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Academic performance under COVID-19: The role of online learning readiness and emotional competence

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Abstract

The COVID-19 pandemic caused school closures and social isolation, which created both learning and emotional challenges for adolescents. Schools worked hard to move classes online, but less attention was paid to whether students were cognitively and emotionally ready to learn effectively in a virtual environment. This study focused on online learning readiness and emotional competence as key constructs to investigate their implications for students' academic performance during the COVID-19 period. Two groups of students participated in this study, with 1,316 high school students (*Mean age* = 16.32, *SD* = 0.63) representing adolescents and 668 college students (*Mean age* = 20.20, *SD* = 1.43) representing young adults. Structural equation modeling was conducted to explore the associations among online learning readiness, emotional competence, and online academic performance during COVID-19 after controlling for pre-COVID-19 academic performance. The results showed that, for high school students, both online learning readiness and emotional competence were positively associated with online academic performance during COVID-19. However, for college students, only online learning readiness showed a significant positive relationship with online academic performance during COVID-19. These results demonstrated that being ready to study online and having high emotional competence could make adolescents more resilient toward COVID-19-related challenges and help them learn more effectively online. This study also highlighted different patterns of associations among cognitive factors, emotional factors, and online academic performance during COVID-19 in adolescence and young adulthood. Developmental implications were also discussed.

Keywords online learning readiness · emotional competence · online academic performance · adolescent · young adult

COVID-19, as a public health crisis, stimulated a subsequent education crisis in which the existing achievement gap, learning loss, and dropout rate were exacerbated due to school closures (Sahu, 2020; United Nations, 2020). To prevent COVID-19 transmission, educational institutions worldwide made massive efforts to shift from in-person to online teaching (Basilaia & Kvavadze, 2020; Chen et al., 2020; Daniels et al., 2021; Subedi et al., 2020). However, little is known about whether students were cognitively and emotionally ready to learn effectively online at the time of transition.

COVID-19 created learning challenges caused by changes in educational platforms, especially for adolescents. Adolescence is a time when peer influences expand (Knoll et al., 2015; Knoll et al., 2016). With the dramatic changes in adolescents' "social brain," these students have a stronger desire for social interaction and are more sensitive to social isolation (Blakemore, 2008; Steinberg, 2005; Yurgelun-Todd, 2007). Social interactions with teachers, peers, and others are crucial elements in adolescents' learning experiences (Perret-Clermont et al., 2004). Therefore, students struggle to be cognitively engaged in class without the motivation of in-person interactions with teachers and peers during online learning (Kim & Frick, 2011; Zembylas et al., 2008). Moreover, the new platform delivers information in an entirely different way within a totally different environment (i.e., school vs. home), which requires students to use technology and communicate effectively virtually while resisting distractions in the new environment (Aguilera-Hermida, 2020; Chen & Jang, 2010;

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Ferrer et al., 2020). In short, learning effectively online was extremely challenging during the pandemic.

In addition, COVID-19–related mental health difficulties, such as loss of relatives, social isolation, and heightened stress and anxiety (Hamza et al., 2020; Son et al., 2020; Wang et al., 2020), made students' academic lives even more challenging (Grubic et al., 2020; Liang et al., 2020; Thakur, 2020; Zhai & Du, 2020; Zhao, 2021). As mentioned above, adolescence is a developmental stage characterized by a particularly sensitive “social brain” (Blakemore, 2008), and it is a critical period for emotional competence development (Booker & Dunsmore, 2017; Trentacosta & Fine, 2010). As such, any interpersonal and social-emotional suffering is magnified for adolescents when compared to individuals in other developmental stages. Students during this developmental stage need to have higher emotional competence to cope with emotional distress effectively, allowing them to be more resilient to the challenges of the COVID-19 pandemic and perform better academically (Baba, 2020; Bao, 2020). Therefore, this study focused on online learning readiness and emotional competence as key constructs to investigate their implications for students' academic performance during the COVID-19 period.

