olomouc were approached *via* e-mail. Of this number of students, 800 students took part in the study, divided into two groups from the spring (N = 438) and autumn (N = 362) pandemic waves. The data were collected online *via* Google Forms using a battery of questionnaires and analyzed using the Wilcoxon–Mann–Whitney test, One-Sample Wilcoxon Signed Rank Test and binary logistic regression. The results showed a high prevalence of depressive symptoms (38.4 and 51.4%), significant anxiety (43.8 and 37%), and high stress (19.9 and 22.9%) among students in both waves of the pandemic. Depression and stress also increased significantly during the second wave compared with the first one (r = 0.18 [0.12, 0.25] and r = 0.08 [0.01, 0.14]). Finally, university students showed significantly higher levels of mental distress than the general population in all of the variables and in both waves (r = 0.42–0.86). A variety of factors influenced different aspects of mental distress in the spring and autumn pandemic waves. Emotion regulation emerged as the most significant and pervasive factor, both influencing all of the three indicators of mental distress and being a significant predictor in both waves.

Keywords: COVID-19, pandemic, mental health, university setting, risk factors

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INTRODUCTION

The COVID-19 pandemic, which began in early 2020, has caused huge changes in the way societies function and affected the way almost everyone lives. In the year and a half of its duration, it has spread all over the world and different countries have experienced one or more waves of increase in the number of COVID-19 cases, which has forced them to apply various restrictions and epidemic measures to combat the spread of the pandemic. These measures have affected many areas of life such as travel, social interaction, shopping, education, health care delivery and more. In addition, the repeated local suppression of the epidemic, coupled with the relaxation of measures and the simultaneous emergence of new mutations of the coronavirus (Torjesen, 2021) which again increase the spread of the virus and lead to the reintroduction of measures creates a state of uncertainty with

little possibility of predicting future developments. This multitude of changes, the fear of COVID-19 and the uncertainty about the future course of the pandemic also has a significant negative impact on the mental health of the population, as confirmed by a number of studies (e.g., Lakhan et al., 2020; Novotný et al., 2020; Rossi et al., 2020; Bueno-Notivol et al., 2021; Wang et al., 2021). The impact on mental health is also related to the degree of personal experience of the pandemic and how much change the pandemic and the restrictions have caused in personal life.

One group that has been greatly affected by the COVID-19 pandemic and its consequences is university students. They have had to cope not only with the general societal changes but also with the disruption of their studies. The closure of schools, the banning of face-to-face tuition and the rapid transition to distance learning, including the resulting uncertainty about the future course of their own studies (and, figuratively, concerns about future professional life, especially for graduating classes) as well as the mandated work obligation not only pose practical challenges for everyday life but also create increased pressure on mental health. Increased mental distress is then risky not only because of the disruption to mental health itself but also because of its potential long-term negative impact on further studies and on everyday functioning in general.

A number of studies have already addressed the impact of the COVID-19 pandemic on students' lives and mental health, confirming the negative impact of the pandemic (e.g., Son et al., 2020; Browning et al., 2021; Fruehwirth et al., 2021; Křeménková and Novotný, 2021; Villani et al., 2021; Xu et al., 2021). But although a number of findings and observations are available, much is still unknown. At the same time, not all of the findings are easily transferable globally, as students in each country live in different conditions, are affected by different pandemic progression, disruptions in society as well as limitations to their studies. Meanwhile, understanding properly how the COVID-19 pandemic affects students' mental health in a given context and which factors represent risk or protective influences is crucial for providing effective help to students in their studies and on a personal basis. The aim of this paper was therefore to examine the changes in the mental health of university students during the first and second waves of the COVID-19 pandemic in the Czechia, to compare the level of mental distress in students with the general population and to identify the factors that influence the presence of depression, anxiety and stress in each wave of the pandemic.

MATERIALS AND METHODS

Study Design and Sample

The study was conducted in two phases. The first data collection took place from April 8 to April 30, 2020. This period corresponded to the first wave of the COVID-19 pandemic in the Czechia and the summer[1] semester of the 2019/2020 academic year. The second data collection took place from October 30 to November 30, 2020. This period coincided with the middle of the winter semester of the 2020/2021 academic year and the peak of the second wave of the COVID-19 pandemic in the Czechia. In addition to a number of strict epidemic measures imposed in the Czechia limiting normal daily functioning and social interaction, both data collection periods saw the long-term closure of all schools, including universities (in the second wave, universities were closed for almost the entire academic year 2020/2021) and students participated in compulsory online classes.

A total of 1,053 (wave 1) and 972 (wave 2) students of the Faculty of Education at Palacký University Olomouc in Olomouc were invited to participate in the study *via* their university emails (students were required to check their email regularly). This included all students in core psychology courses in all years of study and covered core students of the Faculty of Education as well as a minority of students from other faculties of Palacký University Olomouc attending courses at the Faculty of Education as part of their study. 438 (41.6%) students in wave 1 and 362 (37.2%) students in wave 2 participated in the study. To compare mental distress between university students and the general population, partial data (youngest group aged 24–40, $N = 265$) from the population-based epidemiological cohort from a Kardiovize study (Novotný et al., 2020; unpublished data for wave 2) were used.

Measure and Instruments

The data were collected using a Google Forms online survey consisting of several parts. The first part contained demographic questions, items regarding the COVID-19 pandemic and government measures concerning life and study (measured on a 5-point Likert-type scale ranging the magnitude of the negative effect), related concerns about family members' health and about finishing the semester (measured on a 5-point Likert-type scale ranging from "totally disagree" to "total agree") as well as the perceptions concerning the university's approach and communication (measured on a 5-point Likert-type scale ranging from "totally disagree" to "totally agree" and by means of dichotomic yes/no items).

The second part consisted of a battery of 6 psychological tools. The Patient Health Questionnaire (PHQ-4; Löwe et al., 2010) is short four-item tool with a 4-point Likert-type scale measuring the severity of depressive symptoms and anxiety (scoring 0–6 for depressive symptoms and anxiety). A score of three or more represented the presence of depressive and anxiety symptoms. The Perceived Stress Scale (PSS-4; Cohen and Williamson, 1988) is a short four-item uni-dimensional tool with a 5-point Likert-type scale measuring stress levels (scoring 0–16). A score of 11 or more represented the presence of high stress. The Prosocial Behavioral Intentions Scale (PBIS; Baumsteiger and Siegel, 2019) is a four-item uni-dimensional tool with a 7-point Likert-type scale measuring the levels of intention to behave prosocially (scoring 4–28). The Internal External Locus of Control-4 scale (IE-4; Kovaleva, 2012) is a four-item uni-dimensional tool with a 5-point Likert-type scale measuring the presence of internal and external locus of control (scoring 1–5). The Connor-Davidson Brief Resilience Scale (CD-RISC; Vaishnavi et al., 2007) is a

[1]The academic year in the Czechia is divided into two semesters: winter (September to January) and summer (February to June).

two-item uni-dimensional tool with a 5-point Likert-type scale measuring resilience (scoring 0–8). The Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004) is a 18-item tool with a 5-point Likert-type scale measuring the presence of the seven types of emotion-related difficulties (subscale scoring 3–15, total scale scoring 18–90). The following three indicators of COVID-19 impact on psychological well-being were used: severity of depressive symptoms and anxiety level (as subscales of PHQ-4) and stress level (as measured by PSS-4). The presence of significant depressive symptoms and anxiety was defined as a PHQ score equal to or greater than 3, while the presence of high levels of stress was defined as a PSS score greater than 10.

Data Analysis

Descriptive statistics were performed on demographic variables. Mann-Whitney test with r effect size calculation was performed to compare mental distress across waves. One-Sample Wilcoxon Signed Rank Test with continuity correction was used to compare mental distress in university students and the general population. A series of binary logistic analyses were used to assess the effect of other factors on mental distress. The binary variables of presence of depressive and anxiety symptoms and high stress were used as outcomes. Any two-sided $P < 0.05$ was considered statistically significant. Statistical analyses and data visualizations were performed R v.4.1.1[2] using BSDA (v.1.2.1), coin (v.1.4-2), dplyr (v.1.0.7), ggplot2 (v.3.3.5), ggpubr (v.0.4.0), rcompanion (v.2.4.1), rstatix (v.0.7.0), and stats (v.4.1.1) packages.

Ethical Consideration

All participants were informed of the confidentiality of their answers and signed an online informed consent form prior to the completion of the questionnaire. No specific information enabling the identification of specific students (such as IP address, student name or ID number, specific field of study, etc.) was obtained as part of the online data collection. The research protocol of the study was approved by the Ethics Committee of the Faculty of Education.

RESULTS

Sample Demographics

The study population consisted of 800 university students, 438 in wave 1 (mean age = 23.8 ± 7, 408 [93.2%] women) and 362 in wave 2 (mean age = 26.6 ± 9.8, 342 [94.5%] women). This sex ratio acceptably corresponded to the distribution of students at the Faculty of Education. The majority of participants were in the non-graduate year (393 [89.7] and 302 [83.4%]) and were full-time students (354 [80.8] and 318 [60.2%]).

Mental Distress During Two Waves of the COVID-19 Pandemic

The prevalence of significant symptoms of each indicator of mental distress in the whole sample in the spring and autumn waves was 38.4 and 51.4% for depression, 43.8 and 37% for anxiety and slightly lower 19.9 and 22.9% for stress. This prevalence was similar for both sexes in the first wave but in the second wave the prevalence of mental distress was noticeably lower in men than in women (2.5–4 times). In the context of the type of study, the prevalence of mental distress was approximately half as high in distance learners compared with full-time students concerning most variables, especially in the second wave (**Table 1**).

Comparisons across the pandemic waves revealed that depressive symptoms ($P < 0.001$, $r = 0.18$ [95% CI = 0.12, 0.25]) and stress levels ($P = 0.032$, $r = 0.08$ [95% CI = 0.01, 0.14]) increased in the second wave compared with the first wave, while anxiety levels remained the same ($P = 0.072$). To control for the possible effect of a general atypical ratio of the two sexes and a slightly different ratio of full-time and distance students between the two waves, a detailed analysis was performed for each subset. In the context of sex, differences between the two waves of the pandemic were only found in women, both in depressive symptoms ($P < 0.001$, $r = 0.20$ [95% CI = 0.12, 0.27]) and stress levels ($P = 0.011$, $r = 0.09$ [95% CI = 0.03, 0.17]) but not in anxiety ($P = 0.062$). Men did not show any differences in mental distress between the waves ($P = 0.71$, 0.81, and 0.64 for depressive symptoms, anxiety and stress, respectively). In terms of the type of study, the results showed differences between the two waves only in full-time students for depressive symptoms ($P < 0.001$, $r = 0.29$ [95% CI = 0.22, 0.36]) and stress levels ($P < 0.001$, $r = 0.20$ [95% CI = 0.12, 0.27]), while anxiety did not differ between the

TABLE 1 | Mean scores ± SD and prevalence of mental distress in waves 1 and 2.

	Depression	Anxiety	Stress
Wave 1 (Spring)			
Mean score ± SD	2.18 ± 1.74	2.29 ± 1.6	7.37 ± 3.39
Males	1.9 ± 2.47	1.4 ± 1.59	6.0 ± 5.04
Females	2.2 ± 1.68	2.36 ± 1.58	7.47 ± 3.22
Full-time study	2.16 ± 1.72	2.39 ± 1.62	7.46 ± 3.34
Distant learning	2.25 ± 1.86	1.89 ± 1.46	7.0 ± 3.59
Prevalence of significant mental distress (N [%])	168 [38.4%]	192 [43.8%]	87 [19.9%]
Males	12 [40%]	12 [40%]	6 [20%]
Females	156 [38.2%]	180 [44.1%]	81 [19.9%]
Full-time study	132 [37.3%]	168 [47.5%]	78 [22%]
Distant learning	36 [42.9%]	24 [28.6%]	9 [10.7%]
Wave 2 (Autumn)			
Mean score ± SD	2.77 ± 1.63	2.13 ± 1.67	7.9 ± 3.29
Males	1.7 ± 1.45	1.2 ± 0.89	4.5 ± 2.44
Females	2.83 ± 1.62	2.19 ± 1.68	8.09 ± 3.23
Full-time study	3.17 ± 1.59	2.34 ± 1.77	8.9 ± 3.12
Distant learning	2.17 ± 1.51	1.82 ± 1.45	6.38 ± 2.96
Prevalence of significant mental distress (N [%])	186 [51.4%]	134 [37%]	83 [22.9%]
Males	4 [20%]	2 [10%]	1 [5%]
Females	182 [53.2%]	132 [38.6%]	82 [22.6%]
Full-time study	134 [61.5%]	96 [44%]	78 [35.8%]
Distant learning	52 [36.1%]	38 [26.4%]	5 [3.5%]

[2]https://www.r-project.org/

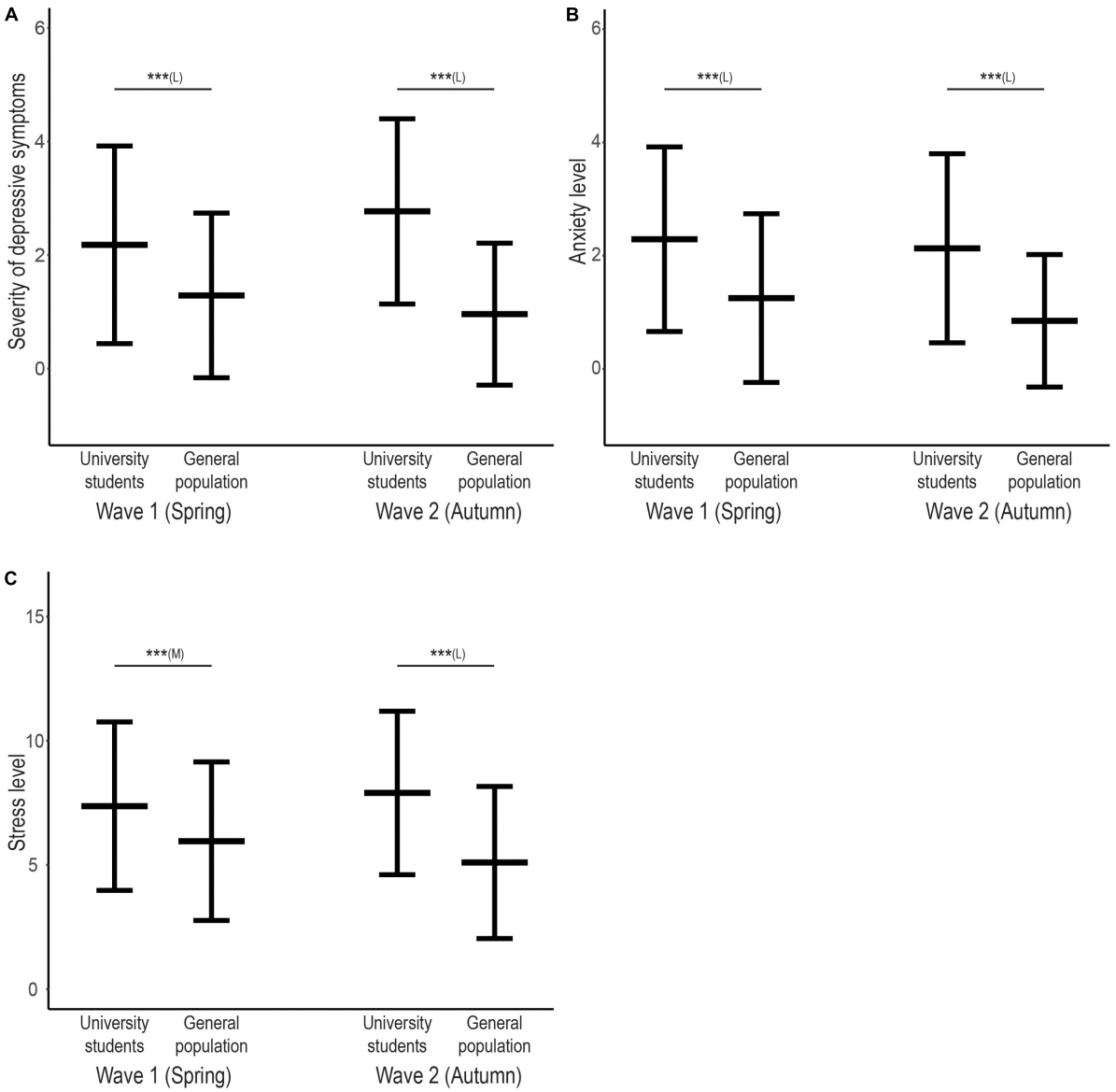

FIGURE 1 | Levels of mental distress in university students and the general population in each wave of the COVID-19 pandemic. Line graphs showing mean score and ± 1 Standard Deviation range for **(A)** severity of depressive symptoms, **(B)** anxiety levels, and **(C)** stress levels. Upper horizontal bars indicate significant differences in mental distress outcomes between university students and the general population in a particular pandemic wave (***$P < 0.01$), letters indicate effect size (M = moderate, L = large).

two waves ($P = 0.51$). Similarly, there were no differences in depressive symptoms ($P = 0.98$), anxiety ($P = 0.52$) or stress levels ($P = 0.36$) in distance learning students.

Differences in Mental Distress Between University Students and the General Population

A comparison of the individual indicators of mental distress between university students and the general population showed that in both pandemic waves university students experienced significantly stronger depressive symptoms ($r = 0.54$ and 0.86, respectively), levels of anxiety ($r = 0.64$ and 0.86, respectively) and perceived stress ($r = 0.42$ and 0.79, respectively) (**Figure 1** and **Table 2**). This substantially higher mental distress was also observed in all subgroups by sex and type of study, except for depressive symptoms (first spring wave) and stress levels (both pandemic waves) in men (**Supplementary Table 1**).

Risk Factors Associated With Increased Depressive Symptoms

A series of logistic regressions revealed a number of effects of individual predictors on mental distress in waves 1 and

TABLE 2 | Comparison of mental distress in university students and the general population.

	Present study mean ± SD	Kardiovize study (24–40 years) mean ± SD	*P*	95% CI	r[a]
Wave 1 (spring)					
Depression	2.18 ± 1.74	1.29 ± 1.45	<0.001	[2.500, 3.000]	0.54 (L)
Anxiety	2.29 ± 1.6	1.25 ± 1.49	<0.001	[2.499, 2.500]	0.64 (L)
Stress	7.37 ± 3.39	5.96 ± 3.19	<0.001	[7.000, 7.500]	0.42 (M)
Wave 2 (autumn)					
Depression	2.77 ± 1.63	0.96 ± 1.25	<0.001	[2.999, 3.000]	0.86 (L)
Anxiety	2.13 ± 1.67	0.85 ± 1.17	<0.001	[2.499, 2.500]	0.86 (L)
Stress	7.9 ± 3.29	5.10 ± 3.06	<0.001	[7.500, 8.499]	0.79 (L)

[a]*Letters indicate the size of the effect (M–moderate, L–large).*

2 (**Supplementary Table 2**). Within depression, two common factors emerged for both waves: a lack of emotional clarity increased the risk of depressive symptoms (OR [95% CI]: 1.14 [1.03, 1.27] and 1.28 [1.12, 1.47]), whereas a lack of emotional awareness decreased the risk of depressive symptoms (OR [95% CI]: 0.87 [0.77, 0.98] and 0.76 [0.65, 0.88]). In terms of effect size, spring compliance with government regulations (OR [95% CI] = 1.82 [1.19, 2.78]), negative perceptions of government actions (OR [95% CI] = 1.70 [1.31, 2.19]) and concerns about completing the year (OR [95% CI] = 1.70 [1.33, 2.16]) appeared to increase the risk of depressive symptoms (**Figure 2A**). Within the autumn wave, involvement in volunteer activities emerged as the strongest predictor (OR [95% CI] = 8.68 [3.16, 23.88]). Women (OR [95% CI] = 3.89 [0.88, 17.22]) and students who felt supported by the university (OR [95% CI] = 2.03 [0.76, 5.44]) also had higher rates of depressive symptoms (**Figure 2B**).

Risk Factors Associated With Increased Anxiety

In the context of anxiety, several factors appeared to increase the risk of anxiety symptoms across both waves. Concerns about completing the year (OR [95% CI]: 1.65 [1.31, 2.08] and 1.78 [1.28, 2.48]) and a lack of emotional clarity (OR [95% CI]: 1.15 [1.03, 1.28] and 1.46 [1.25, 1.70]) were associated with increased the risk of anxiety symptoms across both waves. Impulse control difficulties were associated with increased the risk of anxiety in the spring wave (OR [95% CI] = 1.18 [1.06, 1.33]) but decreased it in the autumn wave (OR [95% CI] = 0.86 [0.76, 0.96]). Finally, higher resilience (OR [95% CI]: 0.68 [0.57, 0.83] and 0.71 [0.56, 0.90], respectively) seemed to be acting as a protective factor against increased anxiety. Students who perceived information from the university as more clear in the spring (OR [95% CI] = 1.96 [1.47, 2.60]) and who were concerned about completing the year (OR [95% CI] = 1.65 [1.31, 2.08]) showed the highest levels of anxiety (**Figure 2C**). In the spring, women were significantly less anxious than men (OR [95% CI] = 0.22 [0.07, 0.66]), whereas in the autumn they were already more anxious than men (OR [95% CI] = 2.38 [0.36, 15.64]). In conjunction with this, students who felt supported by the university (OR [95% CI] = 4.55 [1.47, 14.05]), were anxious about completing the year (OR [95% CI] = 1.78 [1.28, 2.48]) and were involved in volunteer activities (OR [95% CI] = 1.63 [0.66, 4.01]) were more anxious in the autumn (**Figure 2D**).

Risk Factors Associated With Increased Stress

Regarding stress, across both waves, engagement in volunteer activities (OR [95% CI] = 2.60 [1.12, 6.0] and 7.48 [2.41, 23.16]) and a lack of emotional clarity (OR [95% CI] = 1.23 [1.07, 1.42] and 1.50 [1.22, 1. 83]) represent risk factors, whereas greater resilience (OR [95% CI]: 0.79 [0.62, 1.0] and 0.62 [0.44, 0.86]) and greater internal locus of control (OR [95% CI]: 0.33 [0.17, 0.61] and 0.12 [0.03, 0.50]) represent protective factors (**Figures 2E,F**). In addition to engaging in volunteer activities, the most significant predictors of high stress in the spring were negative perceptions of government action (OR [95% CI] = 1.87 [1.35, 2.60]) and difficulty engaging in goal-oriented behavior (OR [95% CI] = 1.50 [1.28, 1.77]). In contrast, women were at a significantly lower risk of stress in the spring than men (OR [95% CI] = 0.12 [0.02, 0.55]) (**Figure 2E**). In addition to volunteering, positive perceived awareness from the university appeared to be a risk factor in the autumn wave (OR [95% CI] = 2.07 [1.28, 3.36]). Conversely, perceived support from the university was a significant protective factor against high stress (OR [95% CI] = 0.12 [0.03, 0.50]) (**Figure 2F**).

DISCUSSION

The objectives of this study were threefold: first, to analyse the level of mental distress in university students during the first and second waves of COVID-19 in the Czechia; second, to compare the mental distress of students with that of the general population; and third, to identify the factors that might associate with the presence of depression, anxiety and stress in either wave of the pandemic. The findings showed that the COVID-19 pandemic posed a significant risk to the mental health of university students as the prevalence of each type of mental distress in both waves of the pandemic was around one-fifth of the sample for high levels of stress and between one-third and one-half of the sample for depression and anxiety, reaching as many as 51% (over half of the sample) of students showing significant depressive symptoms during the second wave of the pandemic. This prevalence of mental distress is similar to that of healthcare professionals who have been hit hardest by the effects of the COVID-19 pandemic (Kang et al., 2020; Şahin et al., 2020; Guo et al., 2021; Hao et al., 2021). In agreement with previous reports (Di Tella et al., 2020; Holingue et al., 2020; Luo et al., 2020) we also found a more pronounced impact of COVID-19 associated measures on the mental health of women. The lower prevalence of mental distress among students in the distance form of study can be explained by the different characteristics of these two forms of study. For distance learners who are usually already employed while studying the changes and threats to their studies associated with the COVID-19 pandemic do not pose a substantial disruption to their study routine nor do they pose a

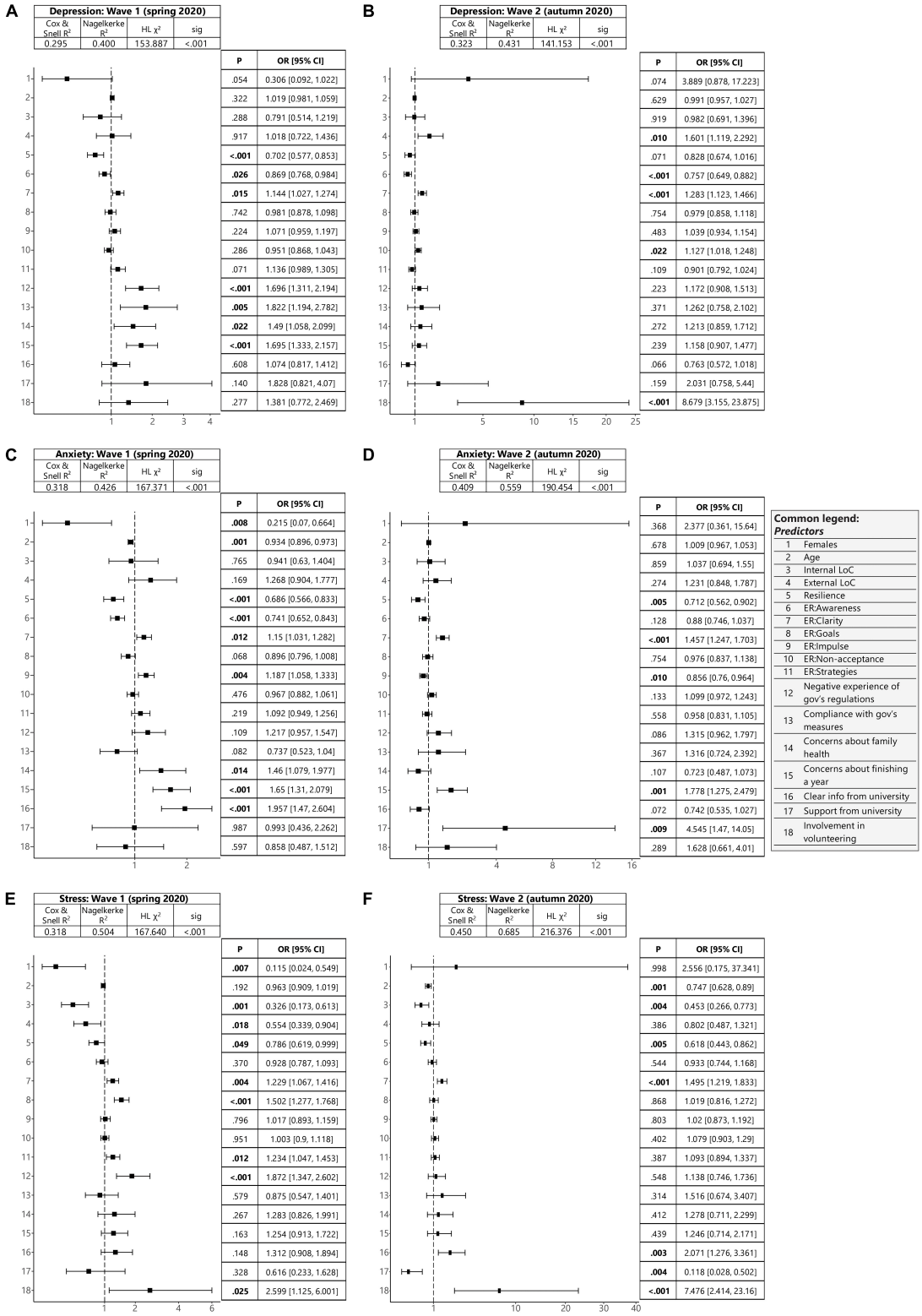

FIGURE 2 | Binomial logistic regression model assessing the association between increased mental distress and risk factors. Forest plots of odds ratios with indicated model characteristics and *P*-values plus odds ratios with confidence intervals for each predictor showing **(A)** predictors of depressive symptoms in wave 1, **(B)** predictors of depressive symptoms in wave 2, **(C)** predictors of anxiety symptoms in wave 1, **(D)** predictors of anxiety symptoms in wave 2, **(E)** predictors of high stress in wave 1, and **(F)** predictors of high stress in wave 2. The *x*–axes (odds ratio) are plotted using square-root transformation.

direct threat to their current employment or future professional career as they do for full-time students (Cao et al., 2020).

Further, we observed that depression and stress increased among students during the second wave of COVID-19 compared with the first spring wave, with anxiety remaining the same, which is similar to previous findings in another directly affected group—healthcare professionals (Magnavita et al., 2021b). This increase is likely influenced by repeated experiences of disruption in the course of study. During the first wave, students were coping with an unfamiliar situation and an unexpected transition to the online environment, which increased their level of mental distress. However, this was a new situation and the tranquil course of the pandemic (with low infection rates) created the impression that this study disruption was only a one-off. The arrival of the second wave in the autumn and the re-closure of universities was thus perceived more negatively by students in the context of previous experiences. Students thus already knew what problems they could expect and it was the second disruption to their studies in a short space of time. The course of the pandemic in the Czechia was also more dramatic with a rapid increase in the number of new cases, supporting the assumption that the second university closure would be longer and the disruption to studies would be more intense. These findings are consistent with previous studies (Nurunnabi et al., 2021; Rudenstine et al., 2021; Viner et al., 2021; Zheng et al., 2021), however, the knowledge of the impact of repeated disruption is still limited.

A both intriguing and concerning finding was the significantly higher level of mental distress of university students compared with the general population that was present across both waves of COVID-19. The reasons for this difference may be several. The younger population in general appears to be more negatively affected by the COVID-19 pandemic (Novotný et al., 2020; Gasteiger et al., 2021; Simon et al., 2021; Varma et al., 2021). This may be due to the association of greater worries about studies, job security and financial stability with younger age, and richer life experiences and reduced life expectations in the older (Roberts et al., 2018; Cao et al., 2020; Russo and Terraneo, 2020). University students (and students in general) also have a much more pronounced direct experience of the effects of the COVID-19 pandemic (similar to health professionals) as the pandemic has affected the key element of their lives compared with the general population. Consistent with this is the fact that unlike the general population where the rates of mental distress decreased slightly in the second wave of the pandemic, they remained the same or even increased in university students, underscoring the devastating impact of the direct and widespread negative experiences of the pandemic on mental health (Magnavita et al., 2021a). However, it is worth noting that although the general population sample was selected to be as similar as possible to the sample of university students, the two samples were understandably somewhat different in their characteristics and composition, including for example the different sex proportions. On the other hand, a detailed analysis of the individual subsets (by sex and type of study) indicated that the observed differences between university students and the general population were indeed universal. Either way, these findings highlight the need to pay attention to the mental health of university students as a group at a greater risk.