COVID-19 and online learning readiness

Online learning readiness refers to students' preparation to learn effectively in an online environment (Demir Kaymak & Horzum, 2013; Wei & Chou, 2020). Although whether students are ready for the “novice” online learning environment of the COVID-19 pandemic is an ongoing question, some preliminary findings provide insight into this question. Within higher education, according to Chung et al. (2020), students were generally ready for online learning in Malaysia. However, other researchers claimed that students' learning readiness was lacking (Widodo et al., 2020). In high school settings, students were found to have inadequate digital skills for online learning in Delhi (Bhaumik & Priyadarshini, 2020). Conversely, Dwiyantri et al. (2020) reported that most junior high school students in Indonesia were ready and only needed a few improvements. Considering that each institution, country, and researcher may have different standards of “being ready” for online learning, a more meaningful question is this: How did online learning readiness influence students' academic performance during the COVID-19 pandemic?

Online learning readiness and academic performance

Facilitating academic success is especially important for adolescents and young adults because academic performance has significant implications for future career development

(Negru-Subtirica & Pop, 2016; Van der Aar et al., 2019). The current pandemic is lowering adolescents' academic motivation (Aboagye et al., 2020), inducing learning loss (Kuhfield & Tarasawa, 2020; Turner et al., 2020), and ultimately causing lower academic performance (Kuhfeld et al., 2020). This phenomenon is partly due to a lack of readiness for online learning. According to the OECD's Programme in International Student Assessment (PISA), most adolescents from diverse countries (i.e., 15-year-olds in the 79 education systems in the PISA database) were not ready to learn online (Reimers & Schleicher, 2020).

Online learning is not purely about having a place or a computer with which to study. More importantly, it requires specific skills and online learning self-efficacy (Smith, 2005). Many studies have recognized the importance of students' motivation in the online learning environment (e.g., Chen & Jang, 2010; Khalilzadeh & Khodi, 2021). One challenge of online learning readiness research is that researchers have used different constructs, some of which overlap with self-directed learning and motivation (e.g., Cigdem & Ozturk, 2016; Pintrich, 2000; Zimmerman, 2008). Based on previous studies and in an effort to distinguish online learning readiness from self-directed learning and motivation, the current study focused on the three most-used factors in the online learning readiness literature: computer and Internet self-efficacy, learners' self-control in online contexts, and online communication self-efficacy (Hung et al., 2010; Yu, 2018).

Studies have indicated that these three online learning readiness factors are associated with students' online academic performance. *Computer and Internet self-efficacy* concerns students' confidence with computer and Internet use (Hatlevik et al., 2018; Torkzadeh et al., 2006). Having confidence in using Microsoft Office software or conducting Internet research enables online problem-solving, lessens the stress caused by technology, and improves academic performance (Compeau & Higgins, 1995; Eastin & LaRose, 2000; Tsai & Lin, 2004). *Learners' self-control in online contexts* refers to students' ability to avoid distractions from social media (e.g., Facebook or Instagram) and video games and to focus on online courses and assignments (Teng et al., 2014; Wang & Beasley, 2002). Finally, *online communication self-efficacy* reflects students' willingness and confidence in online interactions with instructors and peers to deepen understanding, which benefits their learning outcomes and learning satisfaction (Roper, 2007; Yilmaz, 2017). Having computer and Internet self-efficacy, self-control in online contexts, and online communication self-efficacy assists students with the transition to the online learning environment (Miao et al., 2020). Ultimately, these three factors all contribute to students' online learning performance.

Overall, online learning readiness has been shown to positively correlate with college students' academic performance

in the online learning environment (Davies & Graff, 2005; Lee & Choi, 2013; Yu, 2018). Moreover, research results have been consistent across studies in diverse college samples (Bernard et al., 2004; Joosten & Cusatis, 2020). However, before the current pandemic, the majority of online learning readiness studies focused on higher education. More studies are needed to address the role of online learning readiness in high school students' online academic performance and to determine how to support high school students in preparing for online learning, especially during the COVID-19 pandemic.

COVID-19 and emotional competence

Beyond online learning preparedness (e.g., computer skills or self-control in an online learning environment) for virtual learning during the COVID-19 pandemic, students also need emotional competence to prepare them for the hectic world. Emotional competence is defined as an individual's ability to express, regulate, and understand emotions (Denham et al., 2015; Saarni, 1999, 2000). Special attention needs to be paid to adolescents' emotional competence during the COVID-19 pandemic for two major reasons. First, emotional competence, as a crucial factor in academic performance (Brackett et al., 2012; Oberle et al., 2014; Rhoades et al., 2011) and effective functioning in adulthood (Kotsou et al., 2011; Takšić, 2002), are developed through socialization during adolescence (Valiente et al., 2020). With the unavoidable social isolation caused by COVID-19, adolescents have been shown to be less aware and less accepting of their own emotions (Hurrell et al., 2017; Valiente et al., 2020) and to have a harder time regulating their emotions (Casey et al., 2019; Cole, 2014). Indeed, several early works on COVID-19's immediate impacts reported an increase in low emotional competence-related mental health issues in adolescents and young adults (e.g., Janssen et al., 2020; Orgilés et al., 2020; Smirni et al., 2020).

Second, there is an urgent need for adolescents to be emotionally competent to deal with the extra emotional distress caused by COVID-19, including the experience of illness, loss of relatives, and financial difficulties during the pandemic (Li et al., 2021; Pan, 2020; Wathelet et al., 2020) as well as feelings of anxiety, depression, and sadness (Imran et al., 2020). Having high emotional competence would help students control and regulate their grief, sadness, and stress to cope with the new online learning environment more effectively (Baba, 2020; Morón & Biolik-Morón, 2020).

Emotional competence and academic performance

High emotional competence could not only lessen mental health issues but could also contribute to academic performance in both adolescent and young adult populations

(Brackett et al., 2012; Harley et al., 2019; Parker et al., 2004). Low emotional competence is related to increased mental health problems (e.g., Janssen et al., 2020; Orgilés et al., 2020; Smirni et al., 2020), which in turn interfere with academic performance (Dekker et al., 2020; Tembo et al., 2017). COVID-19 escalated this linkage because adolescents had a harder time regulating emotions due to social relationship changes (Akgül & Atalan Ergin, 2021; Mathews et al., 2016) and experienced higher levels of emotional distress caused by COVID-19-related issues (Magson et al., 2021).

According to recent research, students with a better ability to perceive and regulate emotions had higher online learning readiness levels and were more resistant to online distractions (Engin, 2017), so they were more likely to have better academic performance in an online learning setting (Artino Jr & Jones II, 2012; Kim & Pekrun, 2014). However, most emotional competence studies have been conducted in traditional face-to-face learning settings and focused on specific emotions, so it is necessary to test the role of emotional competence in online settings, especially during the current pandemic. Moreover, emotional competence plays different roles in adolescents' and young adults' lives (Hallam et al., 2014; Kotsou et al., 2011), but few studies have differentiated the roles that emotional competence play in academic performance between adolescence (high school students) and young adulthood (college students). Therefore, more research is needed to address the role that emotional competence plays during the COVID-19 pandemic from a developmental perspective.

The current study

Above all, online learning readiness and emotional competence are critical for understanding adolescents' academic performance during COVID-19. Given the lack of research on high school students' online learning readiness and students' emotional competence in online settings, little is known about whether online learning readiness and emotional competence may influence students' academic performance differently for high school students (adolescents) and college students (young adults). Therefore, this study aimed to (a) investigate how online learning readiness and emotional competence contribute to students' academic performance in both high school and college students during COVID-19 and (b) explore whether the pattern of associations would be different in high school students and college students. As mentioned above, college students with better online learning readiness have been shown to have higher online academic performance (e.g., Tsai & Lin, 2004; Yilmaz, 2017), and in a traditional face-to-face setting, students with higher emotional competence have tended to have better academic performance (e.g., Brackett et al.,

2012; Harley et al., 2019). In aim (a), this study proposed two hypotheses: *Hypothesis 1*—Both high school and college students with a higher level of online learning readiness will have better online academic performance during the COVID-19 pandemic; *Hypothesis 2*—Both high school and college students with better emotional competence will have higher online academic performance during the COVID-19 pandemic. Without enough evidence in the extant literature for us to make a specific prediction, aim (b) will be examined in an exploratory manner.