An analysis of the factors associated with the presence of mental distress symptoms yielded a number of individual findings that confirmed our previously reported findings (Křeménková and Novotný, 2021). In general, the pre-dominant association with the emotional regulation emerged. In most cases, emotional regulation problems were associated with a greater risk of experiencing mental distress but in some cases they were a protective factor or their effect changed over time. The impairment of mental health associated with emotion regulation problems is a previously described phenomenon in which the lack of ability to control and direct one's own emotional experience also makes it difficult to control negative emotions triggered by external stimuli (Markarian et al., 2013; Everaert and Joormann, 2019). However, given that repeated negative thinking is associated with depression and anxiety, reduced awareness of one's own emotions, including negative ones, may protect individuals from their impact on mental health and thus act as a protective factor (Everaert and Joormann, 2019). In the context of regulating the negative emotional impact of a pandemic, the "buffering effect" of resilience as the ability to adapt to adversity, trauma or other major stressors has also been confirmed (Barzilay et al., 2020; Ran et al., 2020). Similarly (in relation to the emotional experiencing of the pandemic), more intense direct experience of other aspects of the COVID-19 pandemic, or the "overloading" of one's own time resources in the form of volunteering also appears to contribute to a higher presence of mental distress (Mo et al., 2021; Zhang et al., 2021). Finally, support and clear communication and organization by universities, or lack of it, has been shown to contribute to better/worse mental health of students, as already shown in previous studies (Magnavita et al., 2021c).

LIMITATIONS

The study has a few limitations. First, the size of the sample is acceptable, however, the proportion of both sexes is rather imbalanced, although on the whole it corresponds to the proportion of students at the Faculty of Education. The results for men in particular should therefore be viewed with some caution. Second, the research sample is limited to university students of a single faculty with a minority of students from other faculties. A more diverse sample including students from different faculties and disciplines could provide a more generalized data on this issue. Third, the participation rate was below 50% (corresponding, however, to the response rate in the matched epidemiological cohort of Kardiovize). Thus, the willingness to participate in the study and consequently the results may be influenced by the different characteristics and current status of students who chose to participate in the study compared with those who declined to participate (including for example greater willingness to share based on the need to vent their worries, spending more time on the computer, etc.). Finally, the cross-sectional nature of the study did not allow to

directly assess the changes in the levels of psychological distress or changes in time. A longitudinal design with multiple time-points for the same respondents might also provide a better insight into the mechanisms of COVID-19 effects on university students.

CONCLUSION

In conclusion, the results of this study confirmed our previous findings of high levels of depression, anxiety and stress among university students during the COVID-19 pandemic. A comparison with the general population further highlighted the importance of this topic and the need to pay increased attention not only to the practical aspects of the implementation of the study during the ongoing pandemic, but also to students' mental health. The provision of psychological help and support needs to be actively promoted both at the individual level (by supporting students in seeking help when needed) and at the institutional level (through university counseling centers).

In this context, the means and procedures for psychological counseling need to be designed or improved. The key tasks in this process should include the increased use of online counseling tools (Renton et al., 2014), the creation/provision of methods to quickly verify the presence of mental distress or increased risk factors as well as support for the development of university counseling centers from the management in terms of creating the time, material and financial conditions for their functioning (Rudnik et al., 2021). This development should be underpinned by the fact that long-term unaddressed depression and stress have a negative impact on mental and psychological health (Houtjes et al., 2014; Belleau et al., 2019), while at the same time most students do not wish to formally address their mental health problems for fear of stigmatization (Ahmedani, 2011; Parcesepe and Cabassa, 2013).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LK and JN conceived the idea of this study and wrote the draft of the manuscript. JN made the statistical analysis. All authors contributed to the critical revision of the manuscript for important intellectual content and reviewed and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.780071/full#supplementary-material

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Changes in Teacher Burnout and Self-Efficacy During the COVID-19 Pandemic: Interrelations and e-Learning Variables Related to Change

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Although the reciprocal relationship of teacher burnout and teacher self-efficacy (TSE) is well documented, the literature still lacks studies investigating their (latent) changes and interrelations of change over time. By applying a latent change regression model in our study, we aimed to contribute to this research gap by examining changes in burnout and their relations to changes in TSE during the COVID-19 pandemic—a very challenging time for teachers. As the implementation of digital learning material played a major role during the pandemic, we were also interested if attitudes and self-efficacy toward e-Learning were related to changes in burnout and TSE. Our sample consisted of 92 German in-service teachers who completed a questionnaire twice during the 2019–2020 school year. Our main findings are that the burnout components depersonalization and lack of accomplishment significantly increased from the pre- to post-COVID-19 outbreak, whereas emotional exhaustion did not. Changes in burnout were negatively correlated to changes in TSE, but we found little evidence for relations of change in burnout and TSE with variables concerning e-Learning. Our findings indicate that the challenge was not the work overload but rather a lack of resources. Implications for research and practice are discussed.

Keywords: burnout, self-efficacy, latent changes, COVID-19, in-service teachers

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INTRODUCTION

There is little doubt that teaching is a burdened profession (for a review, see García-Carmona et al., 2019), and in 2020, teachers faced a completely new challenge: the COVID-19 pandemic, which was described as "the greatest challenge that we have faced since World War II" (Saha and Dutta, 2020). Health-care workers were at high risk for mental illness during the outbreak (Huang and Zhao, 2020), but the psychological impact of COVID-19 on the general population and teachers, in particular, is very serious as well (e.g., Allen et al., 2020; Sokal et al., 2020a; Sokal et al., 2020b; Hansen et al., 2020; Kim et al., 2021). In light of social distancing, 194 countries closed schools to contain the pandemic (UNESCO, 2020). Teachers taught remotely, providing online materials for their students and supporting them during a frightening time from a distance. When schools gradually reopened, teachers were exposed to a particularly high risk of infection.

The pandemic's consequences on teachers' mental health remain largely unknown, very few studies have aimed at discovering effects on teachers during the pandemic (see e.g., Allen et al., 2020; Hansen et al., 2020; Sokal et al., 2020a; Sokal et al., 2020b; Kim et al., 2021). The present study therefore focuses on teacher burnout as an indicator of teachers' mental health and teacher self-efficacy (TSE) as a highly relevant resource against burnout (Bakker et al., 2005) and will investigate their changes during the pandemic. It further analyzes the role of self-efficacy and attitudes toward e-Learning in these changes, as these are potentially relevant variables in times of distance learning.

THEORETICAL FRAMEWORK

Teacher Burnout

High demands on teachers (e.g., the challenging situation of school closures due to the COVID-19 pandemic) can affect teachers' mental health and lead to job burnout (Demerouti et al., 2001). "Job burnout is a psychological syndrome that involves a prolonged response to stressors in the workplace" (Maslach, 2003, p. 189). Research on burnout syndrome began in the mid-1970s in the United States and was primarily based on experiences of people working in human services (e.g., Freudenberger, 1975). Considering the interpersonal aspect of burnout syndrome, the work context, it is distinct from clinical syndromes like depression, which in contrast, affect every domain of a persons' life (Maslach et al., 2001). With the teaching profession's highly demanding nature, researchers have conducted much research on teacher burnout in recent years (for a review, see García-Carmona et al., 2019).

Maslach's (1982) multidimensional theory of burnout is still predominant, with burnout's core dimensions described as "overwhelming exhaustion, feelings of cynicism and detachment from the job, and a sense of ineffectiveness and lack of accomplishment" (Maslach, 2003, p.190). Emotional exhaustion is the key dimension of burnout and is characterized by an actual stress reaction, which is highly related to work overload. Perhaps, as a way to cope with this workload, people distance themselves mentally—either from their work in general (cynicism) or from work relationships (depersonalization). The former is a broad conceptualization of mental distancing and applicable for many professions, however it lacks the interpersonal aspect (e.g., Simbula and Guglielmi, 2010). Thus, depersonalization and cynicism are correlated but clearly distinct constructs (e.g., (Larsen et al., 2017)). In the teaching profession, mental distancing from students (depersonalization) seems to play a more important role which is why it is assessed in the MBI-ES solely rather than cynicism (Maslach et al., 1996). The third component, lack of accomplishment (e.g., a self-evaluated incompetence), can develop either as a consequence of or simultaneously with the other dimensions (Maslach, 2003). In contrast to emotional exhaustion and depersonalization, lack of accomplishment is most clearly influenced by a lack of relevant resources (Maslach, 2003; see also Alarcon (2011) for meta-analysis).

Demerouti et al. (2001) provided the job demands-resources model of burnout (JD-R model) to explain the development of burnout. The researchers divided working conditions into two main categories: job resources and job demands.

"Job demands refer to those physical, social, or organizational aspects of the job that require sustained physical or mental effort and are therefore associated with certain physiological and psychological costs (e.g., exhaustion), [whereas] job resources refer to those physical, psychological, social, or organizational aspects of the job that may do any of the following: 1) be functional in achieving work goals, 2) reduce job demands at the associated physiological and psychological costs, 3) stimulate personal growth and development"(Demerouti et al., 2001, p. 501).

According to the JD-R model of burnout, burnout development follows two processes: First, high job demands result in increased emotional exhaustion. Second, emotional exhaustion is intensified by a lack of resources, resulting in burnout. Specifically, the workload level was often found to strongly predict the emotional exhaustion component (Pogere et al., 2019).

Research has shown that job burnout is negatively related to work engagement (Hakanen et al., 2006), job satisfaction (Skaalvik and Skaalvik, 2017), and subjective health (Hakanen et al., 2006). However, burnout is positively related to the intention to quit the teaching profession (Skaalvik and Skaalvik, 2011), which underlines burnout's role as a mental-health indicator and the need to examine job burnout predictors for the well-being of educational systems.

In light of the JD-R model of burnout, TSE can be seen as an internal resource and is, therefore, investigated in this study.

Teacher Self-Efficacy

Self-efficacy's construct has been strongly influenced by Albert Bandura's social cognitive theory, in which he described people as self-organizing, proactive, self-regulating, and self-reflecting agents of their life circumstances (Bandura, 2001). He defined self-efficacy as "people's judgement of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Accordingly, TSE is 'the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context' (Tschannen-Moran et al., 1998, p. 233).

According to Bandura (1977), one can derive self-efficacy beliefs through four principal sources: performance accomplishments, vicarious experiences, verbal persuasion, and the interpretation of physiological states. Performance accomplishments play a major role in developing one's efficacy beliefs because they are based on personal mastery experiences and formed by successes, which in turn have been attributed as internal and stable. In the context of TSE, mastery experiences occur with successful teaching. Thus, they contribute to the expectation that future teaching performance will be successful. This formation process is especially relevant in an early career; however, research has shown that the relationship between years of experience and TSE is nonlinear (Klassen and

Chiu, 2010), rising between zero and 25 years of experience and declining during the last career stage.

Teachers with a high sense of self-efficacy show greater enthusiasm toward teaching (Allinder, 1994), superior teaching performance (Klassen and Tze, 2014), and higher instructional quality (Holzberger et al., 2013). Recently, Zee and Koomen (2016) have reviewed relevant relationships with TSE.

In the past, TSE has been known as an elusive construct (Tschannen-Moran and Woolfolk Hoy, 2001). However, since about 20 years, there is an agreement on TSE's structure: It can be divided into three subcomponents: instructional strategies, classroom management, and student engagement (Tschannen-Moran and Woolfolk Hoy, 2001). These components have underlined Bandura's formulated need to assess certain levels of specificity in self-efficacy (Bandura, 2006).

Bandura further described the domain specificity of TSE: Teachers can perceive themselves as very effective in teaching, in general, but feel less effective when applying specific teaching practices (Bandura, 2006). Accordingly, adapted measurements for TSE in specific contexts have been developed: for example, inclusive teaching (e.g., Sharma et al., 2012) or implementing self-regulated learning strategies (De Smul et al., 2018). Accordingly, TSE in the context of digital media is also a specific form of TSE. For the purpose of this study, we implanted this specific form of TSE as well as the general form of TSE.

Interplay of TSE and Burnout

In light of the JD-R model of burnout, much research has determined potential burnout predictors, especially in terms of resources of burnout (e.g., Pas et al., 2012). Particularly, researchers have focused on the reciprocal relationship between burnout and TSE (e.g., Brouwers and Tomic, 2000). Some authors have claimed that TSE is a protective resource when it comes to burnout (Dicke et al., 2015) and research has shown that TSE has a buffering effect when it comes to stress (Bakker et al., 2005). Despite the significant research interest in the relationship between TSE and burnout, studies referring to longitudinal changes in both constructs and their interrelations are relatively old (Brouwers and Tomic, 2000), refer to students (Fives et al., 2007), or novice teachers (Dicke et al., 2015). Moreover, no study has investigated the changes and interrelations of burnout and TSE during the COVID-19 pandemic.

Consequences of the COVID-19 Pandemic

Previous research has shown that teachers often feel overstrained from responding to their students' emotional needs, especially after catastrophic events (Pfefferbaum et al., 2004). Moreover, it has been documented that after a crisis, symptoms of posttraumatic stress disorder are significantly higher in teacher samples than in the general population (Zhang et al., 2016). Thus, teachers seem vulnerable to psychological stress, which can lead to emotional exhaustion. Müller and Goldenberg (2020) explained that "in addition to processing their own stress, they are also supporting students through theirs" (p. 29) especially considering that some students have little support at home. This emotional workload could very likely lead to depersonalization, which in turn would have deleterious effects on the students in such a situation. In light of this background, more research is needed to investigate the effectson emotional exhaustion, depersonalization as well as lack of accomplishment in teachers, in the context of crises. Considering the present COVID-19 pandemic, another aspect that is possibly stressful for teachers is their high risk of infections at school due to the virus's human-to-human transmission.

In May 2020, schools in Germany were gradually reopened. However, before schools could reopen, teachers had to spontaneously switch to digital learning material—whether prepared or not—in order to teach students from a distance. This switch noticeably changed daily work routines, especially of those with limited experience in digital learning environments. Consequently, considering the JD-R model of burnout, implementing distance learning was possibly related to a stress reaction (emotional exhaustion), which, in turn, could have led to feelings of depersonalization and a lack of accomplishment. These feelings could emerge if TSE was low—especially if teachers felt inadequate in implementing digital learning material or had negative attitudes toward its use.

Research based on the 'Integrative Model of Behavior Prediction to explain teachers' willingness to use Information and Communication Technologies' (Kreijns et al., 2013) has shown that the intention to use digital learning materials for teaching is mainly influenced by teachers' attitudes (Liaw, 2007) and their specific self-efficacy (Van Acker et al., 2013)The latter, thus TSE for the use of digital learning material, can be understood as a context-specific form of TSE and comprises the teachers' belief in their capability to implement digital learning material. Empirical studies have outlined its relevance with findings suggesting that TSE for the use of digital media is a significant predictor for the actual implementation in class (e.g., Kreijns et al., 2013; Lee and Lee, 2014) as well as for a teachers' competence (e.g., López-Vargas et al., 2017). The other important predictor for the intention as well as actual use of digital media are teachers' attitudes toward e-Learning (e.g., Scherer, 2018), thus whether teachers are generally more or less favorable toward e-Learning. Due to the sudden change to distance learning where digital media played a crucial role, we argue that TSE for the use of digital media as well as attitudes toward e-Learning played an important role in explaining changes in teachers' mental health during the COVID-19 pandemic. Both variables could have contributed to changes in burnout whereby teachers feeling less efficacious and having rather negative attitudes could have felt more stressed and overcharged. At the same time, high TSE for e-Learning and positive attitudes could have contributed to general TSE and less burnout in times of the pandemic. As far as we know, no study has investigated these relationships until now. We therefore analyzed in an explorative way if changes in TSE and burnout were related to attitudes or TSE for e-Learning.

Moreover, we controlled for gender and teaching experience in our analyses because both could have had a significant impact on the changes in burnout. Findings regarding gender in the context of burnout are still inconclusive and assume that they depend greatly on the specific burnout component (Lau et al., 2005; Grayson and Alvarez, 2008; Fernet et al., 2012). However, with

regard to using digital media, male teachers seem to be better prepared (e.g., Gebhardt et al., 2019) and this could have significantly affected the job demand 'distance teaching' and consequently the changes in burnout. Regarding teaching experience and its relation to burnout, findings are rather unclear as well with studies reporting higher burnout rates in more experienced and older teachers (e.g., Klusmann et al., 2008) and others in the opposite (e.g., Lau et al., 2005; Antoniou et al., 2006) but here again, we assume that teaching experience could have affected changes in burnout through teachers' readiness for teaching with digital media. As we wanted to control for such possible effects, we included gender as well as teaching experience as covariates.

Purpose of Our Study

The purpose of our study is twofold: First, we investigate burnout changes in teachers from the pre- to post-COVID-19 outbreak as an indicator of mental health and its relation to changes in (general) TSE as a relevant resource against burnout. Hereby, we claim that the circumstances of the pandemic are a high job demand which would very likely lead to an increase in burnout symptoms (Demerouti et al., 2001). Second, we analyze if those changes are related to specific self-efficacy for using digital media and attitudes toward e-Learning.

1) *Hypothesis 1*: Burnout symptoms increase from the pre- (Timepoint 1; t1) to post- (Timepoint 2; t2) COVID-19 outbreak
2) *Hypothesis 2*: Changes in burnout are negatively related to changes in TSE (Dicke et al., 2015).
3) *Hypothesis 3*: Changes in burnout from t1 to t2 are related to
a. lower specific TSE for using digital media.
b. negative attitudes toward e-Learning.
4) *Hypothesis 4*: Changes in general TSE from t1 to t2 are related to
a. higher specific TSE for using digital media.
b. positive attitudes toward e-Learning.

MATERIALS AND METHODS

This study was conducted in accordance with the ethical standards of the Ethics Committee of the Faculty for Empirical Human Sciences and Economical Sciences (Saarland University) and the data protection committee of the Ministry of Education in Saarland. The participants provided their written informed consent to participate in this study.

Sample and Procedure

Our sample consisted of 92 teachers from 23 primary and secondary schools (41.50% were from secondary schools) working in southwestern Germany. The teachers' ages ranged from 26 to 64 (M = 40.19, SD = 9.63), and the mean teaching experience was M = 10.78 (SD = 8.25). Moreover, 82% of our teacher sample were female. Gender and teaching experience were included as covariates in our analyses.

Links to an online questionnaire, which was designed in Questback's online survey platform, Unipark, were sent twice during the 2019–2020 school year. Participation was voluntary, and teachers were required to provide informed consent before they completed the questionnaires. The first data collection occurred during the beginning of the school year (October–December 2019)—just before the COVID-19 outbreak. The second data collection started in mid-May 2020. The design of the study with its measurement time points had been planned before the outbreak of the pandemic. Initially, the research aim was to capture changes in TSE and burnout to learn more about their development and reciprocity. However, the pandemic provided an interesting opportunity to investigate this research question under unique circumstances.

Instruments

Response scales for all instruments ranged from 1) *don't agree at all* to 6) *agree entirely*. Means were computed for all (sub-)scales. Reliability was determined in terms of internal consistency (Cronbach's α).

To assess burnout in its multidimensionality, we used the well-established Maslach burnout inventory (MBI) by Maslach et al. (1986) in its translated version (Enzmann and Kleiber, 1989). The three scales consisted of emotional exhaustion (e.g., "My work frustrates me," 9 items, $\alpha_{T1} = 0.86$; $\alpha_{T2} = 0.88$); depersonalization (e.g., "I think I treat some students to some extent impersonally," 5 items, $\alpha_{T1} = 0.73$; $\alpha_{T2} = 0.68$); and lack of accomplishment (e.g., "I succeed well in putting myself in the position of my students," 8 items, $\alpha_{T1} = 0.83$; $\alpha_{T2} = 0.73$). The latter is inversely coded and was therefore recoded for better interpretability.

TSE was assessed using Pfitzner-Eden et al. (2014) scale for teacher self-efficacy (STSE) with three dimensions: classroom management (e.g., "I manage to control disruptive behaviour in class," 4 items, $\alpha_{T1} = 0.88$; $\alpha_{T2} = 0.86$); instructional strategies (e.g., "I am able to provide an alternative explanation or another example when students are confused," 4 items, $\alpha_{T1} = 0.65$; $\alpha_{T2} = 0.66$); and student engagement (e.g., "I can motivate students who have little interest in education," 4 items, $\alpha_{T1} = 0.83$; $\alpha_{T2} = 0.77$).

In order to assess TSE for using digital media, we used a 4-item measure (e.g., "I know that I can easily create digital learning environments"). Internal consistency was sufficient ($\alpha = 0.87$).

Attitudes toward e-Learning were assessed by a translated version of Panda and Mishra (2007) 11-item scale (e.g., "e-Learning can solve many of our educational problems," $\alpha = 0.92$).

Data Analysis

We conducted the analysis of our hypotheses with R (R Core Team, 2020) using the lavaan package (Rosseel, 2012) with maximum likelihood estimation. The approach of latent change score models (LCSM; McArdle and Nesselroade, 1994) consists of modeling between-person differences in within-person changes (McArdle, 2009). For this purpose, change is measured by means of a latent difference score that basically represents the difference between two time points. A further extension to the basic LCSM is latent change regression models (LCRM), where the difference score is measured base-free; that is, the difference score is regressed on the Timepoint 1 measurement

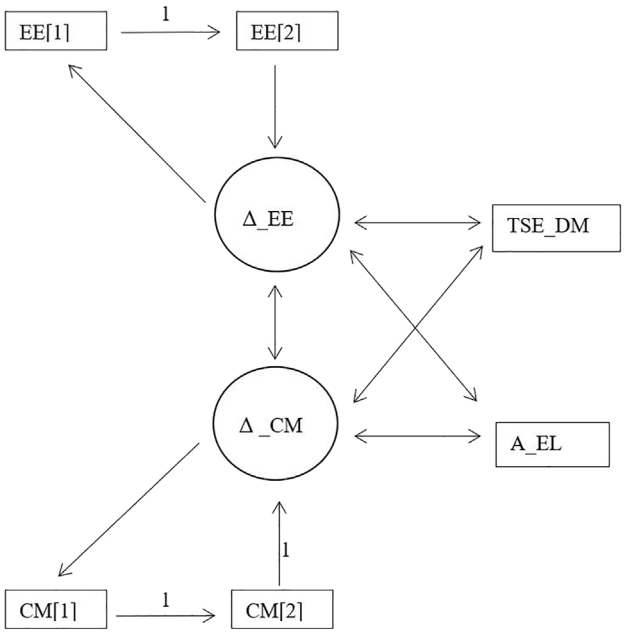

FIGURE 1 | Exemplary simplified illustration for a part of the LCRM. *Note.* EE, emotional exhaustion; TSE_DM, TSE for using digital media; A_EL, attitudes toward e-Learning; CM, classroom management; Δ, latent difference score.

(McArdle, 2009). The mean difference score can then be interpreted as a mean change corrected for Timepoint 1. LCRM is particularly recommended when the change due to a particular event between two measurement time points is to be measured rather than an ongoing process.

For our analyses, we used an LCRM to model the changes of burnout and TSE over time to investigate the relations in change (*Hypotheses 1 + 2*). Moreover, we introduced TSE for e-Learning and attitudes toward e-Learning to investigate their relations to the latent difference variables of the MBI and TSE subscales (*Hypotheses 3 + 4*). All scales, subscales, and difference scores were allowed to be correlated, resulting in a saturated model ($df = 0$). **Figure 1** shows a simplified LCRM for the subscales of emotional exhaustion (burnout) and classroom management (TSE).

In order to analyze the power for each hypothesis, we conducted a Monte Carlo study with 10,000 replications based on our LCRM results (Zhang and Liu, 2019). The number of repetitions for which the null hypothesis is rejected ($\alpha < 0.05$) can then be interpreted as the power. We refer to the details of the power next to the related results. We consider a power of at least 0.5 as sufficient and values greater than 0.8 as optimal (see Kyriazos, 2018).

RESULTS

Before answering the hypotheses in the following sections, we provide an overview of means and variances for all variables of the LCRM (**Table 1**). Please note that differences in means are not comparable to the within-person changes as modeled in the LCRM.

TABLE 1 | Means (M) and standard deviations (SD) of all variables.

	M_{t1}	SD_{t1}	M_{t2}	SD_{t2}
MBI_EE	2.94	0.96	2.48	0.91
MBI_LA	2.31	0.66	2.14	0.51
MBI_DP	1.90	0.87	1.81	0.75
TSE_CM	4.73	0.91	4.88	0.71
TSE_SE	4.64	0.74	4.70	0.65
TSE_IS	4.96	0.62	5.05	0.55
TSE_DM	-	-	4.21	1.10
A_EL	-	-	3.27	1.07

Note. *EE, emotional exhaustion; LA, lack of accomplishment; DP, depersonalization; CM, classroom management; SE, student engagement; IS, instructional strategies; TSE_DM, TSE for using digital media; A_EL, attitudes toward e-Learning.*

TABLE 2 | Correlations of the difference scores for the MBI and TSE subscales.

	Δ_LA	Δ_DP	Δ_CM	Δ_SE	Δ_IS
Δ_EE	0.49***	0.23*	–0.40***	–0.21[a]	–0.40***
Power	0.99	0.57	0.88	0.33	0.99
Δ_LA		0.26*	–0.42***	–0.31**	–0.40***
Power		0.92	0.65	0.25	0.92
Δ_DP			–0.17	–0.17	–0.26*
Power			0.07	0.29	0.50
Δ_CM				0.46***	0.48***
Power				0.83	0.81
Δ_SE					0.56***
Power					0.99

Note. *Δ, latent difference score; EE, emotional exhaustion; LA, lack of accomplishment; DP, depersonalization; CM, classroom management; SE, student engagement; IS, instructional strategies.*
[a]*<.10, p*<.05, p**<.01, p***<.001.*

TABLE 3 | Results of the LCRM for TSE.

	M	*SE*	*Power*
Δ _CM	2.49***	0.41	0.99
Δ _SE	2.31***	0.49	0.98
Δ _IS	2.04***	0.36	0.99

Note. *Δ = latent difference score, CM, classroom management, SE, student engagement, IS, instructional strategies. p***<0.001.*

Hypothesis 1

Following our first hypothesis, we expected all burnout subscales to increase from t1(pre-outbreak) to t2 (post-outbreak). In line with our hypothesis, we found the means of the difference scores for the subscale, lack of accomplishment ($M = 0.53$, $SE = 0.16$, $p < 0.001$, Power = 0.97) as well as depersonalization ($M = 0.94$, $SE = 0.26$, $p < 0.001$, Power = 0.99) to be significant. However, the mean difference score for emotional exhaustion does not indicate a change ($M = -0.24$, $SE = 0.26$, $p = 0.357$, Power = 0.11).

Hypothesis 2

For the purpose of Hypothesis 2, we looked at the latent difference scores, which indicate a change in terms of an increase or decrease and conducted correlations of the difference scores. Results are depicted in **Table 2**. All subscales

TABLE 4 | Correlations of the difference scores and related variables.

	Δ _EE	Δ _DP	Δ _LA	Δ _CM	Δ _SE	Δ _IS
TSE_DM	–0.04	–0.05	–0.17	0.28*	0.11	0.17
Power	0.08	0.51	0.06	0.72	0.07	0.06
A_EL	–0.02	0.02	0.04	0.00	0.03	0.09
Power	0.05	0.23	0.09	0.06	0.08	0.05

*Note. *EE, emotional exhaustion, LA = lack of accomplishment, DP, depersonalization, CM, classroom management, SE, student engagement, IS, instructional strategies, TSE_DM = TSE for using digital media, A_EL, attitudes toward e-Learning. $p < 0.05$.*

of the MBI are negatively and almost always significantly correlated to the TSE subscales: An increase in MBI subscales is related to less increase in TSE subscales (for changes in TSE subscales, see **Table 3**). Moreover, changes in the MBI subscales and the TSE subscales are positively related to each other. The standardized coefficient *r* can be interpreted as the effect size (Durlak, 2009).

Furthermore, we looked at the relations between the change scores and the covariates in an explorative way and found one positive significant relationship between the mean difference score for lack of accomplishment and teaching experience (β = 0.23, $p < 0.01$, Power = 0.97). The more experienced the teacher, the more increase in 'lack of accomplishment' they felt.

Hypotheses 3 and 4

5 In order to answer Hypotheses 3 and 4, we analyzed the correlations of the difference scores with variables from t2—TSE for e-Learning, as well as attitudes toward e-Learning (see **Table 4**). For TSE for using digital media, we found a significant positive correlation with the change in classroom management: the more self-efficacious teachers feel concerning e-Learning, the more increase in classroom management. The standardized coefficient *r* can be interpreted as effect size (Durlak, 2009). Attitudes toward e-Learning are not related to the difference scores.

DISCUSSION

To the best of our knowledge, this was the first study to investigate changes in burnout and TSE by means of LCRM in a sample of in-service teachers. In particular, it is one of the first studies considering mental health changes due to the COVID-19 pandemic together with related constructs (see also e.g.,Sokal et al., 2020a; Kim et al., 2021). Thus, this study deals with a critically important topic.

Applying an LCRM, we found that symptoms of depersonalization, as well as feelings of inefficacy (lack of accomplishment) in teachers, significantly increased from the pre- to post-COVID-19 outbreak which is in line with findings from other studies during the pandemic, e.g., where sample means were compared in two measurement time points within the first 3 months of the pandemic (Sokal et al., 2020b) (see also (Kim et al., 2021). However, emotional exhaustion did not show a significant change in our sample. This finding does not align with the JD-R model of burnout, which postulated that emotional exhaustion develops prior to depersonalization and lack of accomplishment. Nevertheless, considering that emotional exhaustion is instead a consequence of work overload, we contend it was not the quantity of work overload per se that affected teachers' mental health during the COVID-19 pandemic, but the amount of emotional workload (e.g., support of students) could have contributed to teachers' depersonalization as a way to cope with these demands. This is in line with findings from an study in England where teachers were interviewed about their experiences in the first weeks of the pandemic: here three the most relevant themes, that were mentioned by the teachers, were the feeling of uncertainty, "finding a way" to cope with the new situation as well as concerns for vulnerable pupils (Kim and Asbury, 2020). Moreover, the increased feelings of inefficacy seem to have developed due to a lack of resources: i.e., insufficient information or tools to do the job (Maslach, 2003). This result is understandable, considering that teachers had to switch to distance learning overnight.