Method

Participants and procedure

High school sample

This study recruited 1,689 first-year students from a high school in northeast China with medium education quality. As recommended by Kline (2015), the minimum sample-size-to-parameters ratio would be 10:1. In the high school sample, the number of model parameters that required statistical estimates was 99. The sample-size-to-parameters ratio in our study was 17:1, meeting the requirement of above 10:1. A survey was set up on Wen Juan Xing (a Chinese survey engine similar to Qualtrics). The head teacher first sent out the consent form to students' parents through WeChat. Parents signed the form electronically and returned it to the head teacher. After obtaining consent from parents or guardians, the head teacher sent the survey link to students through WeChat during students' free time. The survey data were collected over a 2-week period in July 2020. After removing "careless cases" (i.e., the responses from participants who failed the attention check), the final sample consisted of 1,316 first-year high school students (39.1% male, 53.8% female, and 7.1% preferred not to say). We incorporated two attention checking items to avoid careless responses. For example, *for this question, please select disagree*. Participants who answered both attention checking questions correctly were included in this study. Participants' ages ranged from 15 to 18 years old ($Mean = 16.32$, $SD = 0.63$); 94.2% identified their race as Han (i.e., the majority in China), and 5.8% identified as minorities.

College student sample

A sample of 1,049 college students was recruited from a 4-year university in northeast China with medium education quality. In the college sample, the number of model parameters that required statistical estimates was 75. The sample-size-to-parameters ratio was 14:1, above the recommended 10:1 (Kline, 2015). The same survey on Wen Juan Xing was

used to collect data. A university lecturer first sent out the consent form to students or students' parents or guardians through WeChat (with forms sent to parents/guardians only for those students who were under 18). After receiving the signed consent forms, the university lecturer sent the survey link to students through WeChat during students' free time. The survey data were collected over a 2-week period in July 2020. After removing careless cases (i.e., the responses from participants who failed the attention check), the final sample consisted of 668 college students (43.3% male, 51.8% female, and 4.9% preferred not to say). Participants' ages ranged from 17 to 25 years old ($Mean = 20.20$, $SD = 1.43$). Among them, 149 were freshmen, 207 were sophomores, 76 were juniors, and 236 were seniors; 89.2% identified their race as Han (i.e., the majority in China), and 10.8% identified as minorities.

Measurement

Translation

All questionnaires originally in English (i.e., questionnaires on emotional competence and online learning readiness) were translated into Chinese through translation and back-translation procedures (Beaton et al., 2000). Specifically, one Chinese postdoctoral student fluent in English translated the scales to Chinese, and another Chinese university lecturer back-translated all scales to ensure translation accuracy. A bilingual US university faculty member checked both the translated and back-translated scales to further validate the translation. The whole survey included demographic information (e.g., gender, age, race) and questionnaires on emotional competence and online learning readiness.

Emotional competence

Emotional competence was measured by the Short Profile of Emotional Competence (S-PEC), which demonstrated high internal reliability in the original study ($D-G Rho = 0.85$; Mikolajczak et al., 2014). The S-PEC included five parallel subfactors in both the intrapersonal (10 items) and interpersonal (10 items) dimensions. Each of the five subfactors was assessed by two items. These subfactors were identification (e.g., "When I am touched by something, I immediately know what I feel"), comprehension (e.g., "I do not always understand why I respond in the way I do"), expression (e.g., "I find it difficult to explain my feelings to others even if I want to"), regulation (e.g., "When I am angry, I find it easy to calm myself down"), and utilization ("If I wanted, I could easily make someone feel uneasy"). All items were rated on a scale from 1 = *never* to 5 = *very often*. In our study, two items in each subfactor were averaged to create a composite score; a higher value indicated

better emotional competence in that specific subfactor. In our samples, both the reliability (Cronbach's $\alpha = 0.71$ in the high school sample and 0.76 in the college sample) and the constructive validity (high school sample: $\chi^2(25) = 48.12$, $p = 0.004$, CFI = 0.99 , TLI = 0.98 , RMSEA (90% CI) = 0.03 (0.02 – 0.04), SRMR = 0.02 ; college sample: $\chi^2(29) = 59.62$, $p = 0.001$, CFI = 0.98 , TLI = 0.97 , RMSEA (90% CI) = 0.04 (0.03 – 0.05), SRMR = 0.03) of this translated measure were acceptable.

Apart from the confirmatory factor analysis, to further validate the psychometric properties of this translated instrument, we conducted item response theory analyses, like Alavi et al. (2021) and Khodi et al. (2021). Specifically, we applied the polytomous Rasch Rating Scale model (Andrich, 1978) to both the high school and college samples. Rasch measurement theory provides a clear and theoretically based framework that allows researchers to evaluate the degree to which the instrument adheres to invariant measurement (Martha et al., 2021; Wind et al., 2021; Wind & Guo, 2019). We used Winsteps software (Linacre, 2016) to obtain model-data fit statistics (i.e., infit and outfit *MSE*) and the reliability of separation statistics (*Rel*) for students and items. On average, the values of model-data fit statistics were around 1 for both high school students ($M_{\text{infit MSE}} = 1.01$, $SD = 0.73$; $M_{\text{outfit MSE}} = 1.02$, $SD = 0.72$) and college students ($M_{\text{infit MSE}} = 1.02$, $SD = 0.88$; $M_{\text{outfit MSE}} = 1.00$, $SD = 0.84$), and for items, the infit and outfit *MSE* were also close to 1 (high school sample: $M_{\text{infit MSE}} = 1.03$, $SD = 0.28$; $M_{\text{outfit MSE}} = 1.02$, $SD = 0.26$; college sample: $M_{\text{infit MSE}} = 1.00$, $SD = 0.27$; $M_{\text{outfit MSE}} = 1.00$, $SD = 0.26$), indicating acceptable fit to the Rasch model. The reliability of the separation statistic for students (high school sample: $Rel = 0.86$; college sample: $Rel = 0.88$) suggests that the instrument effectively differentiated students with different levels of emotional competence. Similarly, the reliability of the separation statistic for items (high school sample: $Rel = 1.00$; college sample: $Rel = 1.00$) indicates that there were differences in difficulty to endorse each item. We also conducted differential item functioning (DIF) analysis to determine whether the item response differed between high school students and college students while controlling for an estimate of emotional competence. Several researchers (Draba, 1977; Wind & Guo, 2019; Wright et al., 1976) have recommended that absolute logit differences that exceed 0.5 suggest that DIF occurs between two groups. Our results show that the range of differences in Rasch calibrations were from -0.38 logits to 0.43 logits, which indicates that there were no substantively meaningful differences between high school students and college students. In summary, the emotional competence instrument demonstrated acceptable psychometric properties for measuring emotional competence among both high school and college students.

Online learning readiness

Items that directly targeted the online learning environment on the Online Learning Readiness Scale (OLRS; Hung et al., 2010) were employed to measure online learning readiness. Specifically, there were three items in each of the following three subscales: computer/Internet self-efficacy (e.g., "I feel confident in my knowledge and skills of how to manage software for online learning," Cronbach's $\alpha = 0.74$), learner control in online contexts (e.g., "I can direct my own learning progress in online courses," Cronbach's $\alpha = 0.73$), and online communication self-efficacy (e.g., "I feel confident in expressing myself [emotions and humor] through text," Cronbach's $\alpha = 0.87$). All items were rated from 1 = *strongly disagree* to 5 = *strongly agree*. Three items on each of the subscales were averaged to create a composite score so that a higher value indicated higher levels of online learning readiness on that subscale. In our samples, both reliability (Cronbach's α ranged from 0.72 to 0.73 in the high school sample and 0.75 to 0.82 in the college sample) and constructive validity (high school sample: $\chi^2(19) = 100.04$, $p < 0.001$, CFI = 0.98 , TLI = 0.96 , RMSEA (90% CI) = 0.06 (0.05 – 0.07), SRMR = 0.02 ; college sample: $\chi^2(22) = 45.70$, $p = 0.002$, CFI = 0.99 , TLI = 0.99 , RMSEA (90% CI) = 0.04 (0.02 – 0.06), SRMR = 0.02) of this translated measure were acceptable.