Moreover, our findings show that changes in accomplishment are highly related to changes in all three STSE subscales, as all STSE subscales significantly increased from t1 to t2. The negative relation of changes means that teachers with less change (increase) in lack of accomplishment show a greater change (increase) in TSE. Strong relations of TSE and accomplishment are a well-known finding, and reduced accomplishment is sometimes described as a negative equivalent to self-efficacy (Lee and Ashforth, 1990). For emotional exhaustion, correlations of change are very similar to those in accomplishment. However, for depersonalization, correlations of change are remarkably smaller, which is consistent with prior research (Brouwers and Tomic, 2000).

Although it was not part of our hypotheses, we briefly address the significant increase in TSE, which may appear surprising. The items of the STSE refer to regular teaching (in classroom) and not to distance learning (online), so we assume that the response tendencies were partly distorted by the different setting and possibly led to overestimations. Additionally, the positive effect could have occurred due to positive mastery experiences (Bandura, 1977) with distance learning and with reduced class sizes (a hygiene measure) when schools reopened.

Furthermore, we analyzed if changes in TSE and burnout were related to attitudes toward e-Learning and self-efficacy for using digital media. Regarding the latter, we found a significant positive relationship with an increase in classroom management. Teachers with higher TSE for using digital media had higher increases in classroom management. If we imagine a teacher with little TSE for using digital mediathe relation with classroom management is understandable if one considers that classroom management for distance learning might have been easier and that back in school, there were smaller classes without interactive methods that were easier to handle. Nevertheless, we found little evidence that changes in burnout and TSE, in general, were related to TSE for using digital media. For attitudes toward e-Learning, we found no evidence at all. Considering the descriptives in **Table 1**, we have seen that both scales have high standard deviations relative to their mean, which indicate much variance within the sample. The missing relations suggest

there must be other reasons for increases in burnout, which should be addressed. Moreover, the power for these analyzes was minimal, which implies that significant effects were hard to detect.

Additionally, we had two covariates included in our model: gender and teaching experience. In an explorative way, we looked at the relations with the other variables in the model but found only one significant relation between teaching experience and the change score for lack of accomplishment: more experienced teachers had a higher increase in this component. This finding is understandable in light of previous research that has shown that younger teachers are more confident with respect to the use of digital media (e.g., Eickelmann and Vennemann, 2017; Tondeur et al., 2018). Consequently, those teachers struggle less and are less likely to feel a lack of accomplishment. However, with regard to gender, we did not find any significant relations to other variables which tells us that the development of burnout and TSE in times of the pandemic was independent of the teachers' gender.

Limitations

The predominant low power is one of our study's main limitations. Furthermore, there are some limits to the interpretation of the results, which generally concern our sample and the associated generalizability of our findings. Teachers took part in our study voluntarily, which could have resulted in a selective sample of teachers willing to provide very personal information.

Our sample mainly consisted of teachers working in southwestern Germany, as well as female teachers (82%). Regarding the latter, research in gender effects in teacher burnout is still inconclusive (e.g., Timms et al., 2006). Thus, we cannot estimate to what extent our mainly female sample has contributed to our results.

Furthermore, the interpretation of our results is limited by the fact that we know relatively little about what the teachers did between t1 and t2—whether or how they taught online and what their situations were at home. Additionally, when we collected the data for t2, teachers were just about to return to school. Thus, we were able to capture short-term effects in mental health but further data a few weeks or months later would have given insight into long-term effects. The question whether these effects are remaining, cannot be answered.

Implications for Research and Practice

Despite these limitations, we have significantly contributed to the research and practice with this study by investigating systematic interrelations in the change of burnout and TSE, which have hardly been investigated thus far. Moreover, this is one of the first studies to analyze teachers' mental health during the COVID-19 pandemic (see also e.g., Sokal et al., 2020a; Kim et al., 2021). A further and particularly important strength lies in the application of latent change score regression modeling, which allowed us to model the relations of change with other variables.

Future research should investigate the interrelation of TSE and burnout in longitudinal designs with more time points and different cohorts to gain insight into whether TSE and burnout development, as well as their interrelations, change over different phases of the professional career. Thus far, only a few studies have investigated Bandura (1977) sources for TSE, and those have focused on teacher practicum or preservice teachers (e.g., Pfitzner-Eden, 2016). However, we still do not know what happens during teachers' professional careers and whether Bandura's sources can predict those changes.

Furthermore, findings must be replicated in different cultures and with samples consisting of a balanced gender ratio to generalize findings. Of further interest would be the closer examination of intraindividual differences, especially in self-efficacy and attitudes toward e-Learning considering the COVID-19 pandemic.

Concerning the specific context of the pandemic, future studies could focus more closely on what exactly contributes to teachers' higher burdens in terms of specific job demands; the findings could help identify the best possible support for teachers. This avenue is also relevant for political decisions, as this pandemic may not be the last. The different development of burnout subscales indicates that the problem was probably not due to work overload but rather to a lack of preparation and information. Finally, the question remains of how the pandemic and the additional burden placed on teachers have affected students.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the Faculty for Empirical Human Sciences and Economical Sciences (Saarland University). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MW designed the study and collected the data. MW and EK analyzed the data. MW wrote the first draft of the article. EK and FP critically reviewed the article. FP supervised the project.

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Impact of Postgraduate Student Internships During the COVID-19 Pandemic in China

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To understand the impact of the COVID-19 pandemic on postgraduate students' internships in China, 911 students from different regions of China were surveyed through online questionnaires. Among the postgraduate students surveyed, 48.51% of which believed that the pandemic had its greatest impact on colleagues interaction, and 59.60% believed that the pandemic had a strong impact on practical skills. In total, 31.8% of postgraduate internship programs were impacted by COVID-19. The proportions of respondents having severe, moderate, and mild anxiety levels were 1.42%, 4.72%, and 15.92%, respectively; and the rates of severe, moderate, and mild depression were 1.64%, 10.86%, and 21.84%, respectively. ANOVA found that major, degree type, and degree of impact of the pandemic on colleague interactions and improved practical abilities all affected postgraduate mental health. The findings suggest that the mental health of postgraduate students should be monitored during a pandemic, and targeted psychological counseling should be offered. Postgraduate internships should be emphasized as to ensure a smooth internship process during a pandemic period. Psychological counseling and assistance should be provided to those whose internships were affected by the pandemic, and programs should be set up to aid postgraduate students in adapting to the new internship and employment conditions brought on by the "new normal" of pandemic prevention and control.

Keywords: COVID-19, postgraduate student, internship, anxiety, depression

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INTRODUCTION

With the spread of COVID-19, a large part of the global economy is in a state of "shutdown." The UN Department of Economic and Social Affairs stated that "Against the backdrop of COVID-19, the world economy is expected to shrink by 3.2% in 2020, marking the strongest contraction since the Great Depression of 1930." China's economy has also received serious shocks, with many micro-, small- and medium-sized enterprises facing the risk of layoffs and closures. The severe economic situation has had the most direct impact on the postgraduate student population through changes in employment pressure. The number of workforce employed in the first half of 2020 was significantly lower than that in previous years. According to China's Ministry of Education (2020) National Education Development Statistics Bulletin, 728,600 postgraduate students graduated in

2020, showing an increase of 13.89% compared with 2019 (China's Ministry of Education, 2020). Moreover, owing to the worldwide spread of the pandemic, postgraduate students originally scheduled to study abroad had to postpone or even cancel their plans, and some of them rejoined the domestic job market. The sudden increase in employment pressures has affected the psychological expectations of school students, and this change has made the next stage of employment competition even more intense.

Since the second half of 2020, the direct impact of COVID-19 on postgraduate employment has gradually decreased as the effectiveness of epidemic prevention and control started to emerge, and China's economy started to gradually recover. According to 2021 Graduate Employment Trend Report published by Boss Zhipin[1], a popular Chinese job recruitment website, the demand for spring recruits in 2021 increased by over 40% year-on-year. However, in the current job market, internship experiences are essential for postgraduate students to secure a job. Postgraduate internships generally are placed on long holidays such as summer and winter vacations. However, during the winter and summer vacations, population density tends to rise, resulting in the increase of the risk of sporadic COVID-19 outbreaks. In fact, in 2019, after the virus was first detected in Wuhan, sporadic outbreaks occurred throughout China during the following winter and summer holidays. There is an inevitable contradiction between the needs of postgraduate students for internships and the need to strengthen pandemic control during long holidays. In the context of the normalization of pandemic control, COVID-19 continues to adversely affect postgraduate employment. To reduce the risk of COVID-19 spreading, companies and organizations are trying to adopt new forms of online work and work from home options. This change has also been applied to postgraduate internships. Thus, online internship has become an option that postgraduate students have to consider.

According to Lazarus and Folkman's psychological stress theory (Folkman and Lazarus, 1988), when encountering a great crisis, individuals will have a series of physiological, behavioral, and emotional stress reactions that are based on their own cognitive assessment. In the face of public health crisis, the public is the first to experience emotional fluctuations and negative feelings, such as anxiety, anger, helplessness, and panic. Stress reaction under crisis conditions can trigger defensive behaviors and such behaviors have adaptive significances. However, if negative emotions cannot be regulated and relieved, then the individual is exposed to a longer state of stress, which can damage the physical and mental health of the individual, easily leading to depression, anxiety, and other psychological problems.

Anxiety and depression are common psychological problems and conditions for the public during the pandemic (Ren et al., 2020). For postgraduate students, the initial COVID-19 outbreak was at the end of the year, a critical time for postgraduate internships and employment. Over the next 2 years, prevention and control of the pandemic will impact the mental health status of postgraduate students in a manner that is different from other student groups. According to statistics, the total number of students enrolled in higher education in China is 41.83 million, among which postgraduate students accounting for approximately 7.5%, including 0.46 million Doctoral degree students and 2.67 million Master degree students. Compared with other groups of students, the postgraduate group has the following characteristics: (1) Postgraduate students are mainly adults between the age 20–30; (2) They have received higher education; (3) They have a clearer perception about realistic pressure (Moss et al., 2021); (4) Their body and mindset are in upward stages of development; (5) They usually face higher expectations from employers, especially on the quality and length of their internship experiences (Barry et al., 2018); and (6) They have both greater autonomy and stronger pressure on internship selection other students.

In summary, research on internships and mental health of the postgraduate students during the pandemic is urgent and necessary. Many scholars have conducted research on the mental health of students in the context of the pandemic. Research by Wei et al. (2020) demonstrated that children and adolescents in severely affetcted areas, or those whose family members are infected with COVID-19, will experience negative emotions, such as anxiety and depression, and severely affected individuals may be overly scared, restless, and confused. The impact of the pandemic has been evident, and a higher detection rate of negative emotions in college students, such as depression and anxiety, has been reported compared with before the pandemic (Cao et al., 2020; Chang et al., 2020; Chen et al., 2020; Khan et al., 2020; Li et al., 2020; Og et al., 2020; Son et al., 2020; Niu et al., 2021).

However, there is a lack of research into the mental health of postgraduate students as a specific group. Some scholars have also conducted research on the internship practices of Chinese college students during the pandemic. Shen et al. (2020) explored the "cloud practice" teaching strategy for traditional Chinese medicine subjects during the pandemic; Chai et al. (2021) brought forward suggestions for online internship-related teaching. Even though the above studies provided us with insights into internship placement and practical training of university students during the COVID-19 pandemic, they have the following limitations: (1) Most studies focused on students of specific majors, such as medicine or management, therefore, the issues discussed and conclusions drawn were limited to specific groups of students; (2) Most surveys targeted undergraduates or senior students, and did not take into consideration the differences between the differences in internship placements between postgraduate and undergraduate students; and (3) the research samples have geographical limitations; consequently, it was not possible to represent the large population of colleges and universities in mainland China.

Therefore, while investigating the levels of anxiety and depression among Chinese postgraduate students during the pandemic, current study also investigated the extent of the impact specifically on the internship activities. The aim was to understand the internship activities and mental health status of postgraduate students in the context of both the COVID-19 pandemic and the "new normal" of pandemic prevention

[1]www.zhipin.com

and control measures, to provide an important reference for targeted psychological counseling, and also to provide advice on postgraduate internship and employment guidance.

In addition to being the first country to detect the coronavirus and achieve effective control of the virus, China is also the first major economy to recover. As postgraduate students are representatives of highly qualified job-ready groups, it is necessary to look into problems associated with postgraduate student internship and their mental health status. It will provide an important reference for economic recovery and job promotion in other major economies of the world.

MATERIALS AND METHODS

Participants

A total of 911 postgraduate students (96.20% valid response rate) were randomly selected from 33 provinces or autonomous regions in China *via* the popular professional survey website WenJuanXing[2]. All respondents participated voluntarily and signed informed consent. This study was approved by the local Ethics Committee of the School of Psychology, South China Normal University (SCNU-PSY-2021-021). The sample included 195 male students (21.40%) and 716 female students (78.59%); 834 master-degree students (90.18%) and 77 doctoral-degree students (8.45%); and 279 academic degree postgraduates (30.62%) and 632 professional degree postgraduates (69.37%).

Data Analysis

In this study, we used R 4.0.2 for data analysis. *T*-test and one-way analysis of variance (ANOVA) were used to explore the main factors influencing depression, anxiety, and social anxiety score.

Measures

Self-Rating Anxiety Scale

The Self-Rating Anxiety Scale (SAS) was used to assess individual's anxiety in the recent week (Zung, 1971). The scale included 20 self-rating items out of which 5 items were scored in the reverse order. The scale used 4-point Likert scale with scores on responses ranging from 1 (occasionally) to 4 (always). The sum of the item scores was referred to as the total rough score, then it was multiplied by 1.25 to obtain the standard score. The scale had a Cronbach's alpha equal to 0.85. A standardized scoring algorithm was used to define anxiety symptoms: scores 50∼59 indicated mild anxiety; scores 60∼69 indicated moderate anxiety; and scores > 69 indicated severe anxiety.

Self Rating Depression Scale

The Self Rating Depression Scale (SDS) was used to assess individual's depression in the recent week (Zung, 1965). The scale included 20 self-rating items out of which five items were scored in the reverse order. The participants responded on the 4-item Likert scale with scores ranging from 1 (occasionally) to 4 (always). The total rough score was the sum of scores of all items, and the total rough score was multiplied by 1.25 to obtain the standard score. The Chinese version of the scale had a Cronbach's alpha equal to 0.88. A standardized scoring algorithm was used to define depression symptoms: scores 53∼61, 62∼71, and above 72 indicated mild, moderate, and severe depression, respectively (Wang et al., 1986).

Questionnaire on the Impact of COVID-19 on Postgraduate Students Internship

Questionnaire on the impact of covid-19 on postgraduate student's internship was designed to measure how postgraduates' internship were affected by the pandemic. Respondents reported the level of impact on their internship caused by the pandemic on a 4-point Likert scale with severity-centric options, namely "no impact," "little impact," "moderate impact," and "strong impact."

The three scales used in this study generally maintain their original versions. The Harman one-way test The test for common method bias using the Harman one-way test means showed that the first factor has had an interpretation rate of variance of 39.4%, not below 50%, so there which indicated there is was no common method bias.

Ethical Considerations

The ethic committee of South China Normal University approved the study. All participants voluntarily gave their informed consent to participate in the study after being informed about the purpose of the study. The procedures of this study complied with the provisions of the Declaration of Helsinki regarding research on human participants.

RESULTS

Anxiety and Depression

The descriptive results of SAS and SDS are shown in the table below. **Table 1** shows that the postgraduate anxiety scores and depression scores during the pandemic were higher than their corresponding Chinese norms, and the differences were highly statistically significant ($p < 0.001$).

Specifically, according to the Chinese Norms, 201 (22.06%) and 313 (34.35%) postgraduate students were identified with symptoms of anxiety and depression, Incidence rates of mild, moderate, and severe anxiety were 15.92, 4.72, and 1.42%, respectively. and those of mild, moderate, and severe depression were 21.84, 10.86, and 1.64%, respectively.

Prior to the outbreak, some researchers had studied the utility of SAS and SDS for postgraduate students: Wu et al. (2013) used SAS and SDS to evaluate anxiety and depression in

TABLE 1 | Postgraduate anxiety and depression description statistics.

	Participants		Norms		*t*
	M	SD	*M*	SD	
SAS	42.80	10.03	29.78	5.46	72.91***
SDS	47.67	11.21	41.88	10.57	28.97***

***$p < 0.001$.

[2]www.wjx.cn

TABLE 2 | Comparison of rates of anxiety and depression in other studies and this study.

References	*N*	Research Objects	Rate of anxiety	Rate of depression
Wu et al., 2013	177	Medical college graduate students	10.7%	24.3%
Wang, 2017	941	Professional degree graduate students from 3 universities in Chongqing	2.6%	8.5%
Chang et al., 2020	3,881	Cantonese college Students	26.60%	–
Mao et al., 2020	240	Medical graduate students	24.17%	38.75%
Current study	3,137	Chinese postgraduate students with internship experience	22.06%	34.35%

TABLE 3 | The difference in demographic variables of all study variables (M ± SD).

Demographic variable		*n*	Statistics	Anxiety	Depression
Gender	Male	195		42.09 ± 10.15	46.92 ± 11.43
	Female	716		42.75 ± 9.77	47.76 ± 10.91
			T	0.04	0.08
Degree type	Academic degree	276		43.08 ± 10.32	47.97 ± 11.24
	Professional degree	632		42.20 ± 9.42	47.25 ± 10.83
			t	7.86**	1.71
Professional Type	Science and engineering	109		42.92 ± 9.51	47.99 ± 11.26
	Liberal arts	159		43.42 ± 10.25	48.98 ± 11.53
	Social science	643		42.36 ± 9.83	47.19 ± 10.84
			F	0.86	3.40*

*$p < 0.05$ and **$p < 0.01$.

177 graduate students and found that the corresponding rates were 10.7 and 24.3%, respectively. Wang (2017) conducted a survey on 941 students pursuing a professional degree and found that the rates of detection of anxiety-related and depression-related symptoms were 2.6 and 8.5%, respectively, both of which are lower than the rates observed in the current study. With regard to other studies on the mental health status of Chinese college students during the COVID-19 pandemic, Chang et al. (2020) conducted a survey on 3,881 Cantonese college students and found that the incidence of anxiety among university students was 26.60%; Mao et al. (2020) found depression- and anxiety-related symptoms in medical-major postgraduate students were 38.75% and 24.17%, respectively. Other researchers detected a higher rate of anxiety and depression in post-graduate students during the pandemic than before the pandemic (see **Table 2**).

Mental Health Status of Postgraduate Students Based on Demographics Various Categories

Demographic variable such as gender, degree type, and major were used as independent variables; anxiety and depression scores were used as dependent variables.

Statistical analysis of the differences in demographic variables were performed using independent *t*-test for binary factors (i.e., gender and degree type) or ANOVAs for multi-level factors (i.e., major).

Gender

The *t*-tests were conducted on anxiety and depression scores of postgraduate students of different genders. There were no significant differences in anxiety scores and depression scores among postgraduate students of different genders (**Table 3**). Jiang et al. (2016) conducted a meta-analysis on the mental health of postgraduate students in China, and had concluded that gender has no significant influence on postgraduate student mental health. The findings of current study, consistent with most previous studies, indicate that the mental health status of both males and females were affected by the pandemic.

Academic Degree and Profession Degree

The *t*-tests were conducted for postgraduate students of different degree types. As shown in **Table 3**, significant differences occurred in anxiety scores ($t = 7.86$, $P = 0.005 < 0.05$). Academic degree postgraduate students had significantly higher anxiety scores than professional degree postgraduate students, but the degree type did not significantly influence depression scores ($t = 3.39$, $P = 0.066 > 0.05$). Academic degree postgraduate students may be affected more by the pandemic because of their different academic systems, stricter graduation requirements and the need for more academic support, resulting in relatively higher anxiety level, but not depression level.

Major

ANOVA was used to examine the differences between the scale scores of postgraduate students from different majors (**Table 3**). There were significant differences in depression scores ($F = 3.40$, $P = 0.034 < 0.05$), and the highest depression scores were among postgraduate students majoring in liberal arts (48.98 ± 11.53), which were far higher than Chinese norm (41.88 ± 10.57). However, there were no significant differences in anxiety scores among postgraduate students from different major, indicating that major did not significantly affect anxiety.

TABLE 4 | Changes in different internship programs and comparison of scale scores (M ± SD).

Changes in Internship plans	*n*	Anxiety	Depression
On track	478	42.73 ± 10.05	47.40 ± 11.30
Delayed	209	42.70 ± 9.11	48.28 ± 10.51
Cancel	81	44.94 ± 12.34	50.43 ± 12.54
No plans	143	41.94 ± 9.78	46.16 ± 10.94

TABLE 5 | Comparison of different internship sites and scale scores (*M* ± *SD*).

Internship site	*n*	Anxiety	Depression
Company	440	42.58 ± 10.02	47.48 ± 11.31
Home	38	43.50 ± 9.62	49.92 ± 10.63

Relationship Between the Degree Affected on Internships and Mental Health

This study surveyed 911 postgraduate students with internship experience. Since these students already had previous internship experience, they should be able to recognize the potential impacts on internships brought by the pandemic. Thus, this study aims to investigate how changes in internship plans influence students' anxiety and depression levels. The following table shows the anxiety and depression scores related to changes in the internship program.

As shown in **Table 4**, during the pandemic, 209 postgraduate students delayed their internship programs, and 81 students canceled. And 31.80% of the postgraduate internship programs were affected by the pandemic and did not proceed as planned. A total of 478 postgraduate internships, or 52.46% of the total, were back on a regular schedule. On the one hand, these data showed that the pandemic in China has been effectively controlled and that the resumption of work and production is proceeding in an orderly manner. On the other hand, nearly one-third of postgraduate students still failed to complete their internships, which also revealed that postgraduate internship programs had been greatly impacted by the pandemic. Postgraduate students whose internships were canceled had significantly higher anxiety scores (44.94 ± 12.34) and depression scores (50.43 ± 12.54) than other postgraduate students. The mental health status of students whose internship was on track delayed or those who did not plan on participating in internships exhibited no deviation from the sample mean. This indicates that postgraduate students whose internship programs were canceled have significant mental health risks that deserve the attention of mentors, parents, and counselors.

The anxiety and depression scores of 478 postgraduate students whose internships were normally conducted during the pandemic are shown in **Table 5**.

As shown in **Table 5**, 440 postgraduates' internships were taken place at a company. This further illustrates the gradual normalization of life in China and the smooth resumption of work and production. Only 7.95% of the 478 regular postgraduate students completed their internships at home during the pandemic, indicating that online internships are still not accepted by the majority of postgraduate students and enterprises.

Postgraduate students who did internships at home had higher levels of anxiety and depression than postgraduate students who intern in a company, indicating that postgraduate students working from home experienced more serious mental health problems. This may be related to the lack of recognition for online internships, with postgraduate students being skeptical about whether these internships provide the work experience and professional skills on a par with traditional internships. Additionally, during online internships, postgraduate students are unable to communicate face-to-face with superiors, colleagues, and clients, making it difficult to get direct social interactions and positive feedback (Thoits, 2011).

In this survey, "Interaction with colleagues" and "Practical ability improvement" were addressed, and specific items were set up to inquire about the impact of the pandemic on the internships of postgraduate students. The different degrees of impact and corresponding mental health status are shown in **Table 6**.

As shown in **Table 6**, 369 and 73 out of 911 postgraduate students considered that the pandemic had a "moderate impact" and "strong impact" on their interactions with colleagues. In addition, 386 and 157 students considered that the pandemic had a "moderate impact" and "strong impact" on the improvement of practical skills. In summary, more than half of postgraduate students believe that internship activities have been significantly affected by the pandemic.

ANOVA was conducted with the degrees of influence as the independent variables, and anxiety and depression scores were used as the dependent variables. There were significant differences in the degree of impact of COVID-19 on colleague interactions and on anxiety and depression scores (**Table 6**). Using the LSD method to conducted multiple comparisons, postgraduate students whose degrees of impact were "moderate impact" and "strong impact" had higher anxiety and depression scores. This suggested that the greater the impacts on the interactions with colleagues and the improvement of practical skills, the more serious the psychological problems in postgraduate students.

DISCUSSION

This study shows that 20.91 and 33.88% of postgraduate students amid COVID-19 had anxiety and depression symptoms, respectively, and them had significantly higher anxiety and depression scores than Chinese norms. Postgraduate students' mental health problems are worsening compared with pre-pandemic data. During the pandemic, people's concerns and fears over their own situations became more prominent, and the strict prevention and control measures across the country created a tense environment. Additionally, the impacts of the pandemic hampered the economy and industry, as well as postgraduate studies, research, internship, and employment opportunities (Moreira de et al., 2018). Such stresses also cause psychological problems, such as anxiety and depression (Shi et al., 2016).

TABLE 6 | Comparisons of the scores of postgraduate students that were affected to different degrees.

Item		*n*	Statistic	Anxiety	Depression
The impact on interactions with colleagues	No impact	206		41.33 ± 8.88	45.43 ± 10.78
	Little impact	272		41.48 ± 9.28	46.71 ± 10.54
	Moderate impact	369		43.50 ± 9.81	48.93 ± 11.00
	Strong impact	73		48.41 ± 14.07	51.44 ± 14.03
			F	11.63***	7.84***
The impact on the improvement of practical skills	No impact	165		40.89 ± 8.87	45.26 ± 11.04
	Little impact	203		41.60 ± 9.04	45.49 ± 10.51
	Moderate impact	386		43.74 ± 10.00	49.22 ± 10.64
	Strong impact	157		44.05 ± 11.94	49.27 ± 12.73
			F	4.97**	8.84***

$^{**}p < 0.01$, and $^{***}p < 0.001$.

A comparative analysis of the mental health of postgraduate students in different majors and degree types revealed that mental health problems are more serious among academic degree postgraduate students and students majoring in liberal arts. These research results are consistent with previous study by Wang et al. (2020). Academic degree postgraduate students have greater academic pressure, higher dissertation standards, and less vocational skill training than professional degree postgraduate students. The pandemic disrupted their original study plans and intensified job competition, resulting in greater anxiety (Moore and Lucas, 2020).

Therefore, during the pandemic, universities should consider the practical difficulties faced by academic degree postgraduate students, adjust course arrangements appropriately, maintain open and direct communication channels, and provide guidance to postgraduate students (Wang, 2015; Santamaría et al., 2021). In addition, we should also pay attention to employment guidance for academic degree postgraduate students, and cultivate their scientific research and practical abilities. Only in this way can students build up more confidence in the face of drastic changes under pandemic conditions.

Students majoring in liberal arts showed more severe depression, possibly because these students are more empathetic, more emotionally sensitive, and are more susceptible to social circumstances. Therefore, universities and supervisors should pay attention to the mental health of liberal arts postgraduate students, devise specific programs to ensure clear and open communication and to provide psychological counseling and guidance in a targeted manner.

This study found that postgraduate students whose internships were canceled due to the pandemic had severe anxiety, depression and psychological health risks. With China's current postgraduate training scheme and employment situation, individuals whose internship program was canceled does not only face reduced employment competitiveness, but also the risk of not fulfilling graduation requirements. Successful internships in the future will depend on COVID-19 prevention and control measures, and the urgency of time will undoubtedly increase the stress for senior students as their graduation season is approaching (Ryan et al., 2021). Therefore, in view of the fact that a large number of postgraduate internship programs cannot be carried out smoothly due to the pandemic, universities and employers should explore new ways to cooperate, provide more flexible internship methods, and help postgraduate students to complete successfully in the period of normalization of pandemic prevention and control through online internship and remote internship plan.

In the face of the COVID-19 public health crisis, attention should be paid to the mental health problems of postgraduate students and various measures should be taken to intervene actively and effectively. Universities, mentors, counselors, and other relevant personnel should: (1) Actively guide postgraduate students to understand their mental health, encourage postgraduate students to seek help in case of psychological problems, and avoid other negative effects, such as post-traumatic stress disorder; (2) Establish monitoring and early warning system for psychological problems, and improve online and offline psychological counseling service system; and (3) Devise specific and targeted mental health programs according to the different characteristics and needs of various postgraduate students groups.

Faced with postgraduate internship problems during a pandemic, universities should establish new mechanism of cooperation and communication with employers. Both sides should work to provide various options, such as field internships, online internships, remote training, or building internship practice platform. In addition, postgraduate students should also consciously communicate with colleagues and participate in practical training and work practice.

Colleges and universities should pay attention to the mental health of postgraduate students to prevent their emotional state from worsening because of employment pressure. Additionally, universities should guide them to take positive views of problems. With the easing of the pandemic, there will be more internship opportunities in the near term. At present, a comprehensive set of skills and, good job plans should be developed. Only in this way can students better meet the challenges of future job competition.

LIMITATION

There are still a limitation for our study that should be noted. Given the fact that the pandemic had spread worldwide, it is extremely difficult or even impossible to find Chinese

postgraduate students who did not experience such interruptions for comparison. As a cross-sectional survey, there was no follow-up period for the participants, which means we didn't yet know enough about the changes of mental health of postgraduate students during the pandemic.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethic Committee of South China Normal University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

XL, DK, and JQ selected the topic and made some modifications in the manuscript. WZ collected the data and wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Wuhan College Students' Self-Directed Learning and Academic Performance: Chain-Mediating Roles of Optimism and Mental Health

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This study explored the chain-mediating roles of optimism and mental health in the relation of self-directed learning with academic performance among college students in Wuhan during long-term online teaching. In total, 473 valid responses were obtained from students at three Wuhan universities. Self-directed learning, optimism, mental health, and academic performance scales were used as measurement instruments; a 5-point Likert scale was employed for all items. To examine the instruments' reliability and validity, a measurement model was constructed; moreover, structural models were employed for assessing the chain mediation model. This study confirmed that self-directed learning was a positive predictor of academic performance in Wuhan college students. Optimism and mental health were two mediators and partially jointly mediated the relation of self-directed learning with academic performance. The results revealed that self-directed learning only partially positively predicted academic performance. The aforementioned relationship was partially mediated by optimism and mental health, highlighting the essential roles of optimism and mental health in the learning and learning outcomes of Wuhan college students.

Keywords: self-directed learning, academic performance, optimism, mental health, Wuhan

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INTRODUCTION

As a global public health emergency, the COVID-19 pandemic has resulted in an increase in university Students' perception of stress (Husky et al., 2020). Facing the double pressure of the sudden pandemic and online learning, college students may have become more susceptible to anxiety and pressure (Goldmann and Galea, 2013; Byrnes et al., 2020; Safa et al., 2021). In February 2020, at the beginning of the epidemic that originated in Wuhan, China's Ministry of Education issued "Instructions for Adequate Implementation of Online Education Organization and Management in Ordinary Colleges and Universities during Pandemic Prevention and Control," requesting joint implementation and protection of online teaching to achieve class suspension without interrupting learning (Ministry of Education of the People's Republic of China, 2020). Wuhan in 2020 was one of the regions hardest hit by the pandemic. Thus, Wuhan college students have experience in online education for a relatively extended period, and their self-directed learning

skills may have been trained and improved through the online teaching model since the 2020 year (Li, 2020; Zhang W. et al., 2020; Zhang X. et al., 2020; Zhang Z. et al., 2020). Therefore, Wuhan college students were selected as the research targets.

Given the impact of COVID-19, online teaching is likely to become a more prevalent teaching mode (Jaberzadeh and Mansouri, 2021; Yang et al., 2021). Studies have revealed that, in the context of long-term online teaching and the school closure policy, college Students' self-directed learning ability is instrumental to the smooth development of online teaching (Cai et al., 2020; Xiang et al., 2021). Self-directed learning refers to learning with spontaneity and purposefulness that allows for self-management and self-evaluation (Holec, 1979). The level of college Students' self-directed learning also influences the future development and spread of online education (Xie et al., 2020). In the constructivist view, the importance of student-centered autonomous exploration and knowledge construction is emphasized (Piaget, 1980); self-determination theory suggests that targeted and active learning behaviors can generate more favorable learning outcomes (Deci and Ryan, 1985). According to survey-based research, self-directed learning has a strong positive effect on learners' academic performance (Zhou et al., 2010; Kim, 2017; Oducado, 2021). Therefore, this research posited that self-directed learning is a significant positive predictor of the academic performance of Wuhan college students.

Pandemic-induced changes in learning style can cause stress and negative emotions. Studies have revealed that optimism help individuals adapt to stressful life events (Williams, 2003; Yu and Zheng, 2011). According to self-determination theory and psychological capital theory, self-determined behaviors can produce more positive and optimistic emotions. In psychological capital theory, optimism—a type of psychological capital—is described as a quality that drives individuals to achieve better outcomes and performance (Deci and Ryan, 1985; Luthans et al., 2015). Studies on self-directed learning, optimism, and academic achievement have indicated that individuals who are adept at self-directed learning are more likely to experience the positive emotions of satisfaction and optimism (Elliot and Dweck, 1989) and that optimists are more likely to adopt effective coping strategies when facing stressful academic scenarios (Piko et al., 2013; Bai and Xie, 2018), thereby maintaining individual academic outcomes (El-Anzi and Owayed, 2005; Wang et al., 2011). Therefore, this study posited that self-directed learning generates optimistic emotions and affects the academic achievement of college students in Wuhan.

The experience of being in an environment in which many negative life events are occurring during the pandemic can jeopardize an individual's mental health and further trigger a psychological crisis (Zhang W. et al., 2020; Zhang X. et al., 2020; Zhang Z. et al., 2020). The pandemic-induced shifts in teaching and learning modes may have resulted in considerable challenges and psychological pressure on Wuhan college students without online learning experience (Clabaugh et al., 2021; Jin et al., 2021). According to ecological systems theory and self-determination theory, individuals who employ initiative in learning are more likely to meet their own expectations as well as those of their parents and society, thereby obtaining positive emotional feedback and support; such positive support can improve the learner's mental health, which in turn provides support for academic achievement through a healthy psychological state (Maslow, 1954; Bronfenbrenner, 1992; Ryan and Deci, 2000; Luthans and Youssef, 2007). Studies on self-directed learning, mental health, and academic achievement have reported that, relative to those of individuals with lower learning initiative, the mental health levels of individuals with higher learning initiative were generally more favorable (Tuffin et al., 2001; Chen, 2015), and those with more favorable mental health are typically more effective at adjusting to academic pressure to maintain the positive development of their academic performance (Bostani et al., 2014; Zhao, 2020). Thus, this study held that self-directed learning affects Wuhan college Students' mental health and subsequently their academic performance.

Studies assessing the relation between optimism and mental health have highlighted optimism as a major predictor of an individual's mental health (Hanssen et al., 2014), and it is generally regarded as having a psychologically protective role in mental health (Chang, 2002). Optimism can help people withstand the impact of academic pressure on mental health (Zhang et al., 2011). Therefore, both optimism and mental health may mediate the connection of self-directed learning with academic achievement; moreover, optimism and mental health may have a chain-mediating relationship. When viewed collectively, self-determination theory and ecological systems theory suggest that (1) autonomous and spontaneous learning can generate positive emotions and expectations toward learning, (2) positive emotions can help maintain an individual's mental health, and (3) a favorable psychological state is instrumental in maintaining the highly efficient learning outcomes of an individual (Maslow, 1954; Bronfenbrenner, 1992; Ryan and Deci, 2000; Luthans and Youssef, 2007). Empirical research has similarly revealed that autonomous and spontaneous learning behaviors may induce an optimistic emotional experience in learners (Alkhedr, 1999; El-Anzi and Owayed, 2005), and optimistic individuals are particularly adept at maintaining a relaxed state that allows them to resist academic stress (Zhang et al., 2011; Hanssen et al., 2014), thereby ensuring highly efficient learning outcomes (Bostani et al., 2014; Agnafors et al., 2020). On the basis of the preceding discussion, Wuhan college students were selected as the research targets for exploring the relation of self-directed learning with college performance; the chain-mediating roles of optimism and mental health between self-directed learning and performance were also examined. In this manner, the effect that self-directed learning has on the internal relationship mechanism of Wuhan college Students' academic performance was investigated.

Self-Directed Learning and Academic Performance

A central tenet of humanistic learning theory, with psychologist Carl Rogers as the representative, is the importance of people, self-concept, and emotional factors in the learning process; thus, helping students acquire the ability to learn is more central than teachers' knowledge delivery (Rogers, 1983). Constructivist

theory holds that learning is student-centered, and it should emphasize learners' active exploration of knowledge, their spontaneous discovery, and their active construction of the meaning of the knowledge they have acquired (Piaget, 1980). In the triarchic theory of intelligence, the crucial role of individual initiative in the construction of cognitive structure is similarly emphasized (Surhone et al., 2010). Therefore, student-centered as well as autonomous and spontaneous learning behavior is what education strives toward. In the education field, spontaneous learning is also called self-directed learning (Knowles, 1975; Lemmetty and Collin, 2020). Holec (1979) defined self-directed learning as an individual's ability to be responsible for their own learning and specifically explained it as the ability of a learner to define their particular learning objectives, content, and progress as well as to select learning methods and techniques, track the learning process, and assess the learning results. Self-directed learning involves a learner's desire and ability to independently make choices regarding their own learning (Littlewood, 1999). Self-determination theory suggests that individuals have a natural inclination to act on their own willpower. Therefore, people are more motivated by what they wish to do than by what they are required to do (Deci and Ryan, 1985). According to this theory, after learners have independently established their learning goals, the adoption of self-monitoring-based active learning behaviors can lead to greater learning results. Autonomous and independent learning are critical methods for college students given their adult status (Tough, 1989; Loeng, 2020). Khiat (2015) revealed that adult Students' level of perceptive skills regarding indices of self-directed learning directly or indirectly affects their academic performance. A model constructed by Kim (2017) similarly indicated that, in path analysis, self-directed learning can directly affect academic achievement; thus, self-directed learning plays a positive role in college Students' academic achievement (Cazan and Schiopca, 2014; Oducado, 2021). Therefore, on the basis of the theoretical perspectives and literature support provided in the preceding section, Hypothesis 1 was formulated as follows:

> H1: Self-directed learning positively predicts academic performance.

Self-Directed Learning, Optimism, and Academic Performance

Scheier defined optimism as a positive expectation of future results (Scheier and Carver, 1985). When viewed collectively, self-determination theory and psychological capital theory suggest that self-determination behavior can generate positive and optimistic emotions; as a type of psychological capital, optimism is described as a trait that motivates an individual to achieve more favorable outcomes and performance (Deci and Ryan, 1985; Luthans et al., 2015). During self-directed learning, learners generate positive emotions and expectations of learning outcomes. Those who are skilled at self-learning more positively evaluate their learning skills, and thereby, through self-determination, set more optimistic learning goals (Deci and Ryan, 1985). Moreover, optimistic people are adept at adopting direct actions, plans, and coping strategies in learning, thus improving their academic outcomes (Luthans et al., 2015). Studies have similarly confirmed that students can more effectively observe their own performance and assess their own targeted progress when they participate in learning activities with a positive goal and a desire to achieve goals (Schunk, 1990). More positive emotions, accompanied by positive psychological implications, are induced in students with strong self-directed learning skills as their satisfaction with their targeted progress increases. In sum, students with greater self-directed learning skills are more likely to generate optimism as psychological capital. Furthermore, according to the theory of psychological capital, optimism pertains to positive emotions and can motivate an individual to achieve higher performance (Luthans and Youssef, 2007; Luthans et al., 2015). Research has revealed that, compared with individuals with high optimism, those with low optimism are less capable of adopting direct actions, planning, and coping strategies to manage and relieve the stress caused by life events when perceiving stress, thus lowering the efficiency of their work and learning (Brissette et al., 2002). Optimism can predict favorable academic results, and those who are optimistic possess sufficient social adaptability (Alkhedr, 1999; Dougall et al., 2001). El-Anzi and Owayed (2005) also highlighted that academic performance can be improved through optimism. Therefore, on the basis of the abovementioned theoretical perspectives and research findings, Hypothesis 2 was formulated as follows:

> H2: Optimism plays a mediating role in the influence of self-directed learning on academic performance.

Self-Directed Learning, Mental Health, and Academic Performance

Mental health is defined as a state of well-being; in a state of mental health, people feel relaxed and can adapt to circumstances and thoroughly reach their psychophysical potential (Zhang et al., 2013). Social ecological systems theory (Bronfenbrenner, 1992) suggests that difficulties related to people's intimacy and communication in school and family life as well as to people's emotional response and behavioral control may cause mental health problems such as self-isolation and alienation. A healthy mentality provides learners with a favorable mental environment, and this positive mental state determines whether individuals can realize their academic potential (Maslow, 1954). In self-determination theory, environmental factors are also the basis of an individual's self-directed learning behavior (Deci and Ryan, 1985). However, spontaneous learners can adopt active learning behaviors involving self-monitoring to adjust their psychological state and improve their academic outcomes more effectively; those with stronger self-directed learning skills exhibit a more positive and active learning status (Deci and Ryan, 1985; Luthans and Youssef, 2007). Such positive learning behavior is more consistent with the expectations of society, school, and parents, and the learner is more likely to obtain affirmation from teachers and parents, thus sustaining their relaxed psychological state (Tuffin et al., 2001) and achieving learning outcomes. Therefore, students skilled in self-directed learning exhibit behavior that is consistent with social expectations and receive social support

to maintain their mental health (Tuffin et al., 2001; Hefner and Eisenberg, 2010). Favorable mental health provides learners with a positive psychological environment as support, which affects whether they can realize their academic potential (Maslow, 1954). According to studies on learning and well-being, a self-monitoring learning style influences Students' perceptions of successes and improves their mental state (Field, 2009; Teal et al., 2015). Byrd and Mckinney (2012) reported that mentally healthy college students have greater advantages in academic performance in terms of interpersonal adaptation, communication, and acquiring cognitive ability relative to those with lower levels of mental health. Related studies have also revealed that mental health significantly and positively predicts Students' academic performance (Scheier and Carver, 1985; Alkhedr, 1999; Albeg and Castro-Olivo, 2014; Cazan and Schiopca, 2014). Combining the aforementioned theories and research results, Hypothesis 3 was formulated as follows:

> H3: Mental health plays a mediating role in the influence of self-directed learning on academic performance.

Self-Directed Learning, Optimism, Mental Health, and Academic Performance

According to self-determination theory, a direct positive relationship exists between self-determination behavior and performance (Deci and Ryan, 1985). However, the relation of self-determination learning with learning outcomes may be jointly mediated by optimism and mental health. According to psychological capital theory, optimism is a critical positive resource in personality (Luthans et al., 2015). This positive personality tendency represents an effective internal ability for self-reparation and enhancement, acting as a buffer in the process of the psychological stress response and helping people resist mental illness (Chang, 2002; Gustavsson-Lilius et al., 2007). Zhang et al. (2011) revealed that optimism and psychological capital can help people withstand the impact on mental health resulting from the pressure of learning. Similarly, research in other fields has revealed that the mental health of optimistic patients with cancer seems to be superior to that of unoptimistic ones (Schou et al., 2004). Optimism negatively predicts psychological problems including suicidal tendencies and negative emotions (Yu and Zheng, 2011). Optimism is regarded as a predictor of mental health, supporting the notion that optimism and mental health may act as chain-mediators but not in mutually independent mediation roles. When viewed collectively, self-determination theory and psychological capital theory suggest that people with high-level self-learning skills more positively assess their learning skills, thereby inducing positive and optimistic emotional experiences. As positive psychological capital, optimism can help people resist mental health problems caused by stress (Deci and Ryan, 1985; Chang, 2002; Gustavsson-Lilius et al., 2007; Zhang et al., 2011; Luthans et al., 2015). Furthermore, needs theory suggests that a healthy mental state in learners determines whether they can successfully realize their academic potential (Maslow, 1954; Elliot and Dweck, 1989). Studies have also confirmed that people with strong self-learning skills exhibit more positive self-assessment, leading to optimistic emotional perception in such learners (Alkhedr, 1999; El-Anzi and Owayed, 2005), and those with optimistic positive expectations exhibit superior mental health (Chang, 2002; Schou et al., 2004; Gustavsson-Lilius et al., 2007; Zhang et al., 2011; Luthans et al., 2015). Favorable mental health also predicts higher academic performance (Kantomaa et al., 2010; Albeg and Castro-Olivo, 2014; Bostani et al., 2014; Agnafors et al., 2020). Therefore, this study posited that, for Wuhan college students, although optimistic learning attitudes and experiences result from spontaneous learning, such optimistic positive emotions may in turn affect mental health, thereby providing support for academic performance through a healthy psychological state. Thus, Hypothesis 4 was formulated as follows:

> H4: Optimism and mental health play chain-mediating roles in the influence of self-directed learning on academic performance.

Hypothetical Model

This study's hypothetical model (**Figure 1**) was developed with reference to relevant theories and studies. In the model, self-directed learning is assumed to positively predict the academic performance of college students in Wuhan, and optimism and mental health are the two chain-mediating factors in this relationship.

MATERIALS AND METHODS

Materials

Four constructs were investigated through independent scales; each item was scored using a 5-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). The constructs and scales are described in the following section.

Self-directed learning is a learning approach that requires the learner to establish learning goals and a learning plan in addition to employing active self-management and learning self-evaluation (Holec, 1979). The self-directed learning scale contains five items related to self-directed learning ability (Hung et al., 2010). An example item is as follows: "I carry out my own study plan."

Optimism plays a positive role in people's adaptation to stress and coping under challenging conditions. Optimism refers to an expectation of a favorable future outcome (Scheier and Carver, 1985). Eight items are included in the optimism scale (Scheier and Carver, 1985). An example item is as follows: "In uncertain times, I usually expect the best." After confirmatory factor analysis (CFA), three items for which the factor loading was considerably below 0.50 were excluded, and the remaining five items were used in the modeling (Kline, 2010).

Mental health refers to the positive state of an individual's well-being. Those who are in this state have favorable adaptability and can employ their full mental potential (Zhang et al., 2013). The mental health scale contains six items (Zhang et al., 2013). An example item is as follows: "I enjoy my life." In this study,

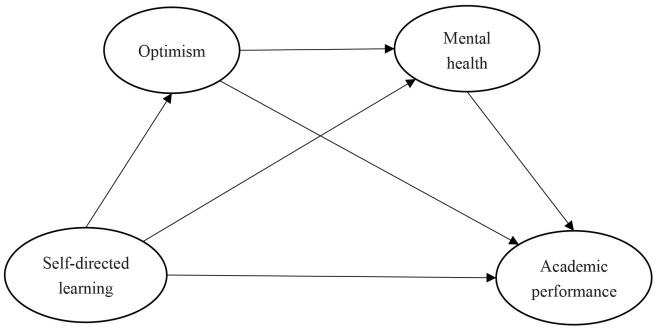

FIGURE 1 | Hypothetical model.

after CFA, one item with factor loading < 0.50 was excluded, and the remaining five items were used in the modeling (Kline, 2010).

Academic performance in the present study refers to the comprehensive ability of Chinese college students in terms of learning cognitive, communicative, and interpersonal skills required for their future endeavors (Li et al., 2016). The academic performance scale contains 14 questions in three parts: learning cognitive, communicative, and interpersonal abilities (Yang and Swekwi, 2021). An example item is as follows: "I can use the knowledge that I learned flexibly."

Participants

Because pandemic-related regulations in China would have severely hampered in-person surveying, an online questionnaire was employed for purposive sampling. Data were collected from 473 college students (age: 18–25 years) from three universities in Wuhan between April 1 and 15, 2020. All three universities, with the same educational goal, attempted to equip students for self-directed learning and implemented extensive and long-term training related to self-directed learning. To ensure students from all majors would be recruited, university counselors assisted the investigators in recruiting participants through the use of WeChat groups that included dormitory residents. After acknowledging their understanding of the study objectives, all respondents provided signed online informed consent. Respondents were informed that their data would remain confidential.

In total, 500 completed questionnaires were received, with 473 (94.6%) remaining after invalid questionnaires were excluded. Among the valid responses, 219 (46.3%) were from men and 254 (53.7%) were from women; 238 (50.3%) respondents were only children and 235 (49.7%) had siblings; 162 participants (34.2%) were freshmen, 79 (16.7%) were sophomores, 152 (32.1%) were juniors, and 80 (16.9%) were seniors (**Table 1**).

Analytical Method

AMOS and SPSS were employed for statistical analyses, and the hypothetical model was assessed through structural equation modeling (SEM). The measurement and structural models were also verified (Bollen, 1989; Schumacker and Lomax, 2004; Byrne, 2010; Kline, 2010). CFA was employed to test a reasonable measurement model. The association of the Students' data with the measurement mode was verified by using maximum-likelihood-estimated model parameters and fit indices obtained as statistical indicators. The statistical indicators were factor loadings per factor and measurement errors. Nine indicators of fit were calculated: normed chi-square (χ^2/df), root mean square residual (RMR), root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), normed fit index (NFI), comparative fit index (CFI), Tucker–Lewis index (TLI), parsimonious normed fit index (PNFI), and HOELTER0.05 (Bollen, 1989; Schumacker and Lomax, 2004). Furthermore, to confirm the reliability and validity of the measurement model, the Cronbach's α reliability coefficient, average variance extracted (AVE), and composite reliability (CR) were used. Harman's one-factor test was employed for common method variance (CMV) verification of the study variables (Podsakoff et al., 2003). A bootstrap method was used to verify the mediator roles.

Reliability and Validity

To evaluate the consistency of variables, Cronbach's α was used. The relevant values were 0.79, 0.84, 0.82, and 0.91 in the self-directed learning scale, optimism scale, mental health scale, and academic performance scale, respectively, indicating high consistency in the measurement results. For model calibration, this study deleted four items with factor loadings much lower than 0.50. Thus, 29 valid items remained (**Table 2**). As a final step, the item–objective congruences of the four scales were assessed by five experts; all items in

TABLE 1 | Demographic distribution of the sample.

Variables	Groups	N	%
Sex	Male	219	46.3
	Female	254	53.7
Only-child	No	235	49.7
	Yes	238	50.3
Age	18–25 years old	473	100
Grade	Freshman	162	34.2
	Sophomore	79	16.7
	Junior	152	32.1
	Senior	80	16.9

TABLE 2 | Questionnaire items employed in this research.

Var	Questionnaire items	M	SRW	Error variance	SE
SL	Q1: I carry out my own study plan.	3.49	0.70	12.55***	
	Q2: I seek assistance when facing learning problems.	3.62	0.54	14.16***	0.07
	Q3: I manage my time well.	3.22	0.76	11.48***	0.09
	Q4: I set up my learning goals.	3.53	0.74	11.84***	0.08
	Q5: I have high expectations for my learning performance.	3.99	0.53	14.23***	0.07
OP	Q1: In uncertain times, I usually expect the best.	3.50	0.63	13.89***	
	Q2: If things can go wrong, I generally end up fine.	3.24	0.63	3.92***	0.09
	Q3: I always look on the bright side of things.	3.50	0.81	11.15***	0.08
	Q4: I'm always optimistic about my future.	3.53	0.75	12.43***	0.08
	Q5: Things always work out the way I want them to.	3.34	0.73	12.86***	0.08
MH	Q1: I enjoy my life.	3.76	0.65	13.59***	
	Q2: I feel that my life is meaningful.	3.89	0.61	13.96***	0.09
	Q3: I can concentrate (for example, thinking, studying, and remembering) on what I want to do.	3.70	0.73	12.64***	0.09
	Q4: I can accept my appearance.	3.72	0.70	13.06***	0.10
	Q5: I am satisfied with myself.	3.61	0.75	12.29***	0.10
LCA	Q1: I can use the knowledge that I learned flexibly.	3.48	0.74	13.27***	
	Q2: I can easily understand what the teacher said in class.	3.47	0.78	12.63***	0.07
	Q3: I can quickly grasp the key to solving a problem.	3.48	0.84	11.16***	0.07
	Q4: I always understand new knowledge and new skills quickly.	3.51	0.81	12.10***	0.07
CA	Q1: I can communicate clearly with people.	3.68	0.72	13.35***	
	Q2: I know how to change the subject in conversations and can master basic talking points.	3.57	0.73	13.22***	0.07
	Q3: I am good at listening and don't like to interrupt others.	3.77	0.58	4.49***	0.07
	Q4: I can communicate with others face to face.	3.85	0.68	13.84***	0.06
	Q5: I am willing to take the initiative to communicate with others.	3.68	0.71	13.53***	0.07
IA	Q1: I always take the initiative to help other classmates.	3.73	0.75	12.67***	
	Q2: I can take care of other classmates very well.	3.70	0.73	12.92***	0.06
	Q3: In diverse situations, I can control my behavior effectively.	3.87	0.69	13.44***	0.06
	Q4: I cooperate very well with my classmates.	3.82	0.73	12.89***	0.06
	Q5: I get along well with other people.	3.94	0.73	12.94***	0.06

*M, mean; SRW, standardized regression weights; SE, standard error; SL, self-directed learning; OP, optimism; MH, mental health; LCA, learning cognitive ability; CA, communicative ability; IA, interpersonal ability. ***$p < 0.001$.*

these scales were determined to have high content validity. The model fit indices are presented in **Table 3**, and the AVE and CR values pertaining to the measurement model and variable correlation matrix are listed in **Table 4**. The 95% confidence intervals of the correlation coefficients for 2,000 bootstrap replications were calculated for discriminant validity (Torkzadeh et al., 2003).

TABLE 3 | CFA results of the model.

Model fit	Standard	Results
X^2/df	<3	2.48
RMR	<0.08	0.04
RMSEA	<0.08	0.06
GFI	>0.85	0.88
CFI	>0.9	0.92
NFI	>0.9	0.90
TLI	>0.9	0.91
PNFI	>0.5	0.78
HOELTER0.05	>200	215

The normality assessment revealed a Mardia coefficient of 286.14, which was lower than $N \times (N + 2) = 899$, with N being the number of questionnaire items; the absolute skewness and kurtosis values for the 29 items ranged from 0.04 to 0.61 and from 0.01 to 0.72, respectively. The results met the standard for the absolute value of skewness and kurtosis (both < 2; Curran et al., 1996), indicating normally distributed data.

CFA of the measurement model revealed an absence of negative error variances; moreover, all variances were significant. The factor loadings were all > 0.50 and < 0.95 (**Figure 2**), with no large standard errors (**Table 2**; Fornell and Larcker, 1981; Bagozzi and Yi, 2012). Thus, the measurement model was reasonable.

The model fit the data from the Wuhan students reasonably well, with the following fit index values: χ^2/df=2.48, RMR = 0.04, RMSEA = 0.06, NFI = 0.90, CFI = 0.92, GFI = 0.88, TLI = 0.91, PNFI = 0.78, and HOELTER0.05 = 215 (**Table 3**; Bollen, 1989; Schumacker and Lomax, 2004).

The measurement model's convergent validity and discriminant validity were subsequently assessed; its CR was > 0.60 and AVE was > 0.40 (Slater et al., 2007). Moreover, the CR and AVE of all variables were 0.80–0.87 and 0.44–0.63, respectively (**Table 4**). These results confirmed that the measurement model was acceptable and that it had convergent validity. The 95% confidence intervals of the correlation coefficients with 2,000 bootstrap replications were calculated; none of the confidence intervals in the lower and upper parameters included 1 (**Table 4**). Thus, the variables had discriminant validity (Torkzadeh et al., 2003).

Finally, because of epidemic prevention and control requirements, this study employed an online questionnaire to limit CMV (Peng et al., 2006). For CMV verification of the study variables, Harman's one-factor test was employed. Exploratory factor analysis was conducted for all 29 items included in the scales of this study, followed by testing of the unrotated factor analysis results. According to the results, the Kaiser–Meyer–Olkin statistic was 0.95, greater than the threshold of 0.80. The Bartlett test of sphericity also yielded a significant result ($p < 0.001$). The explanatory power of the first factor was 37% (threshold value: 50%), indicating that this study had no severe CMV problem (Podsakoff et al., 2003).

TABLE 4 | CR and AVE pertaining to the measurement model and variable correlation matrix.

Var	SL	OP	MH	LCA	CA	IA
SL	0.80 (0.44)					
OP	0.56 (0.46–0.65)	0.84 (0.51)				
MH	0.67 (0.57–0.76)	0.73 (0.66–0.80)	0.82 (0.48)			
LCA	0.72 (0.64–0.79)	0.70 (0.61–0.79)	0.70 (0.61–0.78)	0.87 (0.63)		
CA	0.58 (0.46–0.67)	0.72 (0.64–0.79)	0.74 (0.66–0.81)	0.77 (0.69–0.84)	0.82 (0.47)	
IA	0.45 (0.34–0.56)	0.57 (0.48–0.65)	0.64 (0.54–0.73)	0.58 (0.47–0.67)	0.86 (0.79–0.93)	0.85 (0.52)

The diagonal numbers are CR (AVE). The lower diagonal numbers denote the coefficients of correlation between two variables and 95% confidence intervals of correlation coefficients. CR, composite reliability; AVE, average variance extracted; SL, self-directed learning; OP, optimism; MH, mental health; LCA, learning cognitive ability; CA, communicative ability; IA, interpersonal ability.

RESULTS

Structural Model

SEM of the second-order model was used to obtain a structural model for examining the chain-mediating effect of two mediating variables, optimism and mental health, on the relation of self-directed learning with academic performance (**Figure 3**). The 29 items in the structural model had standardized regression coefficients of 0.55–0.84. The structural model exhibited a reasonable fit: $\chi^2/df = 2.69$, RMR = 0.05, RMSEA = 0.06, NFI = 0.90, CFI = 0.91, GFI = 0.86, TLI = 0.90, PNFI = 0.78, and HOELTER0.05 = 207 (**Table 5**; Bollen, 1989; Schumacker and Lomax, 2004).

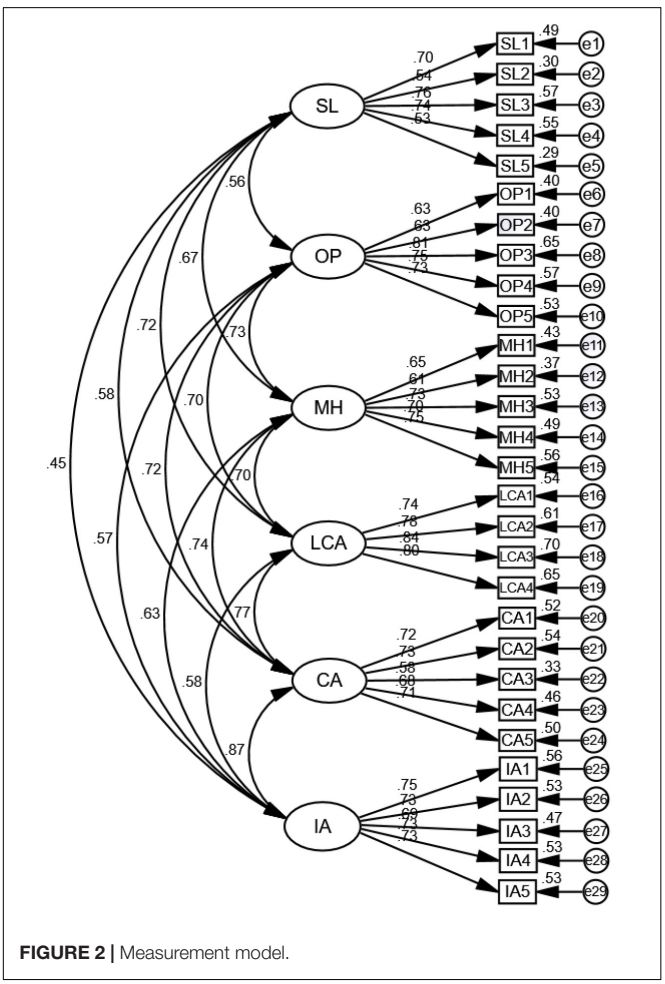

FIGURE 2 | Measurement model.

Direct Effect Analysis

As revealed in **Figure 3**, self-directed learning had positively directly influenced the college Students' academic performance ($\gamma = 0.19$, $p < 0.01$), and 32% of the variation in academic performance could be explained by self-directed learning. The 95% confidence interval of the aforementioned direct effect, as tested using the bias-corrected percentile bootstrap method, was 0.03–0.33 (**Table 6**); that the confidence interval did not include 0 indicated a direct effect, highlighting self-directed learning as a partial predictor of academic performance. Thus, Hypothesis 1 was confirmed.