Apart from the confirmatory factor analysis, to further evaluate the psychometric properties of the translated OLRS, we also conducted Rasch analysis as we did for S-PEC. The results indicate that OLRS exhibited acceptable psychometric properties for measuring both high school and college students' online learning readiness. Specifically, the average values of model-data fit statistics were around 1 for both groups (high school sample: $M_{\text{infit MSE}} = 1.00$, $SD = 0.98$, $M_{\text{outfit MSE}} = 1.00$, $SD = 0.97$; college sample: $M_{\text{infit MSE}} = 0.96$, $SD = 1.15$; $M_{\text{outfit MSE}} = 0.97$, $SD = 1.17$) and items (high school sample: $M_{\text{infit MSE}} = 1.00$, $SD = 0.19$, $M_{\text{outfit MSE}} = 1.00$, $SD = 0.20$; college sample: $M_{\text{infit MSE}} = 0.99$, $SD = 0.19$, $M_{\text{outfit MSE}} = 0.97$, $SD = 0.20$). The reliability of separation statistics for students (high school sample: $Rel = 0.86$; college sample: $Rel = 0.87$) and for items (high school sample: $Rel = 0.99$; college sample: $Rel = 0.98$) suggest that OLRS can effectively differentiate among individuals with different levels of online learning readiness. DIF analysis demonstrated that there were no substantively meaningful differences between high school students and college students ($-0.41 \leq \text{logit difference} \leq 0.33$).

Academic performance

After getting approval from their institutions, consent from students and their parents/guardians (for minor-aged students), we obtained students' academic performance

(indicated by final exam scores) from their teachers in both the high school and the college samples. In the high school sample, we collected students' final exam scores on Chinese, math, and English—three major disciplines in the Chinese high school education system (the maximum possible score for each discipline was 150). In the college sample, we gathered students' average final exam scores across all courses they had taken (the maximum possible score was 100). We collected participants' scores at two time points (T1 and T2) for both samples. T1 was before the COVID-19 pandemic when traditional face-to-face teaching was used, and T2 was during the COVID-19 pandemic when online synchronous teaching was used. Students in both samples had similar online learning experiences. Specifically, the online synchronous teaching adopted Dingding (a Chinese meeting software application like Zoom), and Microsoft Office programs were used for assignments. WeChat (a Chinese messaging app) was utilized for teacher–teacher, teacher–student, student–student, and teacher–parent communication. For the high school sample, data were collected in December 2019 (T1) and July 2020 (T2); for the college sample, data were collected in January 2020 (T1) and June 2020 (T2). Students were assigned a four-digit research ID to confidentially link their final exam scores and the survey results.

Plan of analysis

Data analysis was conducted in Mplus version 8.4 (Muthén & Muthén, 2017). In both the high school and college samples, measurement models via confirmatory factor analysis (CFA) were first estimated on the latent constructs of emotional competence, online learning readiness, and academic performance (high school sample only), individually. Specifically, the latent variable of emotional competence was indicated by 10 composite scores—identification, comprehension, expression, regulation, and utilization in both intrapersonal and interpersonal domains. The latent variable of online learning readiness was indicated by three composite scores of computer/Internet self-efficacy, learner control in online contexts, and online communication self-efficacy.

In the high school sample, the latent variable of pre-COVID academic performance was indicated by students' final exam scores on Chinese, English, and math at T1, and the latent variable of during-COVID academic performance was indicated by these three scores at T2. An overall measurement model including both the T1 and T2 latent constructs of academic performance was conducted after a CFA for each time point. In the college sample, because there was only a single score for each time point, that single score was used as a manifest variable for academic performance at T1 and T2. In each measurement model, correlations between residual variances were added one at a time according to modification indices (Sorbom, 1989).

Next, we used structural regression models to examine the association between emotional competence, online learning readiness, and students' during-COVID academic performance while controlling for their pre-COVID academic performance and the demographic characteristics of age and gender. That is, the T2 academic performance variable was regressed on age, gender, T1 academic performance, emotional competence, and online learning readiness. All predictors were allowed to correlate with each other. This analysis was conducted separately in the high school and college samples.

Both measurement models and structural regression models were estimated using full information maximum likelihood estimation to minimize the bias caused by missingness (Widaman, 2006). Overall model fit acceptability was evaluated using the following criteria: the comparative fit index (CFI) value was greater than 0.95, the Tucker-Lewis index (TLI) was greater than 0.90, the root mean square error of approximation (RMSEA) was less than 0.06, and the standardized root mean square residual (SRMR) value was less than 0.08 (Hu & Bentler, 1999). Standardized path coefficients were reported in each model.