Indirect Effect Analysis

According to the mediation model diagram constructed on the basis of the hypotheses of this study, three indirect effect paths existed between self-directed learning and academic performance.

First, self-directed learning directly positively influenced optimism ($\gamma = 0.56$, $p < 0.001$), and optimism exhibited a direct positive effect on academic performance ($\gamma = 0.37$, $p < 0.001$), with both of these effects being significant. The indirect impact through optimism was of size 0.21 ($\gamma = 0.56 \times 0.37$, $p < 0.01$), with γ referring to the outcome of the path values of Hypothesis 2 (**Figure 3**). The indirect influence of this path was determined using bias-corrected percentile bootstrapping with the 95% confidence interval; the resulting interval was 0.10–0.25, which excluded 0, indicating that the mediation effect of optimism in the first path was significant (**Table 6**); thus, Hypothesis 2 was confirmed and indicated a partial mediation because both direct and indirect effects were observed.

Second, self-directed learning exhibited a direct positive impact on mental health ($\gamma = 0.39$, $p < 0.001$), and mental health

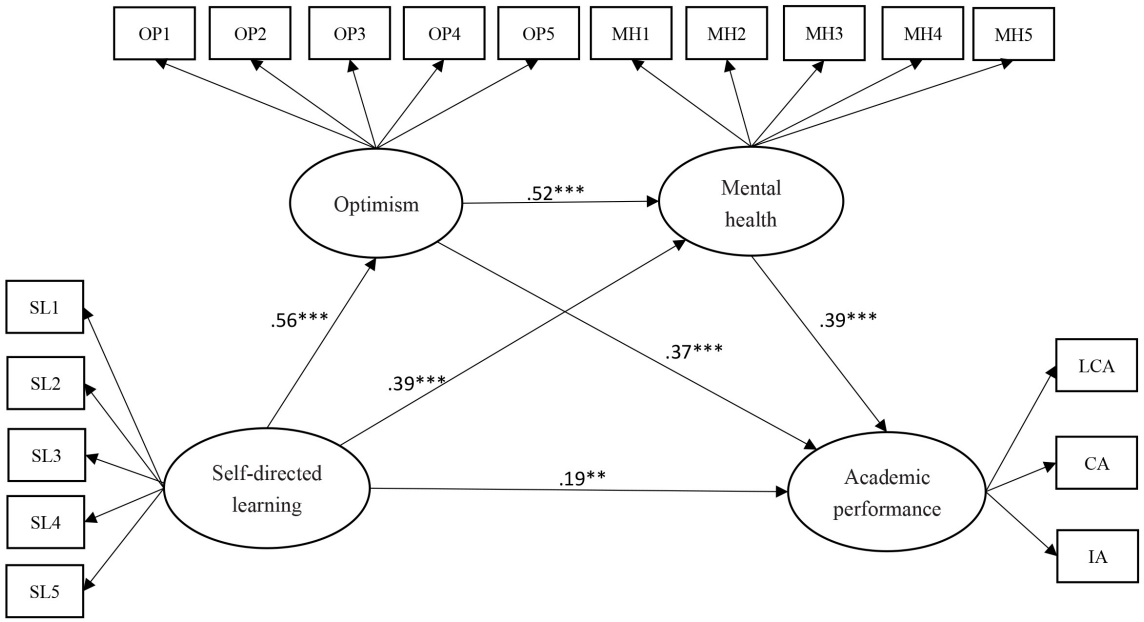

FIGURE 3 | Structural model. $^{**}p < 0.01$, $^{***}p < 0.001$.

positively directly influenced academic performance ($\gamma = 0.39$, $p < 0.001$), with both effects being significant. The indirect effect through mental health was of size 0.15 ($\gamma = 0.39 \times 0.39$, $p < 0.01$), with γ referring to the outcome of the path values of Hypothesis 3 (**Figure 3**). The bias-corrected percentile bootstrap method was used to assess the indirect influence of this path with the 95% confidence interval; the resulting confidence interval was 0.07–0.20, which excluded 0, indicating that mental health had a significant mediating effect in the second path (**Table 6**); thus, Hypothesis 3 was confirmed and indicated a partial mediation because both direct and indirect effects were present.

Third, self-directed learning had an effect on optimism ($\gamma = 0.56$, $p < 0.001$), optimism exhibited a direct positive effect on mental health ($\gamma = 0.52$, $p < 0.001$), and mental health positively influenced academic performance ($\gamma = 0.39$, $p < 0.001$), with all effects being significant. The indirect impact of self-directed learning on academic performance by means of two chain-mediating variables, optimism and mental health, was of size 0.11 ($\gamma = 0.56 \times 0.52 \times 0.39$, $p < 0.01$), with γ indicating the outcome of the path values of Hypothesis 4 (**Figure 3**). The bias-corrected percentile bootstrap method was used to assess the indirect influence of this path. The 95% confidence interval was 0.06–0.15, which excluded 0, indicating that the chain-mediated effects of mental health and optimism in the third path were significant (**Table 6**); thus, Hypothesis 4 was confirmed and reflected partial chain mediation because both direct and indirect effects were observed.

Total Effect Analysis

According to the preceding analysis (**Table 6**), the direct effect of self-directed learning on academic performance was of size 0.19 ($p < 0.01$). Self-directed learning's total indirect impact on academic performance was obtained by summing the effects of three indirect paths: $0.21 + 0.15 + 0.11 = 0.47$ ($p < 0.01$). The 95% confidence interval of the indirect effect was 0.37–0.59, which excluded 0, thus confirming the mediating effect. The model's total effect was $0.19 + 0.47 = 0.66$

TABLE 5 | Fit of the structural model.

Model fit	Standard	Results
X^2/df	<3	2.69
RMR	<0.08	0.05
RMSEA	<0.08	0.06
GFI	>0.85	0.86
CFI	>0.9	0.91
NFI	>0.9	0.90
TLI	>0.9	0.90
PNFI	>0.5	0.78
HOELTER0.05	>200	207

TABLE 6 | Bootstrap path effect analysis.

Effect	Path	Estimate	95% confidence interval	
Direct effect	SL→AP	0.19**	0.029	0.333
Indirect effect	SL→OP→AP	0.21**	0.104	0.247
	SL→MH→AP	0.15**	0.072	0.197
	SL→OP→MH→AP	0.11**	0.055	0.149
Total indirect effect	SL→AP	0.47**	0.373	0.589
Total effect	SL→AP	0.66**	0.545	0.766

$^{**}p < 0.01$. SL, self-directed learning; OP, optimism; MH, mental health; AP, academic performance.

($p < 0.01$). The 95% confidence interval of the bootstrap method was used for assessing the total effect, with the resulting interval being 0.55–0.77, which does not include 0; the total effect thus existed. Because total, direct, and indirect effects were present, the structural model was partially mediated; moreover, the three variables—self-directed learning, optimism, and mental health—explained 71.5% of the variation in academic performance.

DISCUSSION

Hypothesis 1 was verified by the results, thus confirming that Wuhan college Students' academic performance could be significantly positively predicted by their self-directed learning; this result is consistent with those of related studies (Zhou et al., 2010; Kim, 2017; Oducado, 2021). However, the link between these two variables was not straightforward in the current study. The results confirmed Hypotheses 2 and 3 and verified that optimism and mental health partially mediate the impact of self-directed learning on Wuhan college Students' academic performance. Furthermore, the results confirmed Hypothesis 4 and revealed that optimism and mental health, as two associated mediators, chain-mediate a partial relationship of self-directed learning with academic performance.

Self-determination theory suggests that spontaneous learning behavior can lead to more favorable learning outcomes (Deci and Ryan, 1985). The theoretical view has been confirmed in relevant studies into self-directed learning and academic performance (Zhou et al., 2010; Kim, 2017; Oducado, 2021), with the current results also verifying this perspective. In a context where online teaching has become normalized in most colleges and universities, Wuhan college Students' self-directed learning skills appeared particularly crucial. The degree to which students can self-direct their education not only their performance in college but also ensures the smooth development of online teaching (Zhang W. et al., 2020; Zhang X. et al., 2020; Zhang Z. et al., 2020). However, self-directed learning does not contribute to academic performance in a direct and simple manner, a result that differs from those reported in studies into the same topic.

In this study, self-directed learning was revealed to contribute indirectly to academic performance through the mediating effects of optimism and mental health. First, the results indicated that self-directed learning not only directly predicts academic achievement (Zhou et al., 2010; Kim, 2017; Oducado, 2021) but also predicts academic achievement through optimism. A part of the self-directed learning–academic performance relationship appears in an indirect process associated with optimism; self-directed learning makes a significant positive contribution to optimism (Elliot and Dweck, 1989), thereby becoming a significant positive predictor of Wuhan college Students' academic performance (El-Anzi and Owayed, 2005; Wang et al., 2011; Bai and Xie, 2018). According to self-determination theory and psychological capital theory, the indirect relationship suggests that self-determination behaviors can increase the strength of positive and optimistic emotions. Furthermore, optimism is described as a trait pertaining to psychological capital and that motivates individuals to attain superior outcomes and performance (Deci and Ryan, 1985; Luthans et al., 2015). Therefore, individuals with stronger self-learning skills may have more confidence and positive expectations regarding their learning skills and behavior; they are more likely to experience optimistic emotions and maintain highly effective academic performance. Thus, for Wuhan college students, spontaneous learning may be an approach that can stimulate optimistic emotions and result in positive academic outcomes (Deci and Ryan, 1985; Luthans and Youssef, 2007). Second, the relation of self-directed learning with academic achievement (Zhou et al., 2010; Kim, 2017; Oducado, 2021) is also partially mediated through mental health. The indirect process associated with mental health in the connection of self-directed learning with academic performance suggests that self-directed learning makes a significant positive contribution to mental health (Tuffin et al., 2001; Field, 2009; Chen, 2015; Teal et al., 2015), thereby serving as a significant positive predictor of the academic performance of Wuhan college students (Kantomaa et al., 2010; Bostani et al., 2014; Zhao, 2020). When viewed together, ecological systems theory and self-determination theory suggest that individuals who employ initiative in learning are more likely to meet their own expectations as well as those of their parents and society, thereby obtaining positive feedback and emotional support; such positive support, exchange, and communication protect the learner's mental health, which in turn provides support through a healthy psychological state for maximizing academic achievement (Maslow, 1954; Bronfenbrenner, 1992; Ryan and Deci, 2000; Luthans and Youssef, 2007). Thus, learning behaviors involving initiative may help Wuhan college students maintain a healthy psychological state, ensuring optimal academic outcomes.

The indirect relation of self-directed learning with academic performance, however, is not only mediated through optimism and mental health, independently. The optimism–mental health association indicated that optimism can serve as a significant positive predictor of mental health (Chang, 2002; Gustavsson-Lilius et al., 2007; Hanssen et al., 2014). The two mediators (optimism and mental health) thus constitute chain mediation and jointly mediate the partial relation of self-directed learning with academic performance among college students in Wuhan. That is, self-directed learning not only directly predicts the academic performance of Wuhan college students but also supports optimism, thus influencing mental health and predicting academic achievement. When regarded from the perspectives of self-determination theory, psychological capital theory, and ecological systems theory, the chain mediation may reveal that spontaneous learning behaviors provide people with a joyful emotional experience; joyful emotions have a positive effect on mental health, and this positive effect provides support through a healthy psychological state to ensure an individual's academic achievement (Maslow, 1954; Deci and Ryan, 1985; Bronfenbrenner, 1992; Ryan and Deci, 2000; Luthans et al., 2015). The current results, consistent with previously obtained findings, reveal that spontaneous learning behaviors may induce optimistic emotions in learners (Alkhedr, 1999; El-Anzi and Owayed, 2005), and optimistic individuals are more adept at preserving

a healthy psychological state to resist academic pressure (Zhang et al., 2011; Hanssen et al., 2014), thereby optimally benefiting learning outcomes (Bostani et al., 2014; Agnafors et al., 2020). The findings for Hypotheses 1–4 demonstrate that self-directed learning is essential to the academic outcomes of Wuhan college students. Online learning has become ubiquitous; thus, self-directed learning is an indispensable learning ability for Chinese college students, enabling them to adapt to online education and produce favorable learning outcomes (Zhang W. et al., 2020; Zhang X. et al., 2020; Zhang Z. et al., 2020). The benefit of self-directed learning for the learning outcomes of Wuhan college students may have greater relevance than merely suggesting that self-directed learning can predict academic performance in this population. In the chain mediation mechanism through which optimistic emotions are induced by self-directed learning, these positive emotions can help stimulate a healthy psychological state, which then affects academic performance. Thus, this chain mediation may reveal the importance of Wuhan college Students' self-directed learning for motivating them to maximize their achievement while participating in online education.

CONCLUSION

This study found that, during online teaching, self-directed learning serves as a significant positive predictor of the academic performance of college students, but it cannot completely explain the academic performance of these students. The relation of self-directed learning with academic performance can be partially chain-mediated through optimism and mental health.

Suggestions

This research proposes that self-directed learning is an essential learning method that can help Wuhan college students adapt to online education and obtain favorable learning outcomes because of the positive direct and indirect effects prompted by self-directed learning that lead to academic success. On the basis of the importance of self-directed learning for Wuhan college students, this research offers the following two recommendations for administrators of Chinese higher education and student managers:

First, online learning is a safer teaching mode in the current global pandemic context, and self-directed learning can be regarded as a prerequisite for the smooth implementation of online teaching (Zhang W. et al., 2020; Zhang X. et al., 2020; Zhang Z. et al., 2020). This study found that self-directed learning is a predictor of academic achievement. Therefore, Chinese universities (such as those in Wuhan city) should prioritize Students' self-directed learning skills, help these students develop into self-directed learners, and accommodate online education.

Second, the chain mediation results revealed that students with stronger self-directed learning skills may possess an optimistic mindset that also provides them with a healthy mental state for obtaining positive academic outcomes (Alkhedr, 1999; El-Anzi and Owayed, 2005; Zhang et al., 2011; Bostani et al., 2014; Hanssen et al., 2014; Agnafors et al., 2020). Therefore, the positive indirect effect of self-directed learning on academic performance may also serve as a reminder that higher education in China should follow the concept of constructivist teaching, in which students are encouraged to actively explore and discover knowledge as well as keenly construct the meaning of the knowledge they acquire (Piaget, 1980). Through this approach, students may become more optimistic and active by means of self-directed learning, thereby maintaining their mental health, resisting academic stress, and obtaining more favorable learning outcomes. Thus, this research recommends that counselors serve as guides for students in colleges and universities in China (Ministry of Education of the People's Republic of China, 2017), training these students in self-directed learning and helping them become active learners with an optimistic attitude and relaxed mental state during online teaching.

Limitations and Future Directions

Only the self-directed learning situation of Wuhan college students was investigated herein because Wuhan is the most representative area of where the pandemic first broke out in China. However, online teaching has also been applied in other countries and throughout China. Future research may compare the results obtained in diverse regions or countries.

Because of the restrictions related to pandemic prevention and control in China, this study collected data solely through an online survey questionnaire. In the present investigation of Wuhan college students, a group with long-term online learning experience because of the COVID-19 pandemic, only the survey method was employed and relevant behavioral details and manifestations of the interviewees could not be obtained. Therefore, if future policy permits, follow-up research may integrate face-to-face interviews to further supplement the research data.

This was a cross-sectional study, and only the potential relationships between variables could be analyzed using SEM. Future studies may use experimental techniques to examine the connection of self-directed learning with learning performance.

DATA AVAILABILITY STATEMENT

Other data pertaining to this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JL was the primary author of this research and prepared this article, which involved writing and data analysis. ZH worked as an investigator and a writer's assistant. DY prepared the research proposal and served as the research advisor for

specific matters. JL, DY, and ZH revised collaboratively the manuscript. All authors contributed to the article and approved the submitted version.

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Quality of Life and Depressive Symptoms Among Peruvian University Students During the COVID-19 Pandemic

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Objective: To determine the factors associated with quality of life and depressive symptoms in Peruvian university students during the COVID-19 pandemic.

Methods: Multicentre study in 1,634 students recruited by convenience sampling. The quality of life (QoL) was assessed with the European Quality of Life-5 Dimensions at three levels (EQ-5D-3L) and depressive symptoms with the Patient Health Questionnaire-9 (PHQ-9). To assess factors associated with QoL and depressive symptoms, linear regressions and fitted regressions were used, with robust coefficients of variance information (β).

Results: A 345 (21.1%) reported problems in performing daily activities, 544 (33.3%) reported pain and discomfort, 772 (47.2%) were moderately/very anxious or depressed. Furthermore, 207 (12.7%) had moderate-severe and severe depressive symptoms. Men reported better QoL than women (β: 3.2; 95% CI: 1.1, 5.4; p = 0.004) and fewer depressive symptoms (β: −0.7; 95% CI: −1.3, −0.2; p = 0.011). Ayacucho's residents had more depressive symptoms than Ancash's residents (β: 0.8; 95% CI: 0.1, 1.5; p = 0.022) and Piura's residents had fewer depressive symptoms than Ancash's residents (β: −1.195% CI: −1.8, −0.3, p = 0.005). Students who left home during quarantine reported more depressive symptoms (β: 0.7, 95% CI: 0.2, 1.2, p = 0.006).

Conclusion: Problems performing daily activities, pain and discomfort, as well as mild to severe depressive symptoms were found in more than three-quarters of the sample. Authorities could consider depression care to improve quality of life in regions where high rates of infection occurred during the pandemic.

Keywords: quality of life, depressive symptoms, student, university, COVID-19, pandemic, Peru

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INTRODUCTION

Coronavirus disease (COVID-19), classified as a pandemic by the World Health Organization (WHO), is a public health problem that has affected the entire world population. The disease has signs and symptoms similar to those of a common cold, but its complication in at-risk patients can be fatal (World Health Organization, 2020a). In September 2021, it had infected more than 200

million people worldwide and caused more than four million deaths (World Health Organization, 2020b). Latin America has been one of the most affected cities, with more than 40 million cases of COVID-19 and 1,477,000 deaths (Pan American Health Organization, 2020).

Measures to control the spread of COVID-19, such as a state of national emergency and mandatory social isolation (confinement) were declared, have led to changes in people's life routines that could affect their mental health (Brooks et al., 2020; Rajkumar, 2020). A recent review study in China and Singapore reported the prevalence of anxiety and depressive symptoms in the population in ranges of 6–50% and 14–48%, respectively (Pappa et al., 2020). Factors such as low income, being a woman and being unemployed significantly impair mental health in times of a COVID-19 pandemic (Mejia et al., 2020; Parrado-González, 2020). For example, in low-income countries such as Ethiopia, the prevalence of depressive and anxiety symptoms has been reported to be 46.2 and 48.1%, respectively (Necho et al., 2020). Similarly, the COVID-19 pandemic has hurt the quality of life of these populations. A study with the Bangladeshi residents found that more than 50% of respondents had decreased quality of life, mainly due to difficulties in meeting their basic needs, loss of jobs and barriers to accessing education (Mondal et al., 2021). A study in China found that 41.3% of people had depressive symptoms and a significantly lower quality of life (Ma et al., 2020). In Latin America, there is little literature on assessing the association between quality of life and depressive symptoms in times of pandemic (COVID-19), with only one study in a Brazilian population reporting high levels of depressive symptoms (41.9%) and anxiety symptoms (29.0%), which were associated with poorer quality of life (Vitorino et al., 2021).

In education, the rapid transmission of COVID-19 led to the suspension of face-to-face academic activities, affecting 91.3% of the global student population and 23.4 million higher education students in Latin America and the Caribbean, who had to adapt quickly to non-face-to-face education (Instituto Internacional para la Educación Superior en América Latina y el Caribe, 2020). A review study with more than 436,799 students from the United States and China found stress in 23%, anxiety in 29%, and depression in 37%, so that the abrupt adaptation to virtual education may have deteriorated the quality of life and mental health in this population (Wang et al., 2021). In Bangladesh, a high percentage of university students with depressive (54.5%) and anxious (42.9%) symptoms were reported (Islam et al., 2020). Also, in Europe, there are studies in Greece of 1,000 university students who reported prevalences of 42.5% for anxiety, 74.3% for depression, 63.3% suicidal thoughts, and quality of life has worsened by 43.0% (Kaparounaki et al., 2020). In Italy, a study of 655 university students reported feelings of sadness (51.3%), nervousness (64.6%), irritability (57%), difficulty concentrating (55.9%), difficulty sleeping (54.5%), eating disorders (73.6%), tachycardia (65%), and a tendency to cry (65%) (Commodari et al., 2021).

Peru has been a country most affected by the COVID-19 pandemic. The confinement affected the education of Peruvian students due to economic hardship and the digital divide (internet connectivity and computer use). This action led the government to implement economic policies for Peruvian families and the education sector, such as the issuance of economic bonds, educational credits, connectivity, and scholarships (Figallo et al., 2020; Contraloría General de la República, 2021). For example, the National Institute of Statistics and Informatics revealed that during 2020, monetary poverty of Peruvian households amounted to 30.1%, increasing 10 percentage points from the previous year, affecting mainly 45.7% of the rural population and 26.0% of the urban population. Moreover, 85.7 and 82% of these poor households do not have a computer or Internet access, respectively (Instituto Nacional de Estadística e Informática, 2021), there are only studies before the COVID-19 pandemic in Peru where they reported low levels of quality of life and the presence of depressive symptoms in 52.2 and 24.6% of the university population, respectively (Kuong and Concha, 2017; Diaz-Godiño et al., 2019).

Given the above, there is little research in Latin America and non-existent in Peru on the evaluation of the quality of life (QoL) situation associated with depressive symptomatology and the associated factors of the same, in a population of university students in times of COVID-19, considering that the current pandemic situation generates a greater state of vulnerability (Puthran et al., 2016; Ribeiro et al., 2018), making it difficult to implement programmes and interventions to improve mental health and quality of life in the face of such a state of emergency (Figallo et al., 2020). Therefore, this study determined the factors associated with quality of life and depressive symptomatology in Peruvian university students during COVID-19.

MATERIALS AND METHODS

Study Design

We conducted a multicentre cross-sectional study of students at a private university in four regions of Peru (Ancash, Ayacucho, Lima, and Piura), with large student populations and entrenched socio-cultural differences between July and August 2020.

Participants

The study participants were 1,634 university students from four regions of Peru (Ancash, Ayacucho, Lima, and Piura), which were obtained from a non-probabilistic convenience sampling, with an online survey sent through social networks (WhatsApp and email), where informed consent was presented through the presentation of the problem and the objective of the study, to subsequently decide the option to voluntarily participate in filling out the questionnaire; those who agreed to participate in the study answered all the questions of the data collection instrument. The eligibility criteria for a student to participate in the study were as follows: (i) Being over 18 years of age, (ii) Residing in the pandemic crisis within the regions of Peru, where the study was conducted, and (iii) Students studying at the undergraduate level within the private university where the data were collected. On the other hand, the only exclusion criterion was to exclude participants who did not fully answer the questions in the questionnaires. However, it is important to mention that it was impossible to take into account the

evaluation of previous psychiatric comorbidities, because at the time of data collection, it was not feasible in Peru due to the restrictions established.

Procedures

The electronic survey generated for the study followed the quality improvement recommendations for web-based surveys based on the Checklist for reporting results of Internet e-surveys (CHERRIES) (Eysenbach, 2012).

The development and data collection of the electronic instrument was carried out through the Survey Monkey virtual platform (Survey Monkey, 1999). Initially, this electronic instrument consisted of an introduction explaining the composition of the work team, the objectives of the study, anonymity, confidentiality of the data and the use of the information for scientific purposes only. Subsequently, students were given informed consent to continue with the survey. The time to complete the questionnaire was 15 min.

The survey was promoted through emails and university student study groups (WhatsApp), between the period of July and August 2020. Participants were free to opt out of the questionnaire at any time, without explanation, and were not asked to identify themselves due to the confidentiality of the information. Finally, all the surveys completed by university students were securely stored using a password-protected database.

Variables

The primary variables were quality of life (QoL) and depressive symptomatology in university students from four regions of Peru. The QoL variable was measured through the European Quality of Life-5 Dimensions questionnaire in three levels (EQ-5D-3L) (EuroQol, 2017), composed of five items that respond to five dimensions (Mobility, Self-care, Daily activities, Pain or Discomfort, Depression or Anxiety), with three levels of response (absence, moderate presence, and severe presence). It also has a visual analog scale (EQ-VAS) that reports current life status on a range from 0 (worst status) to 100 (best status), this last indicator of QoL. We used the cultural adaptation of the EQ-5D-3L translated into Spanish available for Peru, carried out by the EuroQol Group, which was responsible for the original instrument and its theoretical validation (Herdman et al., 2003). The EQ-5D-3L is a widely used instrument worldwide to assess quality of life. Some studies have conducted psychometric validity of this instrument, reporting adequate indicators of discriminant validity (Shannon's H′: 0.47 and 0.98) and good reliability (weighted Kappa $_{w}$K: 0.39–0.93); however, this type of validation was performed on the original version (Buchholz et al., 2018). On the other hand, there are few psychometric validation studies in the Spanish-speaking version using the general and/or clinical population (García-Gordillo et al., 2015). In Peru, this type of validation has not yet been conducted; however, several studies in the country report similar and consistent results within this geographical context (Taype-Rondan et al., 2017; Figueroa-Quiñones et al., 2019).

The Patient Health Questionnaire-9 (PHQ-9) was used for the variable depressive symptoms. It is a nine-item self-administered questionnaire with five response levels according to the frequency of depressive symptoms in the last 2 weeks: not at all, several days, more than half of the days, and almost every day. The total score is within the range of 0 to 27 points. Depressive symptoms are also reported according to severity levels: minimal (0–4), mild (5–9), moderate (10–14), moderate-severe (15–19), and severe (20–27) (Spitzer et al., 1999; Kroenke et al., 2001; Cameron et al., 2008). This questionnaire has been validated in the Peruvian population, presenting indicators of psychometric properties through confirmatory factor analysis (CFI = 0.936, TLI = 0.914, RMSEA = 0.089 and SRMR = 0.039) and reliability of Cronbach's Omega and Alpha indicators ($\omega = 0.87$ and $\alpha = 0.87$), interpreted in such a way because many indicators such as CFI and TLI are close to 0.90; the RMSEA at 0.08 and the SMRM is lower than 0.08; while, for reliability, the values of Cronbach's omega and alpha indexes are higher than the optimal point (0.80) (Villarreal-Zegarra et al., 2019).

The covariates that participated in the study were age (in tertiles), sex (male or female), regions of residence (Ancash, Ayacucho, Lima, and Piura), marital status (single, separated, widowed, divorced, and married or partner), occupation (studying and working or only working), left home during quarantine (no and yes), decrease in family income in quarantine (no and yes), lives alone (no and yes) and family with chronic disease (no and yes).

Data Analysis

A descriptive analysis was presented using measures of central tendency and dispersion (for numerical variables) and absolute frequencies (for categorical variables). We performed linear regression with robust variance reporting crude, adjusted model with coefficients (β) and their 95% confidence intervals (CI95%) to evaluate the association of the factors associated with the EQ-VAS (quality of life) and PHQ-9 (depressive symptoms) scores. In all cases, variables that obtained a $p < 0.20$ in the crude model were included in the adjusted model. Analyses were performed in Stata v15.0 statistical software (StataCorp, 2017).

Ethics Statement

This study was reviewed and approved by the Ethics Committee of the Universidad Católica Los Ángeles de Chimbote (Los Angeles de Chimbote Catholic University). In addition, the study was anonymous and voluntary, so it does not pose a risk to participants who accepted their participation with the online-informed consent. With the approval of the ethics committee and the ethical steps followed for data collection, we sought to ensure compliance with the National Commission for the Protection of Human Subjects of Biomedical and behavioral Research (Commission for Protection of Human Subjects of Biomedical and Behavioral Research, 1978).

RESULTS

The 1,825 participants were initially recruited, of which 65 did not agree to participate in the study and 126 did not complete the entire survey; therefore, only 1,634 (89.5%) university students

participated in the study. The participants were distributed according to the region of residence: 712 (43.6%) are from Ayacucho, 347 (21.2%) from Ancash, 342 (20.9%) from Piura and, 233 (14.3%) from Lima (**Table 1**).

Participants had a median age of 24 years (interquartile range: 20–30 years), 1,146 (70.1%) were women, 1,270 (77.7%) reported being single, separated, widowed, or divorced. University students studying and working at the same time were 842 (51.5%) with a significant prevalence in Lima. 879 (53.8%) of the university students reported leaving home during quarantine, 1,511 (92.5%) had a decrease in family income, 1,502 (91.9%) declared not living alone and 959 (58.69%) had a family member with a chronic disease (**Table 1**).

On the quality of life during the pandemic, 345 (21.1%) reported problems in carrying out daily activities, 544 (33.3%) reported pain and discomfort and 667 (40.8%) reported being moderately anxious or depressed and 105 (6.4%) reported being severe anxious and depressed (**Table 2**).

In addition, 741 (45.4%) students had mild and moderate depressive symptoms, while 207 (12.7%) had moderate-severe and severe depressive symptoms (**Table 3**).

The univariate analysis reported that during the COVID-19 pandemic, being male and residing in Lima or Piura were associated with higher EQ-VAS (quality of life) scores; whereas, being between 22 and 27 years of age, is dedicated only to study, residing in the Ayacucho region, leaving home during quarantine, suffering a decrease in family income during quarantine, having a family member with chronic illness and depressive symptom scores decreased QoL scores (**Table 4**).

In multivariate analysis, men reported better quality of life than women (β: 3.2; 95% CI: 1.1, 5.4; $p = 0.004$), and men also had fewer depressive symptoms (β:−0.7; 95% CI: −1.3, −0.2; $p = 0.011$). Those residing in Ayacucho had more depressive symptoms than those residing in Ancash (β: 0.8; 95% CI: 0.1, 1.5; $p = 0.022$) and those residing in Piura had fewer depressive symptoms than those residing in Ancash (β:−1.1; 95% CI: −1.8, −0.3; $p = 0.005$) and, finally, students who left home during quarantine had more depressive symptoms than those who did not (β: 0.7; 95% CI: 0.2; 1.2; $p = 0.006$) (**Table 4**).

On the other hand, factors associated with PHQ-9 scores (depressive symptoms) reported that all variables were significantly associated. However, after adjusting the model with all variables, we were find that these were still significant: residing in the region of Ayacucho, leaving home in quarantine, and having a family member with chronic disease have higher scores for depressive symptoms; while being male, residing in the region of Piura and higher QoL score decrease scores for depressive symptoms. Our positive relationship results concerning depressive symptom scores show that university students residing in Ayacucho have higher scores compared to

TABLE 1 | Characteristics of the populations studied.

Variables	Total (n = 1 634)	Ancash (n = 347)	Ayacucho (n = 712)	Lima (n = 233)	Piura (n = 342)
Age: Median (IQR)	24 (20–30)	22 (20–27)	24 (21–30)	22 (19–28)	30 (21–42)
Age in tertiles (years)					
16–21	575 (35.2)	151 (43.5)	198 (27.8)	66 (28.3)	160 (46.8)
22–27	524 (32.1)	110 (31.7)	282 (39.6)	36 (15.5)	96 (28.1)
28–65	535 (32.7)	86 (24.8)	232 (32.6)	131 (56.2)	86 (25.1)
Sex					
Female	1,146 (70.1)	259 (74.6)	491 (69.0)	145 (62.2)	251 (73.4)
Male	488 (29.9)	88 (25.4)	221 (31.0)	88 (37.8)	91 (26.6)
Marital status					
Singer/separate/widowed/divorced	1,270 (77.7)	282 (81.3)	555 (77.9)	156 (66.9)	277 (81.0)
Married/partner	364 (22.3)	65 (18.7)	157 (22.1)	77 (33.1)	65 (19.0)
Occupation					
Study and work	842 (51.5)	153 (44.1)	392 (55.1)	146 (62.7)	151 (44.2)
Only study	792 (48.5)	193 (55.9)	320 (44.9)	87 (37.3)	191 (55.8)
Left home in quarantine					
No	755 (46.2)	120 (34.6)	332 (46.6)	113 (48.5)	190 (55.6)
Yes	879 (53.8)	227 (65.4)	380 (53.4)	120 (51.5)	152 (44.4)
Decreasing family financial income in quarantine					
No	123 (7.5)	25 (7.2)	39 (5.5)	27 (11.6)	32 (9.4)
Yes	1,511 (92.5)	322 (92.8)	673 (94.5)	206 (88.4)	310 (90.6)
Lives alone					
No	1,502 (91.9)	317 (91.3)	636 (89.3)	214 (91.9)	335 (97.9)
Yes	132 (8.1)	30 (8.7)	76 (10.7)	19 (8.1)	7 (2.1)
Family member with disease					
No	959 (58.7)	197 (56.8)	461 (64.8)	116 (49.8)	185 (54.1)
Yes	675 (41.3)	150 (43.2)	251 (35.2)	117 (50.2)	157 (45.9)

IQR, interquartile range.

TABLE 2 | Quality of life in Peruvian university students during the COVID-19 pandemic.

Quality of life	n (%)
Mobility	
I have no problems walking	1,526 (93.4)
I have some problems walking	91 (5.6)
I have to be in bed	17 (1.0)
Personal care	
I have no problems with the personal care	1,558 (95.4)
I have some problems washing myself	69 (4.2)
I'm unable to wash or dress myself	7 (0.4)
Daily activity	
I have no problems in performing my activities	1,284 (78.6)
I have some problems to performing my activities	345 (21.1)
I'm unable to performing my activities.	5 (0.3)
Pain or discomfort	
I have no pain or discomfort	1,052 (64.4)
I have moderate pain or discomfort	544 (33.3)
I have a lot of pain or discomfort	38 (2.3)
Anxiety or depression	
I'm not anxious or depressed	862 (52.8)
I'm moderately anxious or depressed	667 (40.8)
I'm very anxious or depressed	105 (6.4)
EQ-VAS total	
Median (SD)	76.0 (25.6)

SD, standard deviation.

TABLE 3 | Depressive symptoms in Peruvian university students during the COVID-19 pandemic.

Depressive symptoms	n (%)
Depression	
Minimum	686 (42.0)
Mild	475 (29.1)
Moderate	266 (16.3)
Moderate-severe	132 (8.1)
Severe	75 (4.59)

those residing in Ancash (β = 0.8, 95% CI = 0.1 to 1.5), those residing in Ancash (β = 0.8, 95% CI = 0.1 to 1.5) and those residing in Piura (β = 0.8, 95% CI = 0.1 to 1.5), those who were quarantined compared to those who were not (β = 0.7, 95% CI = 0.2 to 1.2) and having a family member with a chronic illness presented higher scores in depressive symptomatology compared to those who did not have family members with an illness (β = 1.5, 95% CI = 1.0 to 2.1); the latter factor being the biggest problem. Meanwhile, concerning the negative relationship, men had lower scores than women (β = −0.7, 95% CI = −1.3 to −0.2), with residents of the region of Piura having lower scores than those residing in Ancash (β = −1.1, 95% CI = −1.8 to −0.3). Finally, the quality of life scores decreased by 1 quality of life points increased by 0.1 points in depressive symptoms (β = −0.1, 95% CI = −0.2 to −0.1) (**Table 4**).

DISCUSSION

University students in relation to QoL during the pandemic reported some problems in performing daily activities 345 (21.1%), pain and discomfort in 544 (33.3%) and reported being moderately anxious or depressed in 667 (40.8%) and severe anxious and depressed in 105 (6.4%). Furthermore, the PHQ-9 reported that 741 (45.4%) had mild and moderate depressive symptoms, while 207 (12.7%) had moderate-severe and severe depressive symptoms. These results are consistent with the study conducted in Vietnamese university students during the COVID-19 pandemic, which reported greater impairment in the anxiety/depression and pain/discomfort dimensions of QoL (Tran et al., 2020). Another study with young Chinese adults reported similar impairment in QoL dimensions during the pandemic (Ping et al., 2020). These findings may possibly be due to bereavement over the death of students' family members, isolation and reduced physical activities (Hamid and Jahangir, 2020) and fear caused by overexposure to the media and the high lethality of the virus (Mejia et al., 2020), which may have increased symptoms of anxiety or depression. In addition, the long months of confinement resulted in constant exposure to stress and often manifested in pain and discomfort (Esquivel-Acevedo et al., 2020). On the other hand, non-face-to-face education meant that the student had to sit in front of the computer for a long time, choosing postures that provided comfort, however, incorrect body postures could have generated pain and tension (Yang et al., 2020).

On the other hand, males reported better QoL than females (β: 3.2; 95% CI: 1.1, 5.4; p = 0.004) and fewer depressive symptoms (β:−0.7; 95% CI: −1.3, −0.2; p = 0.011). This result could be explained by several factors; for example, women nowadays have more responsibilities in the work environment and during confinement the with family support needs (e.g., family caregivers) has increased, leading to more stress, and depression (Verma and Mishra, 2020; Wang et al., 2020). Moreover, confinement as a measure to prevent the spread of COVID-19 and the inability to interact socially with peers has a negative impact on mental health (Brooks et al., 2020; Palgi et al., 2020). Likewise, the new normality that was accompanied by sedentary behavior adopted by students due to non-face-to-face education and financial insecurity for educational expenses may have increased depressive symptoms in university students (Huckins et al., 2020; Islam et al., 2020), as well as; it may have been a reaction associated with confinement and habit changes (Vásquez et al., 2020).

Residents in Ayacucho presented greater depressive symptomatology than those in Ancash (β: 0.8; 95% CI: 0.1; 1.5; p = 0.022) and residents in Piura had less depressive symptomatology than those in Ancash (β:−1.1 95% CI: −1.8; −0.3; p = 0.005). This result could be explained by the fact that during the evaluation months of our study, the rate of COVID-19 infections and deaths in Piura had decreased, while in Ayacucho, in rural Peru, it was at its highest peak (Plataforma digital única del Estado Peruano, 2020).

In addition, students who left home during the quarantine were find to have greater depressive symptoms than those who

TABLE 4 | Factors associated with quality of life and depressive symptoms in Peruvian university students during the COVID-19 pandemic.

Variables	Quality of life				Depressive symptoms			
	Crude β (IC95%)	p	Full β (IC95%)	p	Crude β (IC95%)	p	Full β (IC95%)	p
Age								
16–21		REF				REF		
22–27	−3.4 (−6.5; −0.3)	0.032	−2.3 (−5.0; 0.4)	0.101	0.51 (−0.2; 1.2)	0.170	−0.1 (−0.6; 0.6)	0.986
28–65	−0.29 (−3.2; 2.6)	0.846	−2.0 (−4.8; 0.8)	0.164	−0.76 (−1.5; −0.1)	0.034	−0.6 (−1.3; 0.2)	0.120
Sex								
Female		REF				REF		
Male	7.0 (4.5; 9.4)	0.000	3.2 (1.1; 5.4)	0.004	−1.7 (−2.3; −1.1)	0.000	−0.7 (−1.3; −0.2)	0.011
Marital status								
Singer/separated/widowed/divorced		REF				REF		
Married/partner	1.7 (−1.2; 4.5)	0.239	–	–	−1.1 (−1.7; −0.4)	0.002	−0.5 (−1.2; 0.1)	0.112
Occupation								
Study and work		REF				REF		
Only study	−2.0 (−4.5; 0.5)	0.118	−0.7 (−3.0; 1.7)	0.565	0.8 (0.2; 1.4)	0.006	0.4 (−0.1; 0.9)	0.145
Places of residence								
Ancash		REF				REF		
Ayacucho	−3.5 (−6.8; −0.2)	0.040	−2.1 (−4.8; 0.8)	0.151	0.9 (0.1; 1.7)	0.039	0.8 (0.1; 1.5)	0.022
Lima	4.0 (0.1; 7.9)	0.043	0.6 (−2.8; 4.1)	0.719	−1.6 (−2.5; −0.6)	0.001	−0.7 (−1.5; 0.2)	0.116
Piura	3.6 (0.0; 7.3)	0.049	0.1 (−3.0; 3.3)	0.933	−1.6 (−2.5; −0.8)	0.000	−1.1 (−1.8; −0.3)	0.005
Went out of the house during quarantine								
No		REF				REF		
Yes	−3.2 (−5.7; −0.7)	0.012	−0.9 (−3.1; 1.2)	0.396	1.1 (0.5; 1.7)	0.000	0.7 (0.2; 1.2)	0.006
Decreasing family financial income in quarantine								
No		REF				REF		
Yes	−8.1 (−11.6; −4.6)	0.000	−3.4 (−6.5; −0.3)	0.034	1.9 (0.8; 2.9)	0.000	0.7 (−0.2; 1.6)	0.141
Lives alone								
No		REF				REF		
Yes	−2.1 (−7.1; 3.0)	0.420	–	–	0.8 (−0.4; 2.0)	0.179	0.5 (−0.6; 1.5)	0.383
Family member with chronic disease								
No		REF				REF		
Yes	−8.7 (−11.2; −6.1)	0.000	3.7 (−6.1; 1.4)	0.002	2.4 (1.8 – 3.0)	0.000	1.5 (1.0; 2.1)	0.000
Depressives symptoms^{+}/quality of life^{++}	−2.1 (−2.3; −1.9)	0.000	−2.0 (−2.2; −1.8)	0.000	−0.1 (−0.2; −0.1)	0.000	−0.1 (−0.2; −0.1)	0.000

$^{+}$Depressives Symptoms was obtained from the Patient Health Questionnaire-9 (PHQ-9) total score. $^{++}$Quality of life was obtained from the Visual Analog Scale (EQ-VAS).

were compliant with staying at home (β: 0.7; 95% CI: 0.2, 1.2; $p = 0.006$). Possibly a reason why university students were forced to leave home was the loss of family income, which implies difficulties in accessing treatment, medication and living expenses, affecting the quality of life and leading to the onset of some depressive symptoms (Kretchy et al., 2020; Ping et al., 2020; Tran et al., 2020). A study in China with university students also reported mental health problems due to COVID-19 (Wang and Zhao, 2020). It is important to note that other studies show that these mental health problems are more prominent in students within the adolescent stage (Commodari and La Rosa, 2020) and most likely the entire increase is due to the COVID-19 pandemic; however, the extent of influence of the changes themselves has so far not been determined (i.e., mood and mental impairment) o of this stage in mental health reports (Commodari and La Rosa, 2020). Another reason may have been that this age group, according to case-fatality reports, had a lower mortality risk than adults and the elderly, but the fear of bringing the virus home and infecting their family members may have generated the depressive symptoms (Figueroa-Quiñones and Ipanaqué-Neyra, 2020; Johnson et al., 2020). Depressive symptoms influence and impact the quality of life of university students (Gan and Yuen Ling, 2019).

The strength of our study is that it is the first study to report up-to-date evidence on the quality of life and mental health status of university students in Peru after the confinement of the COVID-19 pandemic. However, the study has some limitations. Due to the confinement by COVID-19, is the non-probabilistic nature of the sampling, which affects the representativeness of the study sample and the probable impossibility of generalizing the results obtained; however, a significant sample size was achieved in different cities of Peru, which produces consistent evidence of university students, and the results obtained were similar to other studies conducted (Chang et al., 2020; Tran et al., 2020). Another

limitation of the study was that it did not take into account the inclusion of any restrictions on particular clinical characteristics, the subjects may have had previous psychiatric comorbidities, so the problems found may possibly be slightly inaccurate, and it is recommended that future studies include previous history or mental health treatment. Likewise, the instrument used (EQ-5D-3L) to assess psychometric quality of life was not validated in Peru, however, this instrument has been used in other studies and populations in Peru (Taype-Rondan et al., 2017; Figueroa-Quiñones et al., 2019), moreover, it was translated into Spanish by the EuroQol Group and has been adapted in other countries and languages (EuroQol, 2017).

CONCLUSION

It is concluded that university students reported some problems in performing daily activities, pain and discomfort, as well as mild to severe depressive symptoms in more than three quarters of the sample in relation to their QoL during the pandemic. Therefore, our health authorities also consider psychological interventions to reduce depressive symptoms and improve QoL. On the other hand, men reported better QoL than women and lower depressive symptoms. The female students would be a priority in the Peruvian university population for managing depressive symptoms. In addition, Ayacucho's residents had higher depressive symptoms than Ancash's residents and Piura's residents reported lower depressive symptoms than Ancash's residents. Health authorities might therefore consider addressing depression in pandemics in settings with high infection rates of infection are reported. A clear example is the professional associations of psychology in the cities of Peru most affected by depression should work in coordination with the health and university sectors to design plans and actions for prevention, detection and subsequent emotional support for their students with depressive symptomatology through virtual platforms (electronic devices, hotlines and internet) and to be able to provide immediate professional help to students affected during COVID-19.

It has also been found that students who left home during quarantine had more depressive symptoms than those who did not. Therefore, education authorities also provide contingency plans for students in pandemic situations, as the lack of resources often forces them to leave home. Universities in Peru could mitigate such depressive symptoms in students by generating a more effective promotion of care programmes with a psychological specialist, while it is true that such attention promotion exists, the impact on students is mostly low. The increase in student scholarships and the reduction of pension costs by universities and/or subsidies and economic bonuses for families by the government could also help reduce students' worries about paying for their studies, considering that in an undeveloped country, many university students must study and work simultaneously to survive and achieve their academic goals.

Furthermore, suicidal tendencies are prevalent behavior in subjects with anxiety/depression problems and are often complicated by underlying pathophysiological factors and due to our findings in the current context by COVID-19 we believe that it might increase the risk for subjects' mental health and quality of life. Therefore, mental health authorities should plan assessments, interventions and treatments in clinical practice for affected students.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://doi.org/10.7910/DVN/93WCEZ.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Research Ethics Committee of Los Angeles Catholic University of Chimbote. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JF-Q carried out the administration of the manuscript. MI-Z performed the methodology, data retention, formal analysis, and supervision of the manuscript. JF-Q and MI-Z were responsible for the visualization and validation of the manuscript. JC was responsible for the acquisition of funds for the manuscript. JF-Q, JC, DM-P, and MI-Z were responsible for the preparation of the first report and the final version of the original manuscript. All authors contributed to the article and approved the submitted version.

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E-Learning Research Trends in Higher Education in Light of COVID-19: A Bibliometric Analysis

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This paper provides a broad bibliometric overview of the important conceptual advances that have been published during COVID-19 within "e-learning in higher education." E-learning as a concept has been widely used in the academic and professional communities and has been approved as an educational approach during COVID-19. This article starts with a literature review of e-learning. Diverse subjects have appeared on the topic of e-learning, which is indicative of the dynamic and multidisciplinary nature of the field. These include analyses of the most influential authors, of models and networks for bibliometric analysis, and progress towards the current research within the most critical areas. A bibliometric review analyzes data of 602 studies published (2020–2021) in the Web of Science (WoS) database to fully understand this field. The data were examined using VOSviewer, CiteSpace, and KnowledgeMatrix Plus to extract networks and bibliometric indicators about keywords, authors, organizations, and countries. The study concluded with several results within higher education. Many converging words or sub-fields of e-learning in higher education included distance learning, distance learning, interactive learning, online learning, virtual learning, computer-based learning, digital learning, and blended learning (hybrid learning). This research is mainly focused on pedagogical techniques, particularly e-learning and collaborative learning, but these are not the only trends developing in this area. The sub-fields of artificial intelligence, machine learning, and deep learning constitute new research directions for e-learning in light of COVID-19 and are suggestive of new approaches for further analysis.

Keywords: e-learning, higher education, COVID-19, bibliometric analysis, Web of Science (WoS) database

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INTRODUCTION

The idea of e-learning was originated in the 1990s to explain learning thoroughly through technical advances. When instructional architecture and technologies have advanced, more attention has been paid to studying with the pedagogy. University education, further education, and e-learning have also recently adopted prominent roles in e-learning, too. It is now possible to provide e-learning for off-the-formal training through the internet. It also increased the need for personalization and advanced social people's tools (Siemens, 2005). In addition, it is often referred to as being able to read. It will help mix much learning more conveniently, but it has to be done, given the success of "traditional" e-learning pages. When the educational and technological assets join, this will be something more than a personal matter.

The COVID-19 pandemic has forced the closure of many activities, especially educational activities. To limit the spread of the pandemic, universities, institutes, and academic schools had to switch to e-learning using the available educational platforms. Social distancing is critical, and the COVID-19 pandemic has brought an end to face-to-face education, negatively impacting educational activities (Maatuk et al., 2021). This closure has stimulated the growth of distance education activities as an alternative to face-to-face education in their various forms. Accordingly, many universities have shared the best ways to deliver course materials remotely, engage students, and conduct assessments.

The concept of e-learning, although widely known has not yet been fully explored (Nicholson, 2007). Many countries designed and deployed distance education systems during the COVID-19 pandemic to ensure that higher education could continue without interruption (Tesar, 2020). Several opportunities and challenges related to e-learning, higher education, and COVID-19 arose as a result of this, prompting a flurry of research into the area. When looking at the scientific studies published during the COVID-19 pandemic, it shows clearly that many international journals have published a large number of academic articles about e-learning in higher education during COVID-19 (Karakose and Demirkol, 2021). Furthermore, a vast amount of bibliometric research has been carried out in this field. However, there is very little research focused entirely on the relationship between e-learning, higher education, and COVID-19, using scientometric or bibliometric analysis (Furstenau et al., 2021).

This paper will discuss bibliometric indicators for e-learning in higher education during COVID-19 studies and proceed with a network analysis to define the most important sub-areas in this topic. To define the trends of e-learning in higher education during COVID-19, the following questions are proposed:

Q1: What are the most important sub-fields of e-learning in higher education in light of COVID-19?

Q2: Who are the most influential authors on the subject of e-learning in higher education in light of COVID-19?

Q3: What countries and research institutions are the most referenced for research on the subject of e-learning in higher education in light of COVID-19?

Q4: What are the research gaps and recent trends in the subject of e-learning in higher education in light of COVID-19?

An analysis was conducted to provide a broad and long-term perspective on the vocabulary of learning publications. It helps to recognize emerging problems within the multifaceted and increasing study fields of the world of e-learning. Newly published studies can improve knowledge and bridge the knowledge gap through findings regarding e-learning trends; this applies particularly to higher education due to the importance of knowing the latest information about distance learning and its methods. For this reason, the research is valuable for analyzing the volume of publications that have been made on the subject matter and to solidify the knowledge base on what has been studied by different expert researchers in education. So this will create new progress and new proposals to improve education in the event of a future pandemic.

In recent years, there has been an increasing interest in research within areas related to e-learning: online learning, blended learning, technology acceptance model, smart learning, interactive learning environments, intelligent tutoring systems, digital learning were reported (Oprea, 2014; Castro-Schez et al., 2020; de Moura et al., 2020; Kao, 2020; Nylund and Lanz, 2020; Pal and Vanijja, 2020; Patricia, 2020; Şerban and Ioan, 2020).

A substantial quantity of literature has been written and published on the bibliometric analysis of e-learning. These studies mainly aim to identify the most critical areas (keywords) of e-learning. Networks such as that conducted by Chiang et al. (2010) showed that the significant research areas in e-learning are as follows: Education and Educational Research, Information Science and Library Science, and Computer.

Science/Multidisciplinary Applications

Cheng et al. (2014) analyzed data from 324 articles published between 2000 and 2012 in academic journals and conference proceedings from 2000 to 2012 to determine the vital research areas (the results identify six research themes in the field e-learning). Tibaná-Herrera et al. (2018a) used VOSViewer to conduct a bibliometric analysis of SCOPUS and SCImago Journal & Country Rank to establish the "e-learning" thematic category of scientific publications, thereby contributing to the discipline's consolidation, accessibility, and development by researchers.

Bai et al. (2020) have also pursued similar work in analyzing 7,214 articles published in 10 journals on the subject of e-learning from 1999 to 2018; this study offers valuable hints on the future direction of how e-learning may evolve. Fatima and Abu (2019) examined 9,826 records from the Web of Science (WoS) database between 1989 to 2018 to identify significant contributions to the area of e-learning. The findings of this study show that the United States and the United Kingdom have contributed more than half of the research in e-Learning. According to a recent survey by Mashroofa et al. (2020), the University of London is the most prolific institution globally. According to the WoS database, the institution has published 131 studies on e-learning; the bibliometric analysis of 6,934 results revealed that the publications received 59,784 citations.

Hung (2012) employed text mining and bibliometrics to examine 689 refereed journal articles and proceedings, comparing them to these research results. These works are divided into two domains, each of which has four groups. The study's findings now offer evidence that e-learning methods vary across top countries and early adopter countries.

There have been multiple previous attempts to do a systematic review of e-learning publications (Lahti et al., 2014; Zare et al., 2016; Garcia et al., 2018; Rodrigues et al., 2019; Araka et al., 2020; Valverde-Berrocoso et al., 2020), these studies mainly aimed to identify research areas, the most used and most important methods, and tools in e-learning.

Many studies have examined the results of e-learning publications through meta-analysis (ŠUmak et al., 2011;

Lahti et al., 2014; Mothibi, 2015; Cabero-Almenara et al., 2016; Yuwono and Sujono, 2018).

The study's contribution is that no controlled studies have compared differences in networks, models, and software outputs to define the most critical research areas in e-learning and the most influenced authors, organizations, and countries.

The study makes an important contribution to the analysis of current models and networks of e-learning in higher education during the COVID-19 pandemic, aiming to define the most critical research areas in e-learning and the most influenced authors, organizations, and countries. In addition, it looks at the framework of e-learning and its future research trends in light of COVID-19. This has been done through numerous investigations (Tibaná-Herrera et al., 2018a,c; Hilmi and Mustapha, 2020; López-Belmonte et al., 2021).

MATERIALS AND METHODS

Bibliometric Data

We retrieved published research *via* a topic search of the Science e-learning in higher education during the COVID-19 pandemic using the WoS database on August 12, 2021. The following search terms were used: topic = ("e-learning" "COVID-19" "higher education"), in title-abs-key from 2020 to 2021, and were 602 studies (475 articles, 80 articles; early access, 25 proceedings paper, 22 reviews) distributed over 2 years, as shown in **Figure 1**.

The following selection criteria were used to choose the studies. First, for the title, we looked at the following: the studies that looked at the topic of e-learning in higher education during COVID-19. Second, for the abstract, we looked at the following: the studies that addressed the problem of e-learning in COVID-19. Third, for the keyword, we looked at the following: the studies that included e-learning, higher education, universities, and COVID-19. Fourth, the subject areas were limited to a selection of works that dealt with this subject in the following disciplines: business management and accounting, educational sciences, social sciences, and psychology.

The bibliometric study data represents the overall research on "E-learning in higher education in light of the COVID-19" in the WoS database. These data covered the last 2 years (2020 and 2021) in which the use of e-learning was expected due to the closure and quarantine procedures.

The reasons for choosing this database over others, particularly Scopus and ScienceDirect, are due to several considerations; due to WoS data, the field of scientometrics has advanced significantly. WoS is more than simply a database of academic papers. Many information objectives are supported by this selected, organized, and balanced database, including full citation links and improved metadata (Birkle et al., 2020). WoS databases include high-quality research covering Science Citation Index Expanded (SCI-Expanded), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI), Emerging Sources Citation Index (ESCI) (Falagas et al., 2008).

Figure 1 illustrates how interest in e-learning research has increased in recent years, particularly between 2020 and 2021. Among the 602 studies with 4,280 citations, 230 in 2020 (1,400 citations), and 372 in 2021 (2,880 citations), the importance of higher education institutions, including universities, in this modern teaching and learning approach and their significance in the educational process during COVID-19 is evident. They are different from the periods approved in the previous studies (Chiang et al., 2010; Cheng et al., 2014; Bai et al., 2020; Fatimah et al., 2021). Therefore, this field of research (e-learning) has been renewed, and researchers should pay more attention to it to provide effective methods and approaches in light of the continuing epidemic.

Methods and Tools

According to the methods and approaches of bibliometric analysis (see: Zupic and Čater, 2015, p. 04). the study relied on the co-occurrence indicator (co-word) to find out the main keywords on which previous studies focused as well as the co-authorship, publications, and citations indicators to find prominent authors, organizations, and countries in the topic of e-learning in higher education in COVID-19.

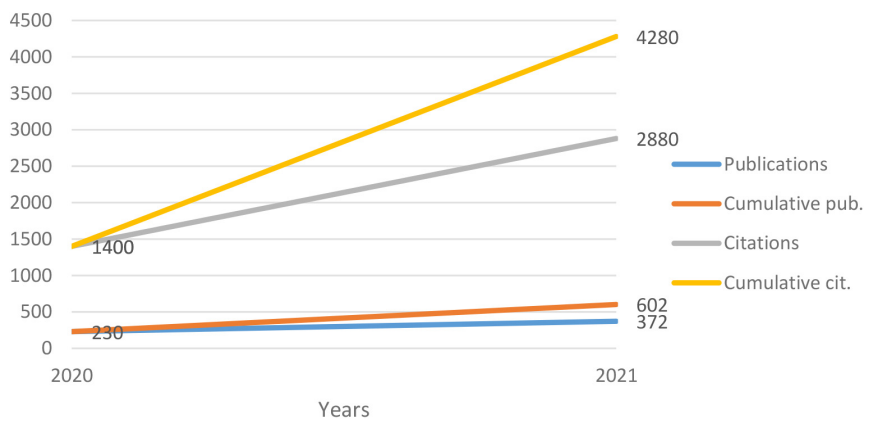

FIGURE 1 | Publications per year (KnowledgeMatrix Plus outputs).

Following the methodology of preparing the bibliometric study in management and organization, which was explained by Zupic and Čater (2015), the bibliometric analysis was carried out by completing the following steps: research design, study questions, and analysis approach selection (co-occurrence, publication, citation, and co-authorship); bibliometric data compilation, selection, and filtration, analysis (choosing the appropriate bibliometric software, clean the data, and generate networks); visualization, and interpretation.

The bibliometric analysis was performed to design networks of e-learning and define the most frequent keywords and the most cited authors, organizations, and countries to explain new and current trends within this topic. This is achieved depending on different software: CiteSpace converts research domain concepts into mapping functions between research frontiers and intellectual bases and is effective for information visualization (Chen, 2016); VOSviewer is used to design the networks and is a powerful function for co-occurrence analysis and citation analysis (Van Eck and Waltman, 2013). KnowledgeMatrix Plus is a powerful tool for analyzing frequency and statistics (Chen and Song, 2017). This software was not used in previous studies (Chiang et al., 2010; Cheng et al., 2014; Bai et al., 2020; Fatimah et al., 2021).

RESULTS AND DISCUSSION

Keywords Frequency

Figures 2A,B and **Supplementary Table 1** present the most frequent keywords that have been repeated more than five, which amounted to 131.

Figure 2A shows nine sub-areas (clusters) for research in e-learning within higher education during the era of COVID-19. First, the red cluster shows searches related to the following: higher education, students, motivation, attitudes, systems, technology acceptance model, and user acceptance. Second, the green cluster shows searches related to the pandemic, blended learning, online learning, hybrid learning, flipped classrooms, virtual learning, and distance education. Third, the navy-blue cluster shows searches related to higher education online, online teaching, online assessment, formative assessment. Fourth, the yellow cluster relates to stress, health, care, quarantine, mental health, anxiety, college students, adults, children. Fifth, the violet cluster shows searches related to surgery, surgical education, skills, strategies, student satisfaction, and simulation. Sixth, the light blue cluster shows searches related to e-learning, performance, quality, remote learning, digital learning, assessment, evaluation. Seventh, the orange cluster shows searches related to education, Covid-19, coronavirus, sars-cov-2, distance learning, medical education. Eighth, the brown cluster included: computer-based learning, self-instruction/distance learning, internet/web-based education, curriculum, knowledge, science, and technology. Finally, the pink clusters showed searches related to artificial intelligence, machine learning, and deep learning. The researcher can also take these subfields as topics for research in e-learning, especially the last cluster, which formed a recent research trend for many scholars (Bhardwaj et al., 2021; Kashive et al., 2021; Rasheed and Wahid, 2021).