Last, group invariance tests were conducted across gender groups in both the high school and college samples to indicate whether the overall structural regression model was significantly different by gender. This was done by comparing two multiple group models that did not include gender as a control variable: in the first model, all regression paths were freely estimated across groups; in the second model, all regression paths were constrained to be the same across groups. Changes in the CFI (Δ CFI) were used as a preferred approach for model fit comparison, with Δ CFI equal to or greater than 0.01 indicating a significant change in model fit caused by path constraints (Cheung & Rensvold, 2002). This approach was more suitable than the Chi-square difference test for a large sample.

Results

Table 1 includes descriptive statistics and correlation information for the variables used in the structural regression models. The lower panel shows correlations in the high school sample, and the upper panel depicts correlations in the college sample. Overall, variables were correlated in the expected directions in both samples. Moreover, the CFA models for emotional competence, online learning readiness, and academic performance across T1 and T2 all showed a good fit with the data (see Table 2).

In the high school sample, the structural regression model had acceptable model fit, where $\chi^2(153) = 669.25, p < 0.01$; CFI = 0.94; TLI = 0.92; RMSEA = 0.05 (90%: 0.05–0.06); SRMR = 0.05. All regression paths are listed in Fig. 1 (a). Both

Table 1 Correlations, Means, and Standard Deviations

Correlations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. ECintra_id	–	.39	.22	.32	.21	.42	.37	.30	.28	.30	.51	.41	.52	.02	.08	-.02	.02
2. ECintra_co	.27	–	.42	.47	.12	.42	.51	.33	.36	-.03	.29	.26	.32	-.01	.02	.01	.05
3. ECintra_ex	.10	.34	–	.33	.09	.36	.35	.27	.42	.06	.22	.22	.34	.01	.03	.05	-.01
4. ECintra_re	.15	.40	.29	–	-.08	.30	.34	.22	.28	.06	.29	.23	.30	-.01	.05	.01	-.05
5. ECintra_ut	.20	.06	-.05	-.09	–	.18	.09	.12	.00	.01	.05	.07	.10	-.05	-.05	-.05	-.02
6. ECinter_id	.35	.36	.32	.24	.15	–	.41	.39	.38	-.01	.29	.23	.29	.01	.03	-.02	.09
7. ECinter_co	.26	.31	.25	.23	.09	.41	–	.33	.35	-.05	.26	.24	.29	.01	.08	-.03	.04
8. ECinter_ex	.19	.19	.29	.15	.04	.33	.27	–	.29	-.01	.31	.25	.31	.01	.03	-.02	.07
9. ECinter_re	.20	.25	.38	.24	.05	.36	.27	.39	–	.07	.26	.29	.31	-.05	.02	.04	.02
10. ECinter_ut	.23	.00	.12	-.02	.03	.09	.04	.04	.13	–	.22	.15	.28	-.11	-.09	-.05	-.11
11. OL_eff	.35	.10	.16	.21	.05	.14	.12	.12	.19	.18	–	.71	.77	.07	.19	-.02	.00
12. OL_con	.24	.10	.19	.19	-.04	.08	.10	.06	.17	.09	.66	–	.68	.06	.13	.04	.01
13. OL_com	.36	.16	.31	.25	.06	.19	.17	.20	.29	.26	.68	.58	–	-.01	.08	.00	-.04
14. T1 score	.09	.02	-.03	-.01	.10	-.01	.03	-.07	-.09	.00	.08	.06	.02	–	.64	-.01	.27
15. T2 score	.15	.06	.05	.02	.08	.04	.05	.01	-.04	.05	.13	.14	.11	.72	–	.04	.23
16. Age	-.01	.03	.03	-.02	-.07	-.01	-.01	-.01	.02	-.05	-.05	.02	-.07	-.09	-.08	–	-.15
17. Gender	.17	.04	.02	-.08	.07	.12	.07	.13	-.04	-.03	-.05	-.06	-.07	.04	.13	-.06	–
Mean	H. 3.75	3.20	2.75	3.11	3.30	3.34	3.32	3.20	2.99	2.76	3.25	2.94	3.16	95.52	103.92	16.32	1.58
	C. 3.81	3.47	3.15	3.42	3.23	3.55	3.43	3.35	3.19	2.97	3.78	3.59	3.64	76.03	76.00	20.20	1.54
S.D.	H. 0.94	0.81	0.92	1.02	0.71	0.85	0.83	0.88	0.87	0.96	0.94	0.90	0.90	16.64	13.61	0.63	0.49
	C. 0.85	0.78	0.87	0.86	0.64	0.78	0.75	0.77	0.80	0.93	0.83	0.83	0.87	6.75	8.59	1.43	0.50