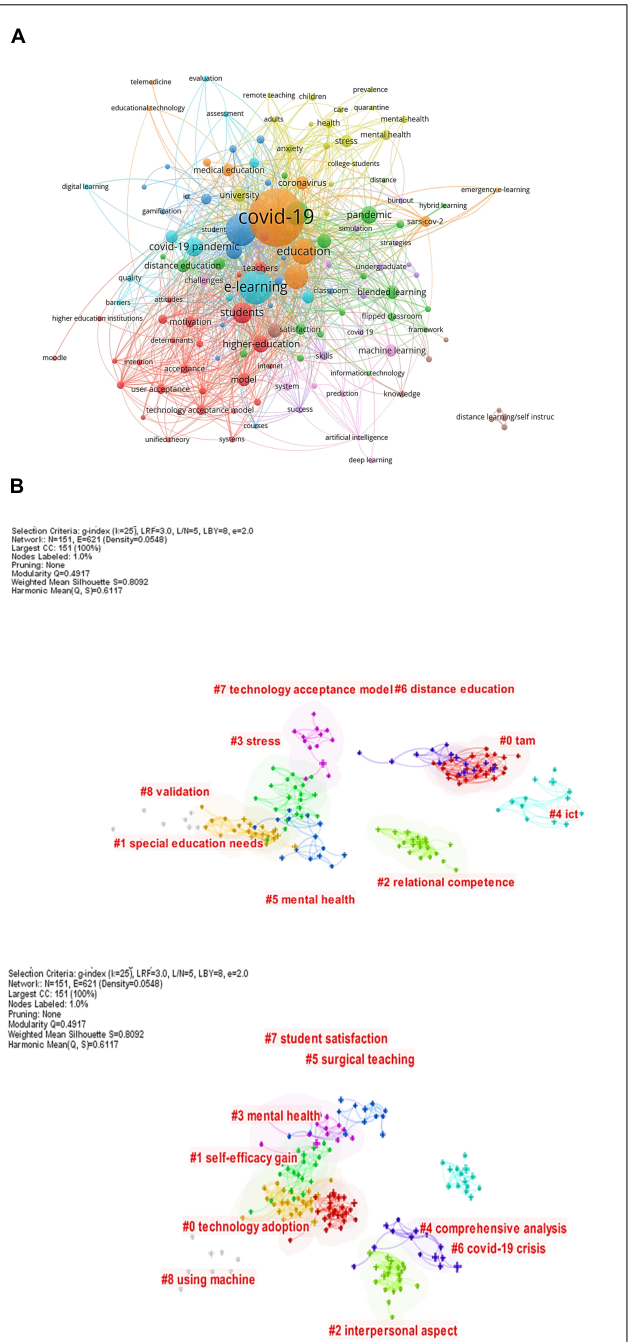

FIGURE 2 | (A) Network of keywords (VOSviewer outputs). **(B)** Network of keywords (CiteSpace outputs).

Figure 2B shows that the research on this topic requires focusing on several issues. These are the most frequently mentioned keywords in **Supplementary Table 1**, including COVID-19 crisis, technology acceptance model (TAM), distance education, stress, ICT, special education needs, mental health, student satisfaction, surgical teaching, self-efficacy, technology

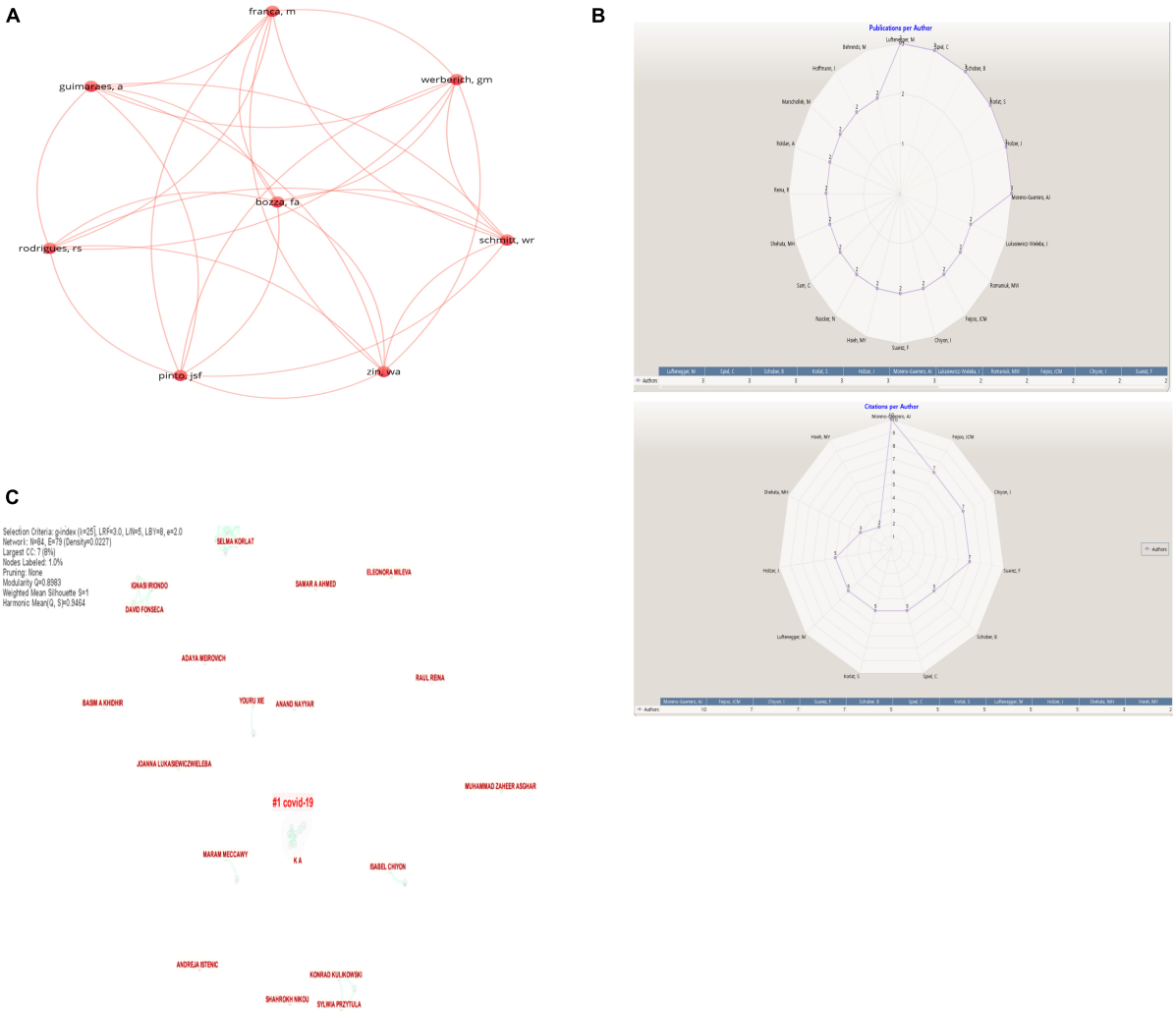

FIGURE 3 | (A) Network of authors (VOSviewer outputs). **(B)** Publications and citations per author (KnowledgeMatrix Plus outputs). **(C)** Network of cited authors in COVID-19 (CiteSpace outputs).

adoption, using the machine, and e-learning. At the same time, many studies used different terms to express the same meaning, such as interactive learning, online learning, and Distance learning. This is similar to what was found in previous studies on e-learning (Chiang et al., 2010; Cheng et al., 2014; Bai et al., 2020; Fatimah et al., 2021).

Reference Authors

Figures 3A–C show the network of the most referenced authors on the topic of "E-learning in higher education in COVID-19" based on co-authorship:

Figure 3A shows that there is a research partnership between eight authors. The co-authorship is the affiliation and the country: Fernando Augusto Bozza, Rosana Souza Rodrigues, Walter Araujo Zin, Alan Guimaraes and Gabriel Madeira Werberich, Federal University of Rio de Janeiro, Brazil. Joana Sofia F. Pinto, Willian Reboucas Schmitt and Manuela Franca, Complexo Hosp Univ Porto, Radiol Dept, Porto, Portugal. As for the rest, they have separate and individual publications. **Figures 3A–C** present the top authors based on publications and citations.

Figure 3B shows that the first author on this topic on "E-learning in higher education in COVID-19" is Antonio José Moreno-Guerrero, Univ Granada, Dept Didact & Sch Org, Spain. Among this research, we find "Impact of Educational Stage in the Application of Flipped Learning: A Contrasting Analysis with Traditional Teaching" (Pozo Sánchez et al., 2019). We also find research on e-learning in mathematics teaching: an educational experience in adult high school (Moreno-Guerrero et al., 2020) as well as research on the following: the effectiveness of innovating educational practices with flipped learning and remote sensing in earth and environmental sciences (López Núñez et al., 2020); machine learning and big data and their impact on literature; a bibliometric review with scientific mapping in WoS; and a flipped learning approach as an educational innovation in water literacy (López Belmonte et al., 2020; López Núñez et al., 2020). Moreno-Guerrero talked about

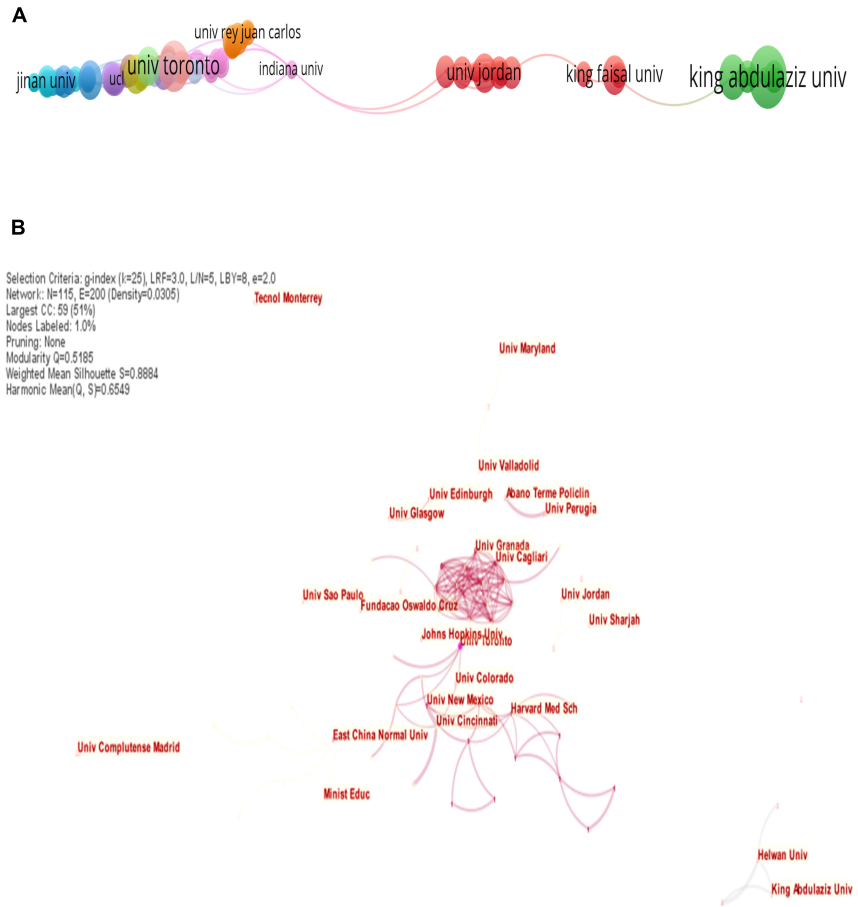

FIGURE 4 | (A) Network of organizations (VOSviewer outputs). **(B)** Network of organizations (CiteSpace outputs).**(C)** Citations per publications by the organization (KnowledgeMatrix Plus outputs).

e-learning and did not discuss the COVID-19 (Moreno-Guerrero et al., 2020); otherwise, Lüftenegger discussed e-learning and COVID-19 (Holzer et al., 2021; Korlat et al., 2021; Pelikan et al., 2021).

Figure 3C shows that the most important authors searched in COVID-19 and touched on e-learning are Maram Meccawy, Isabel Chiyon, and Anand Nayyar among others.

Reference Organizations

Figures 4A–C displays the most referenced organizations on the topic of "E-learning in higher education in COVID-19" based on publications, citations, and co-authorship.

Figures 4A–C demonstrate that the leading research organization for publications, citations, and co-authorship on this topic is the University of Toronto with 16 publications and 207 citations, followed by the University of King Abdulaziz with 15 publications and 57 citations the Jordan University of Science and Technology with 11 publications and 115 citations, then the University of Vienna with 10 publications and 30 citations, then the University of Sharjah with 10 publications and 20 citations, then the University of Granada with 9 publications and 79 citations, then the University of Porto with 9 publications and 14 citations, then Monterrey Institute of Technology and Graduate Studies with 9 publications and 2 citations, then the University of Jordan with 8 publications and 46 citations, and finally, the University of Colorado with 8 publications and 16 citations. That is due to several reasons, including the interest of these organizations in publishing in the WoS database. Then their interest in publishing in the subject of the study. We thus find it among the top 500 universities.[1]

Reference Countries

Figures 5A–C display the most referenced countries on the topic of "E-learning in higher education in COVID-19" based on publications, citations, and co-authorship.

Figures 5A–C illustrate that the top countries for publications, citations, and co-authorship in this topic are as follows: the United States with 344 publications and 1,167 citations, the United Kingdom with 132 publications and 530 citations, China with 117 publications and 592 citations, Spain with 104 publications and 321 citations, Italy with 98 publications and 175 citations, Brazil with 74 publications and 224 citations, Canada with 67 publications and 368 citations, India with 64 publications and 139 citations, Saudi Arabia with 60 publications and 216 citations, and Germany with 59 publications and 133 citations. These show extensive collaboration, especially between the United States and the United Kingdom with 11 collaborations, between the United States and Canada with 10 collaborations, and between the United States and China with 9 collaborations; other countries show an average of 3–5 collaborations.

[1]https://www.topuniversities.com/university-rankings/world-university-rankings/2021, https://www.timeshighereducation.com/world-university-rankings/2021/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats

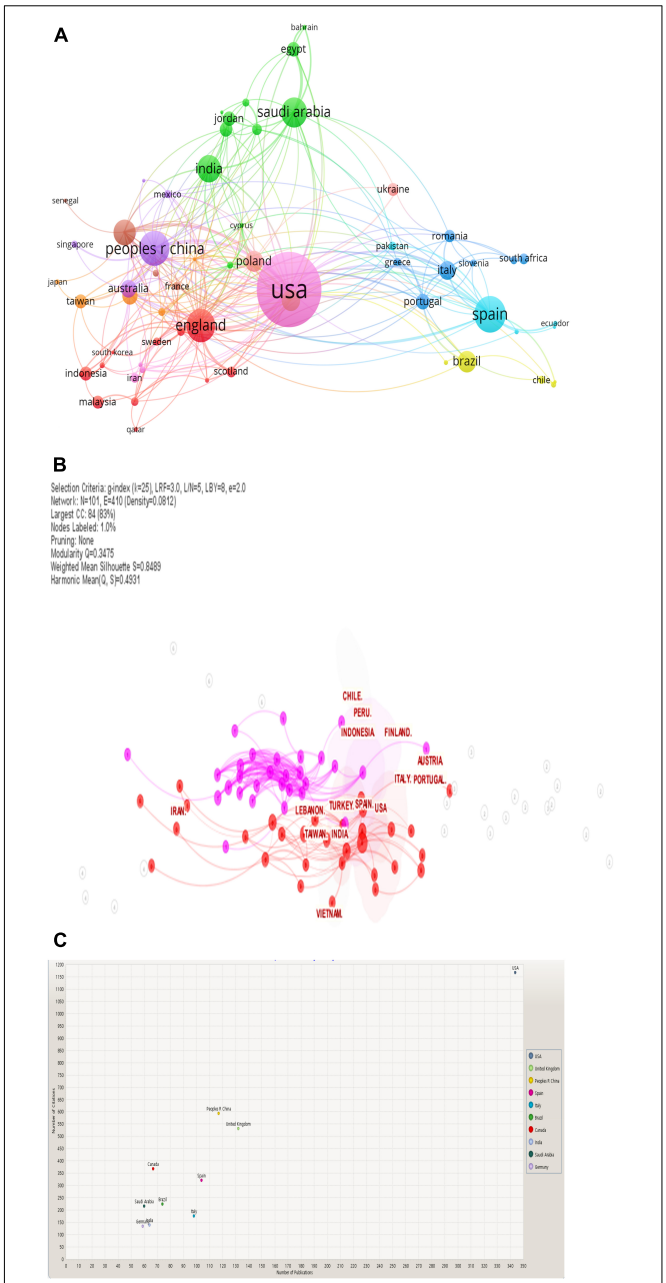

FIGURE 5 | (A) Network of countries (VOSviewer outputs). **(B)** Network of countries (CiteSpace outputs). **(C)** Citations per publications by country (KnowledgeMatrix Plus outputs).

Discussion

The results of the bibliometric analysis showed that there are nine sub-fields of research within a topic: motivation and students' attitudes to e-learning systems in higher education (technology acceptance model), comparison between blended learning and virtual learning, online assessment versus formative assessment of students in higher education, stress, anxiety, and mental health of college students in COVID-19, surgical education strategies to develop students' skills, quality and

performance of higher education strategies of e-learning in COVID-19, challenges of medical education and distance learning during COVID-19, and changing higher education curricula using technology.

Finally, using artificial intelligence, machine learning, and deep learning to transform the e-learning Industry, this final sub-field formed a recent research trend for many scholars (Bhardwaj et al., 2021; Kashive et al., 2021; Rasheed and Wahid, 2021).

The bibliometric study shows that the first author in e-learning is Antonio José Moreno-Guerrero, Univ Granada, Dept Didact & Sch Org, and Spain. His writings (Pozo Sánchez et al., 2019; López Núñez et al., 2020; Moreno-Guerrero et al., 2020) are considered a useful reference in e-learning and blended learning. Therefore, Marko Lüftenegger is one of the most influential author in the topic of "E-learning in higher education in COVID-19" (Holzer et al., 2021; Korlat et al., 2021; Pelikan et al., 2021)

The results of the bibliometric analysis showed that the top research organizations in this domain are as follows: the University of Toronto, the University of King Abdulaziz, Jordan University of Science and Technology, the University of Vienna, the University of Sharjah, the University of Granada, the University of Porto, Monterrey Institute of Technology and Graduate Studies, the University of Jordan, and the University of Colorado. The results also illustrate that the top countries are: United States, United Kingdom, China, Spain, Italy, Brazil, Canada, India, Saudi Arabia, Germany, due to several reasons, including the interest of these organizations and countries in publishing in the Web of Science database and their interest in publishing in the subject of the study.

Our research overlaps with that of López-Belmonte et al. (2021), who tried to investigate the development of e-learning in higher education in the academic literature listed on the WoS. The same analysis, as well as bibliometric analysis, was carried out. The findings revealed no set path for research because of the research on e-learning in higher education, recent creation, and a scarcity of relevant research. According to the results of the bibliometric analysis, the study was aimed at determining acceptance and implementation of the educational curriculum in the teaching and learning processes.

CONCLUSION

This paper discusses the use of a bibliometric approach to track e-learning trends in higher education during the COVID-19 pandemic through the WoS database. From a methodological perspective, our proposed approach can visually represent the temporal links of the most cited articles internally in various streams and provide a comprehensive overview of the evolution of topics in the WoS database. Also, direct citation network analysis enables researchers to test articles important in e-learning and get a comprehensive overview of the issues published.

The study provided an insight into the world's e-learning research in terms of mapping research publications. A scientific study was conducted using 602 e-learning documents from 2020 to 2021, and these were obtained through the WoS database. Over the years, the analysis identified trends in contributions in this area and headline sources for most researchers and leading institutions. The study is convergent with many previous studies in this area, including Chiang et al. (2010), Hung (2012), Cheng et al. (2014), Tibaná-Herrera et al. (2018b), Fatima and Abu (2019), Bai et al. (2020), and Mashroofa et al. (2020). However, our study relies on many software to compare various theoretical models and networks of e-learning.

Based on the analysis data's inference, growth trends in research publishing in e-learning of different forms have increased in recent years, especially so for the last 2 years (230 in 2020 and 386 in 2021). The significant findings of the bibliometric analysis are as follows: there are nine sub-fields of study in the subject of "E-learning in higher education in COVID-19," and the prominent authors in this area are as follows: Antonio José Moreno-Guerrero and Marko Lüftenegger; the University of Toronto Canada is the most frequently cited organization in this domain; the United States is the leading country in terms of publications and citations; and the sub-field of artificial intelligence, machine learning, and deep learning to transform the eLearning Industry has emerged as a recent research trend for many scholars.

The study examined a very important topic, which is one of the current topics, "e-learning in higher education during COVID-19," using bibliometric analysis of 602 studies published in Web of Science databases from 2020 to 2021. We found that the study sample should be larger; it needs further studies and a longer time, especially when we analyze citation, and research on this topic will thus continue in future years. Also, there are many tools and methods used in the bibliometric analysis that were not used in our study, including what has been mentioned (Tibaná-Herrera et al., 2018b; Gul et al., 2020; López-Belmonte et al., 2021; Rashid et al., 2021).

The findings of this study will assist interested academics and educational policymakers (Brika et al., 2021) in the field of e-learning in understanding the current state of e-learning and identifying the different research trends in light of COVID-19. Additionally, it will serve as the beginning point for new research during the COVID-19 crisis, which will examine various problems and trends.

The findings of this research may help evaluate e-learning institutions' quality and promote future educational trends. The findings may be utilized by e-learning institutions to evaluate quality as strategic dimensions and policy makers' vision.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors contributed to the design and implementation of the research, performed the revision, verified the

analytical methods, supervised the findings of this work, discussed the results, and contributed to the final manuscript.

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ORIGINAL RESEARCH
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The Influence of Sense of Place on Elementary School Students' Creativity During the COVID-19 Pandemic: The Mediating and Buffering Effects of Psychological Resilience

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Purpose: To understand the relationship between sense of place and creativity and the mechanisms that affect this relationship, the researchers constructed a mediation model to examine the effect of sense of place on creativity and the mediating role of psychological resilience in elementary school students during the COVID-19 pandemic.

Methods: A total of 1,711 students in an elementary school in Beijing, China, were surveyed using Chinese-language versions of the Sense of Place Scale, the Psychological Resilience Scale-Short Version, and the Innovative Behavior Inventory. SPSS (version 23) and PROCESS plug-in (version 3.3) were used for correlation and mediation analyses.

Results: (1) Correlation analysis revealed that sense of place was positively related to psychological resilience ($r = 0.445$, $p < 0.01$) and creativity ($r = 0.590$, $p < 0.01$). (2) Psychological resilience was also positively correlated with creativity ($r = 0.625$, $p < 0.01$). (3) Further, after controlling for gender and grade level, it was found that sense of place directly predicted creativity and that sense of place also indirectly predicted creativity through psychological resilience. The direct effect (0.45) and the mediating effect (0.23) accounted for 65.95 and 34.05% of the total effect, respectively.

Conclusion: The results demonstrate that sense of place is a positive predictor of creativity and can play a facilitating role to some extent. Moreover, psychological resilience is a mediating factor, acting as a buffer between sense of place and creativity. These results contribute to a more comprehensive understanding of the mechanisms influencing creativity.

Keywords: sense of place, creativity, psychological resilience, mediating and buffering effects, COVID-19

INTRODUCTION

The novel COVID-19 has had a dramatic impact on humans (Zhao et al., 2020). This global public-health emergency is likely to persist for a long time (Zhou et al., 2020). As the epidemic developed, the government of Chinese, like those of other countries, adopted quarantine in the home and mask-wearing outside the home as the core means of reducing widespread interpersonal transmission of the virus (Wang et al., 2020). As a result of these prevention and control measures, the student population presented with varying degrees of anxiety and depression during the acute epidemic phase for reasons such as financial stress, academic delays, impact on daily life, and shortage of social support (Dhar et al., 2020). These conditions have deeply affected the mental health of students, and therefore, it is crucial to study how the COVID-19 pandemic influenced them psychologically.

Psychological resilience is a factor that encompasses many aspects of students' ability to change and to recover and maintain their mental health in the face of changes brought about by an unexpected event. It is the ability or dynamic process by which an individual is able to adapt and continue to develop after a serious threat (Huntsinger and Ray, 2016). Past research has shown that psychological resilience can buffer against psychological trauma from public-health events (Ran et al., 2020), terrorist attacks (Zeidner and Kampler, 2020), cancer (Mystakidou et al., 2015), depression (Howell et al., 2020), and negative emotions (Abiola and Udofia, 2011), and it can help people reduce their vulnerability to challenges and difficulties in their work environment (Howell et al., 2020). However, few studies have examined the mechanism of action of psychological resilience as an outcome variable in elementary school student populations during the COVID-19 pandemic. Therefore, it may be important to study in depth how the psychological resilience of elementary school students has influenced and been influenced during the COVID-19 pandemic.

In addition, *creativity* may also be stimulated during the COVID-19 pandemic, as exemplified by the 4C model of creativity (Kapoor and Kaufman, 2020). The 4 Cs which consisted of Mini C, Little C, Pro C, and Big C were proposed by Kaufman and Beghetto in 2009. Mini C is considered as novel, individualized, and meaningful interpretations of experiences, behaviors, and events; Little C, also known as everyday creativity, encompasses all walks of life of ordinary people; Pro C refers mainly to the professionalism demonstrated by creative people in the relevant fields; and Big C, also known as outstanding creativity, generally refers to the creativity exhibited by great people or people with extraordinary achievements. For instance, people might generate a variety of novel or useful ideas to distract themselves from or find fun in their boring isolated life during the COVID-19 pandemic, which is the concentration of Mini C and Little C. Still, schools at all levels transformed traditional offline classes into online courses during the COVID-19 pandemic, which is a manifestation of Pro C. In addition, Pro C is more prominent in scientific creativity. A case in point is that researchers have begun developing a vaccine against this novel coronavirus since its genetic sequence was detected in February 2020 after the outbreak of COVID-19 pandemic (Ren et al., 2020). Further, since the COVID-19 pandemic began spreading around the world, clinical trials for this vaccine have been underway; researchers have shifted their agenda from developing a MERS vaccine to developing a COVID-19 vaccine and have thus been motivated to get ahead of the race with this novel virus (Masetti et al., 2020). This is often referred to as the Big C. However, under the context of the COVID-19 pandemic, few studies are focused on the mechanism of action with creativity as an outcome variable among the population of elementary school students. Therefore, it may also be important to delve into how the situation of the COVID-19 pandemic is influenced by the creativity of this particular population.

The existing literature offers many studies related to psychological resilience (e.g., Marx et al., 2017; Liu et al., 2020; Xu et al., 2021). Its relationship to creativity has also been of interest to researchers (Marwa and Milner, 2013; Chen, 2015; Anser et al., 2020; Xu et al., 2021). In one study, it was mentioned that artistic ethnographic innovation best begins with the experience of a sense of place, one of the conjunctions of environment and sensation (Kapoor and Kaufman, 2020). Further, this also shows the importance of the sense of place, which is one of the combinations of environment and sensation, for creativity. Other factors have also been found to be related to creativity, including environment (e.g., Richards, 1992; Cole et al., 1999; Walter, 2012; Pugsley and Acar, 2020), senses (e.g., Chessick, 1996; Berg and Hallberg, 1999; Fraser et al., 2021), and emotions (e.g., Kopcso and Lang, 2017; Demetriou and Nicholl, 2021) have been found to be related to creativity. However, few studies have focused on the relationship between sense of place—the combination of environment and perception/emotion—and creativity, the relationship between sense of place and psychological resilience, and the possible relationship between sense of place, psychological resilience, and creativity.

To enhance recognition of elementary school students' creativity during the COVID-19 epidemic, this study explored the relationship between sense of place and creativity and also the mediating role of psychological resilience. In the next section, the definitions of these three variables, the influencing variables, and the relationships among them are presented. Two frequently reported factors that might have influenced students' psychological resilience and creativity—gender and grade level—were considered as covariates and controlled for in the process.

THEORETICAL BASIS AND HYPOTHESIS

Sense of Place

Since the 1970s, scholars have gradually developed the concept of sense of place in the face of the loss and blurring of local identity brought about with globalization (Changhu, 2020). Lowenthal and Tuan (1975) were the first to propose the concept of *sense of place*, which they believed encompasses both the inherent characteristics of a place and people's sense of attachment to that place. Zhu and Liu (2011) maintained

that the sense of place is mainly shown by the objective materials and social functions of a locality, i.e., its meaning, and that it creates an emotional link between human beings and the place. It is also a response to the gradual integration of the self into the environment through human-place interactions. It is influenced by personal emotional integration, values, and other emotional factors. According to Steele and Steele (1981), human sense of place is an outcome of the interaction between people and place, an experience acquired by people with respect to place. The concept has been widely used in management, sociology, psychology, and architecture.

There remains no consensus on the definition of sense of place. For instance, Tuan creatively proposed *topophilia*, which implies that humans have always experienced and experimented with their environment through their sense and unique experience, a process in which they develop a sense of place (as cited in Tapsuwan et al., 2011). Steele and Jackoson pointed out that the sense of place is a sense of belonging that is constructed along with a sense of time (as cited in Steele and Steele, 1981), and Massey (1994) proposed that the sense of place is a dynamic concept that changes over time. According to existing literatures, the sense of place is a multidimensional complex structure (Lowenthal and Tuan, 1975; Jorgensen and Stedman, 2001; Tapsuwan et al., 2011; Changhu, 2020). Scholarly analysis of its intrinsic elements has produced different perspectives (Lowenthal and Tuan, 1975; Jorgensen and Stedman, 2001; Tapsuwan et al., 2011; Changhu, 2020). It has been classified as having two to six dimensions by scholars (Zhu and Liu, 2011; Juan, 2014; Tingting and Zhao, 2015). The most influential one is the Sense of Place Scale proposed by Jorgensen and Stedman (2001). This scale, represented by a 12-item scale ranging from low to high, quantifies the sense of place as having three dimensions (place identity, place attachment, and place dependence).

Creativity

The term "creativity" was first defined by American psychologist Guilford (1950) as a thinking and behavioral process that generates a valuable and original idea, product, or solution. Since the term was proposed, the connotation and theoretical basis of creativity have been continuously enriched and expanded (Plucker et al., 2004; Xu et al., 2021). However, to date, there is still no universally accepted academic definition of creativity, except for a generally accepted view that creativity is a cognitive process that is characterized as the ability to generate novel ideas (Runco and Basadur, 1990; Xu et al., 2021). Such a cognitive process has long been shown to be closely related to intelligence (Sternberg and Lubart, 1991), e.g., to the breadth of attention (Fredrickson and Branigan, 2005), creative problem solving (Isen et al., 1987), and divergent thinking (Zhu et al., 2019).

As mentioned earlier, the sense of place is an environmental and perceptual complex like that, and when it is related to creativity, the theoretical framework is considered in relation to the following theories of creativity. The first is Rhodes' (1961) proposal of the *4Ps model of creativity* which integrates people, process, product, and environment. The second is Amabile's (1988) model of the components of creativity, which takes into account cognitive, individual, motivational, and social factors and includes domain-relevant skills, creativity-relevant skills, and task motivation. Later, he enriched the model by adding a "social environment component" to it (Amabile, 1996). The third is the theory of *creativity investment* proposed by Sternberg and Lubart (1991), which states that intelligence, knowledge, thinking style, personal traits, motivation, and environment may influence creativity, and so creativity is the result of a mix of individual psychological mechanisms and environmental factors. In addition, at the beginning of the 21st Century, Plucker et al. (2004), after reviewing 90 influential journal articles, proposed that creativity is the result of the interaction among ability, process, and environment, and that individuals or groups have the potential to produce novel and useful works. In Kaufman and Beghetto (2009) proposed the *4C model* of creativity performance, namely, "Big C" (the creative capability of an outstanding, eminent person), "Pro C" (the innovative capability of a professional in a certain field), "Little C" (innovation in everyday life), and "Mini C" (experiences, activities, and events that are fresh to an individual).

All of the above theories fit, to a greater or smaller extent, with the focus of this study on the relationship between elementary school students' sense of place and creativity. However, the theory of creativity investment and the 4C model fit better. Therefore, they lay a theoretical foundation for exploring the relationship between elementary school students' sense of place and creativity in this study.

According to the above-mentioned theories, clearly, several recent studies have been dedicated to discussing the factors influencing creativity, such as motivation, cognition, sense, perception, emotion, and environment (Cole et al., 1999; Edl et al., 2014; Du et al., 2020; Xu et al., 2021). The main body of this research provides a broader interpretation of what creativity is and what processes are involved. It can be inferred that creativity is influenced by many factors, and this inference agrees with the results of these current studies (e.g., Isen et al., 1987; Runco and Basadur, 1990; Fredrickson and Branigan, 2005; Xu et al., 2021). A number of recent studies have been devoted to discussing factors influencing creativity, such as motivation, cognition, sense, perception, emotions, and environment (e.g., Cole et al., 1999; Edl et al., 2014; Du et al., 2020; Xu et al., 2021). Different contexts, emotions, and feelings have been shown to affect creative performance differently, e.g., corporate innovation (Ding et al., 2019), artistic creativity (Xurui et al., 2018), and everyday emotional creativity (Han et al., 2019), but these still come down to cognitive processes in essence (Leschziner and Brett, 2019). According to Janssen (2000), creativity in this study is considered as the process through which people promote and practice creative ideas as they are generated. It consists of three stages: idea generation, idea promotion, and idea practice.

Among the available literatures, based on the theoretical framework of creativity investment, studies on the relationship between creativity and environment (e.g., Cole et al., 1999; Dul and Ceylan, 2011; Gong et al., 2019), sense (e.g., Chessick, 1996; Berg and Hallberg, 1999; Fraser et al., 2021), and the

interaction between creativity and emotion (e.g., Kopcso and Lang, 2017; Mastria et al., 2019; Xu et al., 2021) have also received much attention. One mainstream consensus among many studies is that a favorable environment promotes creativity (e.g., Cole et al., 1999; Dul and Ceylan, 2011; Gong et al., 2019). Another mainstream view is that positive emotions and perceptions promote creativity (e.g., Rouff, 1975; Humke and Schaefer, 1996; Yawen et al., 2021).

Despite differences in perspective, all conceptualizations share the commonality that the sense of place is a mix of environment and perception (Zhu and Liu, 2011; Juan, 2014; Tingting and Zhao, 2015). Currently, few studies have investigated into the relationship between sense of place and creativity; however, some researchers have focused on the relationship between environment and creativity (e.g., Dul and Ceylan, 2011; Gong et al., 2019; Pugsley and Acar, 2020), even arriving at the conclusion that environment is positively correlated with creativity (Richards, 1992; Dul and Ceylan, 2011; Pugsley and Acar, 2020); i.e., the more positive the environment, the higher the level of creativity. In addition, some studies have reported on the relationship between perception (or emotion) and creativity (e.g., Chessick, 1996; Humke and Schaefer, 1996; Rui et al., 2021). Some studies have also found that positive emotional effect is sometimes positively correlated with creativity (e.g., Humke and Schaefer, 1996; Zhuravlyova and Zhuravlyov, 2015). Given that sense of place is a mix of environment and perception (or emotion), these studies help understand the relationship between sense of place and creativity and the relationship among environment, perception (or emotion), and creativity. There were also some explorations on the 4C model during the COVID-19 pandemic. In other words, sense of place may be positively correlated with creativity. This positive correlation may be manifested as: the higher the sense of place, the higher the level of Mini C or Little C (in writing science and art, etc.) of elementary school students. Therefore, we hypothesize that,

H1: Sense of place has a positive predictive effect on creativity.

Psychological Resilience

In the 1970s, psychologists found that sequelae were reported in children who had been abused, but that these consequences were mild (Mrazek and Mrazek, 1987). Scholars attributed this result to the presence of psychological resilience (Luthar et al., 2000). Among other things, *resilience* refers to positive adaptation in the face of stress or trauma (Block and Kremen, 1996; Tugade and Fredrickson, 2004; Xu et al., 2021). Resilience is also seen as a personality trait with a stress-resistant attitude that influences the process of regulation of emotions (Xu et al., 2021). There are also many theories about what psychological resilience is. For example, it has been argued that *psychological resilience* is the ability or dynamic process by which an individual is able to maintain good development even after being exposed to serious threats (Hou and Ng, 2014; Xu et al., 2021). In normal field of developmental psychology, for example, psychological resilience is considered to be the ability of people to react and respond well to events or experiences that may have a significant impact on them (Huisman et al., 2017; Xu et al., 2021). It is a dynamic process that involves senses, emotions, and cognition (Block and Kremen, 1996; Tugade and Fredrickson, 2004). Psychological resilience enables individuals to find the positive in the negative and to adapt and bounce back from the changing external environment (van Riper et al., 2013). Psychological resilience can be divided into individual resilience and collective resilience (Xu et al., 2021). From a behavioral point of view, psychological resilience is seen as a set of attitudes and skills to deal with negative emotions (van der Werff et al., 2013). From these various definitions, it can be concluded that psychological resilience refers to an individual's ability to recover from negative experiences and to adapt to the changing external environment (Campbell-Sills and Stein, 2007).

Rutter (1985) pointed out that protective factors can influence and change a person's response to hazards in the environment, but he also emphasized that they are not the same as positive experiences (Rutter, 1985). Protective factors may comprise experience, the individual's own qualities, perception (or emotion), and the surrounding environment (Rutter, 1985; Mrazek and Mrazek, 1987).

Currently, several theoretical models of protective factors of psychological resilience exist. For example, Mandleco (2000) proposed a systematic model of children's psychological resilience based on an analysis of previous studies. Also, a dynamic model of psychological resilience was jointly developed and proposed by several scientific institutions in the United States (Mandleco, 2000). Both models divide the protective factors for psychological resilience into two types, internal and external (Zeng et al., 2021). Internal factors include biological factors, such as physical condition, temperament, and gender, and psychological factors, such as intelligence, cognitive style, problem-solving skills, and personality. External factors include environmental factors, such as family, society, and school (Zeng et al., 2021).

Few studies have investigated the relationship between sense of place and psychological resilience. However, one study showed that a positive educational environment can increase psychological resilience in medical students (Xu et al., 2021). Another study found a positive correlation among subjective wellbeing, a perception (or emotion), and psychological resilience (Can, 2020). Given that sense of place is a combination of environment and perception (or emotion) and that there is more overlap between it and environment and perception (or emotion), it is highly likely that sense of place is positively correlated with psychological resilience. This leads to the following hypothesis.

H2: Sense of place has a positive predictive effect on psychological resilience.

Related research has shown that psychological resilience is positively correlated with creativity (Xu et al., 2021). In education, psychological resilience may give learners a strong ability to challenge their environment, which in turn stimulates their positive emotional affect and their motivation to learn

(e.g., Chen and Padilla, 2019; Xu et al., 2021). Luthans et al.'s (2006) research found that resilience at work may produce an internal mechanism of adaptation, persistence, or transcendence, which in turn allows individuals to maintain their creativity through steady effort. The following hypothesis emerged from a literature review that addressed this theme.

> *H3*: Psychological resilience has a positive predictive effect on creativity.

Based on the existing literature and the three hypotheses above, we further propose the following hypothesis.

> *H4*: Psychological resilience plays a mediating and buffering role between a sense of place and creativity.

Figure 1 shows a graphic of the mediation model proposed in the four hypotheses and depicts the relationship between the independent variable, the mediating variable, the dependent variable, and the two covariates.

MATERIALS AND METHODS

Participants and Procedures

This study was conducted in an elementary school in Beijing, China. Of the 1,800 students in this school, 1,711 participated by filling out the questionnaire. After the data collection was completed, the researchers checked the validity of the completed questionnaires, and the actual number of valid questionnaires was 1,711. Among them, 914 (53.4%) were completed by males and 797 (46.6%) by females. By academic level, 346 (20.2) were in first year, 329 (19.2%) in second year, 316 (18.5%) in third year, 251 (14.7%) in fourth year, 257 (15.0%) in fifth year, and 212 (12.4%) in sixth year. Prior to finalizing the study design, researchers had conducted exploratory focus-group interviews with students at the school to clarify the emotional characteristics and psychological states of the students. The majority of respondents reported that they were in low spirits during the COVID-19 pandemic. However, their identification and attachment to Beijing and to their school gave them an inner urge to alleviate and recover from this dejection.

This study used a correlational design with an online questionnaire as the data collection method. The questionnaires were filled out between 10 June and 15 July 2020. At the end of a school day, classroom teachers showed students the QR code that linked to the questionnaire. Students who agreed to complete the questionnaire scanned the QR code, entered the fill-in screen, answered the questions, and then clicked Submit ("QR" is an abbreviation for "quick response," and a QR code is a readable barcode that contains a lot of information. A device such as a cell phone or tablet scans the QR code with a camera, recognizes the binary data, and opens a specific link). In China, QR codes are widely used to open specific link interfaces and various applications such as those used for financial payments, personal identification, and information queries. The QR code in this study linked to the webpage where participants could complete the study questionnaire. It should be emphasized that before scanning the code, the classroom teachers briefed in detail the parents and students about the purpose of the study. Before the students filled out the questionnaire, the study was explained to their parents and consent was obtained from the parents.

Materials

The questionnaire used in this study consisted of four sections and included 33 items: demographic information, Sense of Place Scale, Psychological Resilience Scale, and Innovative Behavior Inventory. Demographic information included gender and academic level. The Sense of Place Scale, Psychological Resilience Scale, and Creative Behavior Inventory were originally developed in English and translated into Chinese for this study. In order to improve the quality of translation, the back-translation

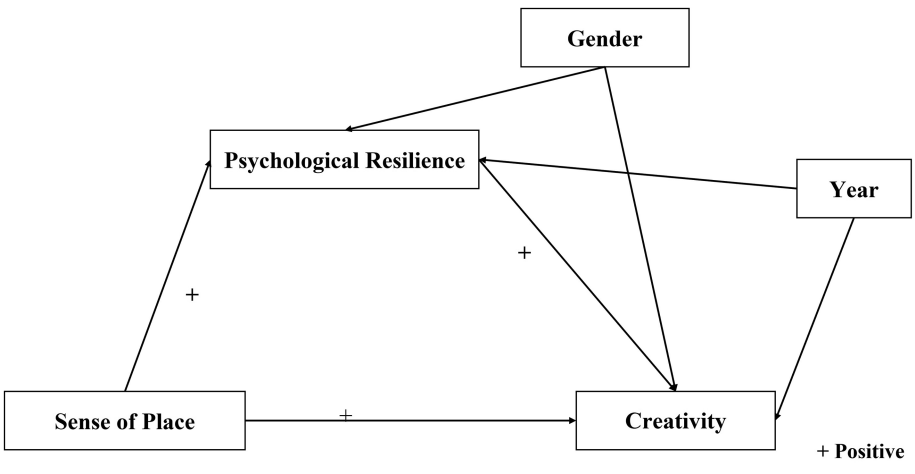

FIGURE 1 | The relationships examined in the study.

method (Brislin, 1970) was used as: the first researcher translated the English scales into Chinese, then the second researcher back-translated the Chinese version into English, and finally the third researcher compared the original, translated, and back-translated versions of the scales to assess the accuracy of the translation. The translation was corrected and optimized before the questionnaire was finalized, which should have ensured the equivalence of the Chinese- and English-language scales.

Sense of Place Scale

This study used the Sense of Place Scale developed by Jorgensen and Stedman (2001). The scale consists of 12 items, and after discussion, some of the wording was modified to fit the language and life experiences of elementary school students. The scale includes place identity (e.g., "The school and the neighborhood where I live are relevant to me and a reflection of my existence" and "The school and the neighborhood where I live are closely related I can be my true self"), place attachment (e.g., "The school and the neighborhood I live in relax me" and "The school and the neighborhood I live in make me happy"), and place dependence (e.g., "When I do the things I like best, I am happy," "When I do my favorite things, I like school and the neighborhood I live in the most," and "When I do my favorite things, there is no substitute for school and the neighborhood I live in"). The scale assesses participants' feelings, responses, and agreement on a 5-point scale (1 = completely disagree; 5 = completely agree). The possible scores for participants ranged from 12 to 60 in this study; the internal consistency coefficient of the scale was 0.792.

Psychological Resilience Scale-Short Version

This study used the Psychological Resilience Scale-Short Version (10-item Connor-Davidson Resilience Scale or CD-RISC-10) as modified by Campbell-Sills and Stein (2007). The original scale consisted of 10 items (e.g., "I can adapt flexibly when changes occur" and "I can respond with humor when faced with problems"). Seven additional items were added to the scale that took into account the actual situation of elementary school students during the COVID-19 pandemic for a total 17 items. To maintain congruency with the two other scales, the original 4-point rating scale was converted to a 5-point scale, ranging from 1 = completely disagree to 5 = completely agree. The score conversion resulted in a range of possible student scores from 17 to 85. In this study, the internal consistency of the scale was 0.848.

Innovative Behavior Inventory

This study used the Innovative Behavior Inventory, which was developed by Janssen (2000) by integrating the conceptualizations several scholars. The scale contains 9 items, and after discussion, some of the wording was modified to fit the language and life experiences of elementary school students. The scale measures the innovative-idea generation stage (e.g., "I often generate new ideas when I encounter difficulties" and "I seek new methods, techniques, or tools"), the idea promotion stage (e.g., "I seek support from my teacher for innovative ideas" and "I facilitate the flow of innovative ideas within my organization"), and the diffusion stage (e.g., "I will translate innovative ideas into achievable practices" and "I will evaluate the benefits of innovative ideas"). The range was from 1 (= almost always not true) to 5 (= almost always true), and participants' possible scores ranged from 9 to 45. In this study, the internal consistency of the scale was 0.954.

Data Analysis

In this study, SPSS 23.0 was used to process and analyze the data. Since the study used self-report for data collection, the common method biases were tested using the Harman one-way test before data processing (Podsakoff et al., 2003) to ensure the validity of the data. The test was conducted by examining 31 items of the questionnaire related to three variables. The results showed that five factors had eigenvalues greater than 1. The contribution of the five factors to the total variance was 64.151%, and the variance explained by the first factor was only 36.969%, which did not reach the critical criterion of 40% (Hao and Long, 2004). Therefore, there is no significant common method bias in this study.

We then performed descriptive analysis, correlation analysis, and model testing of the data based on the research hypotheses. First, we examined the concentration and dispersion trends of the data through descriptive analysis. Then, we analyzed correlations among the variables to test the relationships among the independent, mediating, dependent, and moderating variables by calculating Pearson correlation coefficients. Based on the correlations, the research hypotheses proposed in this paper were further examined by using the PROCESS (version 3.3) plug-in SPSS to test the model's mediating effects [The PROCESS plug-in was developed by Hayes specifically for path analysis-based moderating and mediating analyses and combinations thereof (Bolin and Hayes, 2014)].

RESULTS

Descriptive Statistics and Correlation Analyses

Descriptive statistics and Pearson matrix correlation coefficients were calculated using SPSS 23.0 to analyze the mean, standard deviation, and correlation coefficients for sense of place, psychological resilience, and creativity of elementary school students. The results of descriptive statistical analysis are shown in **Table 1**, and the results of Pearson matrix correlation coefficients are shown in **Table 2**.

As shown in **Table 2**, sense of place was significantly and positively correlated with general creativity ($r = 0.59$, $p < 0.01$) and psychological resilience ($r = 0.45$, $p < 0.01$). Psychological resilience was associated with creativity ($r = 0.63$, $p < 0.01$). The results of the correlation analysis initially supported the subsequent test of mediating effects.

TABLE 1 | Descriptive statistics for the three variables.

Variables	*N*	Mean	SD
Sense of place	1,711	41.47	7.344
Male	914	41.54	7.344
Female	797	41.39	7.348
Year			
1	346	41.37	7.595
2	329	41.86	6.854
3	316	41.56	7.335
4	251	41.7	7.492
5	257	40.82	7.369
6	212	41.46	7.499
Psychological resilience	1,711	62.87	9.774
Male	914	62.79	9.919
Female	797	62.96	9.61
Year			
1	346	62.24	10.211
2	329	62.62	10.004
3	316	62.26	9.181
4	251	63.79	9.967
5	257	63.42	9.268
6	212	63.42	9.872
Creativity	1,711	31.22	8.418
Male	914	31.59	8.444
Female	797	30.8	8.372
Year			
1	346	30.92	8.65
2	329	31.06	8.368
3	316	30.27	8.411
4	251	31.88	8.448
5	257	31.38	7.651
6	212	32.41	8.849

TABLE 2 | Pearson's *r* for the three variables.

S. No.	Variables	Sense of place	Creativity	Psychological resilience
1.	Sense of place	–		
2.	Creativity	0.59**	–	
3.	Psychological resilience	0.45**	0.63**	–

*$p < 0.05$; **$p < 0.01$.

Mediation Analysis

The PROCESS plug-in (version 3.3) was used to conduct a mediation analysis with sense of place as the independent variable, creativity as the dependent variable, and psychological resilience as the mediating variable (model #4). Based on the literature review, the three most commonly reported factors that influenced the dependent and mediating variables—gender and grade level—were considered as covariates in this study. Both were transformed into dummy variables before being entered into the mediating model as covariates.

The results (see **Table 3**) showed that sense of place significantly predicted creativity ($\beta = 0.68$, $t = 30.32$, $p < 0.001$), and the prediction remained significant even when the mediating variable, psychological resilience, was included ($\beta = 0.45$, $t = 20.66$, $p < 0.001$). Sense of place was found to have a significant positive predictive effect on psychological resilience ($\beta = 0.59$, $t = 20.64$, $p < 0.001$); in addition, psychological resilience was found to have a significant positive predictive effect on creativity ($\beta = 0.39$, $t = 23.86$, $p < 0.001$). In addition, the lower and upper confidence intervals (95%) between the direct effect of sense of place on creativity and the mediating effect of psychological resilience were not zero (see **Table 4**). This suggests that, after controlling for age and grade, sense of place directly predicts creativity and sense of place indirectly predicts creativity through psychological resilience. The direct effect (0.45) and the mediating effect (0.23) accounted for 65.95 and 34.05% of the total effect, respectively. **Figure 2** provides a graphic representation of these relationships.

DISCUSSION

Discussion of the Results

In this study, we developed a mediation model that investigated the relationship between sense of place and creativity among elementary school students during the COVID-19 pandemic. It was found that sense of place was positively related to creativity and to psychological resilience; also, psychological resilience was positively related to creativity, and psychological resilience mediated and buffered the direct effect of sense of place on creativity. These results are consistent with the hypotheses of this study and with previous research.

First, the findings are consistent with H1 and the existing literatures on the theory of creativity investment, indicating that sense of place is positively correlated to creativity. Creativity investment theory asserts that creative behavior is the result of the interaction between the individual and the environment. This result also confirms with the assertion in previous studies that positive environment has a facilitative effect on creativity (e.g., Richards, 1992; Ceylan et al., 2008; Pugsley and Acar, 2020) and that positive perception (or emotion) has a facilitative effect on creativity (e.g., Osofsky et al., 2011; Shenesey and Langhinrichsen-Rohling, 2015; Yawen et al., 2021). This finding implies that, during the COVID-19 pandemic, people may have been more creative if they had a stronger sense of local identity, local attachment, and local dependence. Just as creativity may be influenced by factors such as intelligence, knowledge, thinking style, personality traits, motivation, and environment, in accordance with creativity investment theory (Sternberg and Lubart, 1991), creativity is also a result of the interaction of abilities, processes, and environment (Plucker et al., 2004). In addition, different situations (e.g., Humke and Schaefer, 1996; Zhuravlyova and Zhuravlyov, 2015; Verneert et al., 2021) may produce types and levels creativity. Therefore, a person's attachment to a particular environment and their identification with or even dependence on a particular place may affect creativity as such emotions strengthen or as the positive or negative environment around them evolves. On this basis, the stronger the identification, attachment, and dependence that elementary school students develop to the place they live in, the more likely they are creative in academic performance, especially in essay composition, artistic creations, and scientific inquiry activities related to the place they are familiar with.

TABLE 3 | Mediation analysis results for the three variables.

Variables	Equation 1 (Outcome variables: Creativity)					Equation 2 (Outcome variables: Psychological resilience)					Equation 3 (Outcome variables: Creativity)				
	β	Boot SE	*t*	Boot 95% CI		*β*	Boot SE	*t*	Boot 95% CI		*β*	Boot SE	*t*	Boot 95% CI	
				Lower limit	Upper limit				Lower limit	Upper limit				Lower limit	Upper limit
Constant term	3.13	1.04	2.81**	1.07	5.14	36.72	1.57	25.52***	33.67	39.82	−11.11	1.06	−9.78***	−13.17	−8.98
Gender	−0.65 (−0.04)	0.33	−1.98	−1.30	−0.02	0.30 (0.02)	0.42	0.70	−0.53	1.10	−0.77 (−0.05)	0.29	−2.69**	−1.31	−0.19
Year	0.31 (0.061)	0.10	3.12**	0.11	0.50	0.33 (0.06)	0.13	2.63**	0.08	0.58	0.18 (0.04)	0.09	2.08***	0.00	0.35
Sense of place	0.68 (0.590)	0.02	30.32***	0.64	0.72	0.59 (0.45)	0.03	20.64***	0.53	0.66	0.45 (0.39)	0.03	20.66***	0.39	0.50
Psycho-logical resilience											0.39 (0.45)	0.02	23.86***	0.35	0.43
R^2	0.35					0.20					0.52				
F(df)	310.70*** (3,1707)					143.80*** (3,1707)					452.92*** (4,1706)				

***p < 0.01; ***p < 0.001, all bilateral.*

Gender 1 = male, gender 2 = female; year 1 = first year, year 2 = second year, year 3 = third year, year 4 = fourth year, year 5 = fifth year, and year 6 = sixth year.

This type of creativity is exactly what was described earlier as Mini C and Little C. These creative things also have the potential to gradually develop students' Pro C and even the Big C at some point in the future and are most likely related to students' resilience during the COVID-19 pandemic. Second, the results of this study are also similar to the results of similar studies that have concluded that a positive environment positively influences psychological resilience (Xu et al., 2021) and that positive perceptions (or emotions) positively influence psychological resilience (Can, 2020). This result suggests that elementary school students' sense of place may have enhanced their psychological resilience during the COVID-19 pandemic. One possible explanation is that they had developed identity with, attachment to, and even dependence on a specific place in response to a specific emotion, which in turn enhanced both internal and external protective factors. These protective factors may facilitate pupils' recovery from negative experiences such as the novel coronavirus and their ability to adapt to their changing environment.

Third, these results are consistent with H3 and with studies that have showed that psychological resilience has a positive predictive effect on creativity (Xu et al., 2021). In other words, people with a high level of psychological resilience are more creative. This conclusion is consistent with psychological and sociological findings that reveal that when people are more psychologically resilient, individual problem-solving stamina and stress tolerance are stronger, which promotes creativity. Creativity is associated with the social component of psychological resilience because creative activity is a more direct expression of psychological resilience and is social in nature. In turn, psychological resilience is supported in the social environment and in social relationships that reinforce participation in creative activity. As mentioned in the theory of creativity investment, personality has a close relationship with creativity. This is mainly manifested in the resilience, willingness to take moderate risks, self-confidence, and courage to hold on to personal beliefs in the face of obstacles. It can be inferred that creativity is related to the social component of mental toughness. Because creative activity is a more direct expression of psychological resilience and is social in nature, in turn, psychological resilience is supported in the social environment and social relationships that reinforce the engagement in creative activities. Thus, social participation in creativity and psychological resilience are mutually supportive (Hertzog et al., 2008; McFadden and Basting, 2010; Xu et al., 2021). For elementary school students, a possible explanation for this outcome might be that their psychological resilience contributes to the creativity in their personality, which in turn facilitates the development of their creativity. As a result, students may achieve significant development in Mini C and Little C.

Fourth, these results corroborate H4 as well as those of previous studies. We found that psychological resilience can mediate between sense of place and creativity, acting as a pathway for sense of place to act on creativity. Neurologically, psychological resilience is seen to be related to emotional processing, and psychological resilience is also related to the functioning of different regions of the brain. Precisely,

psychological resilience is positively correlated with the level of connectivity between the left orbitofrontal gyrus and the left inferior frontal gyrus, which enables flexible use of emotional resources and flexible control of interest processing, and with the level of connectivity of the right parahippocampal area, which promotes self-assessment (Shi et al., 2019; Xu et al., 2021). This gives highly resilient people the psychological ability to make the most of their emotional resources in the face of adversity or threat (Debbané et al., 2017; Xu et al., 2021), prompting individuals to challenge themselves in positive adaptation to adversity so that they can survive and thrive in their own positive adjustment (Sweetman et al., 2011; Xu et al., 2021). In other words, during negative experiences such as the COVID-19 pandemic, psychological resilience may have a moderating effect on readjustment to learning and life, prompt individuals to find better adaptation to a specific environment they already identify with, attach to, or even depend on after a mood disorder has occurred. At the same time, psychological resilience can also help individuals to more efficiently solve problems of daily life as well as to readjust to society and create new opportunities (Small-C creativity; Xu et al., 2021).

It is evident that, in the current study, psychological resilience partially moderates the relationship between sense of place and creativity. Data analysis showed that sense of place had the greatest impact on creativity (65.95%), which implies that the mediating role of psychological resilience is not dominant (only 34.05%). This also suggests that sense of place itself may have an important influence on creativity.

TABLE 4 | Total effect, direct effect, and indirect effect among variables.

	Effect size	Boot SE	Boot 95% CI		Relative effect size
			Lower limit	Upper limit	
Total effect	0.68	0.02	0.64	0.72	
Direct effect	0.45	0.03	0.39	0.50	65.95%
Indirect effect	0.23	0.02	0.19	0.27	34.05%

Implications

This study has provided perspectives on the sense of place and creativity of elementary school students amid the COVID-19 pandemic. Our findings of the study have important theoretical and practical implications. In terms of its theoretical implications, this study is unique in linking sense of place to creativity, which deepens understanding of the impact of sense of place on creativity. Furthermore, the mediating and buffering role of psychological resilience demonstrated in this study suggests that elementary school students' sense of place during the COVID-19 pandemic may have strengthened their psychological resilience, which in turn may have influenced their creativity. This actually enriches the theory of creativity investment as well. As for the practical implications, first, teachers need to highlight the sense of place among adolescents, so that students who identify with, attach to, and rely on a particular environment can become more creative. In addition, our research has found that psychological resilience has a buffering effect on the sense of place and creativity, suggesting that parents, teachers, and school administrators should focus on developing psychological resilience training for elementary school students to ensure that they will be able to cope with stressful events in future.

Limitations and Future Directions

This study has some limitations. First, its design is cross-sectional. Second, all participants were from one elementary school, which may have affected the representativeness of the results. Future researchers could use a longitudinal study design to collect data over time, or they could look at participants from different schools or even from different sections of school populations. In addition, researchers could explore the relationship between sense of place, psychological resilience, and the various dimensions of creativity. Although the mechanisms by which sense of place affects creativity may be contested, this study provides empirical evidence that will be useful to future researchers.

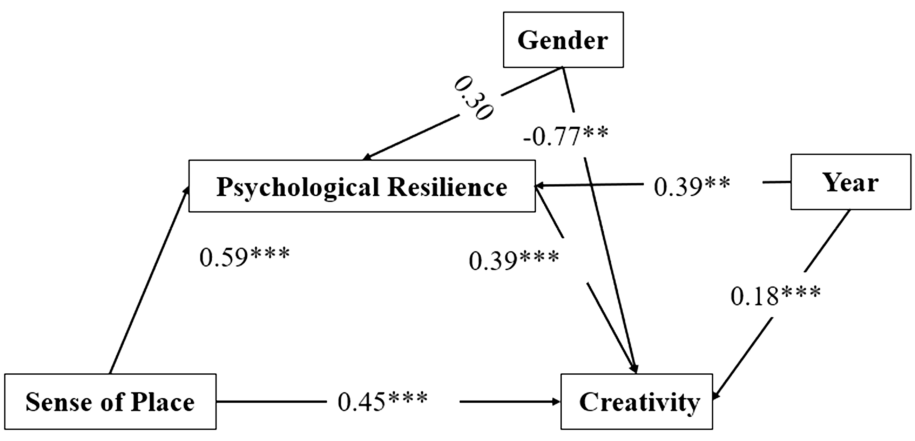

FIGURE 2 | The mediation model showing relationships between sense of place and creativity and the mediating role of psychological resilience. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

CONCLUSION

This study explored the relationship between sense of place and creativity and the role of psychological resilience in mitigating this relationship. The results indicated that sense of place was a positive predictor of creativity, i.e., elementary school students with a stronger sense of place tended to be more creative. Elementary school students with a strong sense of place were more psychologically resilient than those with a weaker sense of place. In addition, elementary school students who were more psychologically resilient were more creative than those who were less psychologically adaptive. Notably, most of the variance in creativity was attributable to sense of place, although psychological resilience did play a role, suggesting that a strong sense of place enhanced students' creativity.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

PL and YX designed the research. YX, QW, and DZ carried out the literature search and data analysis and wrote the paper. All authors have read and agreed to the submitted version of the manuscript.

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Conflict of Interest: The authors declare 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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