Note. Statistically significant correlations are bold and underlined ($p < .05$). For gender: 1=male, 2=female.

The lower panel presents correlations in the high school sample and the upper panel presents correlations in the college sample.

EC=Emotional Competence, intra=intrapersonal dimension, inter=interpersonal dimension, id=identification, co=comprehension, re=regulation, ut=utilization; OL=Online Learning, eff=computer/internet self-efficacy, con=learner control in online contexts, com=online communication self-efficacy; T1 score=pre-COVID final exam score, T2 score=during-COVID final exam score; H.=high school sample, C.=college sample.

Due to space limit, high school T1 score and T2 score were composite scores (i.e. average score of Chinese, English, and Math at T1 and T2) in this correlation table (but they were latent variables in the formal analyses).

emotional competence ($\beta = 0.06, p = .030$) and online learning readiness ($\beta = 0.07, p = .006$) were significantly associated with high school students' during-COVID academic performance, even after accounting for the stability of their academic performance from the pre-COVID to during-COVID periods ($\beta = 0.78, p < .001$) and controlling for the influence of age ($\beta = -0.02, p = .489$) and gender ($\beta = 0.07, p = .009$).

In the college sample, the structural regression model had good model fit, where $\chi^2(95) = 192.80, p < 0.01$; CFI = 0.97; TLI = 0.96; RMSEA = 0.04 (90%: 0.03–0.05); SRMR = 0.04. All regression paths are listed in Fig. 1 (b). Only online learning readiness ($\beta = 0.15, p = .003$) was significantly associated with college students' during-COVID academic performance after accounting for the stability of their academic performance from the pre-COVID to during-COVID period ($\beta = 0.61, p < .001$) and controlling for the influence of age ($\beta = 0.07, p = .061$) and gender ($\beta = 0.08, p = .024$). However, unlike the high school group, the association between emotional competence and during-COVID academic performance was not significant for college students ($\beta = -0.02, p = .756$).

Overall, the pattern of associations among variables was consistent across gender groups in both the high school and college samples, which was indicated by the insignificant change in the overall model fit (high school sample: $\Delta CFI = .000$; college sample: $\Delta CFI = .002$) between the model with constrained regression paths (i.e., constrained model) and the model with freely estimated regression paths (i.e., freely estimated model) across gender groups. This suggests that the association among emotional competence, online learning readiness, and during-COVID academic performance was representative of the whole sample (in the high school sample and college sample) regardless of a participant's gender.

Discussion

The present study was designed to evaluate how online learning readiness and emotional competence are related to students' online academic performance during the COVID-19 pandemic. The results of structural regression

Table 2 Model fit information for measurement models and structural regression models

	$\chi^2(df)$	CFI	TLI	RMSEA (90%CI)	SRMR
High School Sample					
M1: EC	48.12 (25) **	0.99	0.98	0.03 (0.02-0.04)	0.02
M2: OL	–	–	–	–	–
M3: T1 score	–	–	–	–	–
M4: T2 score	–	–	–	–	–
M5: overall (exclude gender, age)	367.90 (123) **	0.97	0.96	0.04 (0.03-0.04)	0.04
S: overall structural regression model	669.25 (153) **	0.94	0.92	0.05 (0.05-0.06)	0.05
College sample					
M1: EC	59.62 (29) **	0.98	0.97	0.04 (0.03-0.05)	0.03
M2: OL	–	–	–	–	–
M3: overall (exclude gender, age)	164.08 (73) **	0.97	0.96	0.04 (0.03-0.05)	0.04
S: overall structural regression model	192.80 (95) **	0.97	0.96	0.04 (0.03-0.05)	0.04

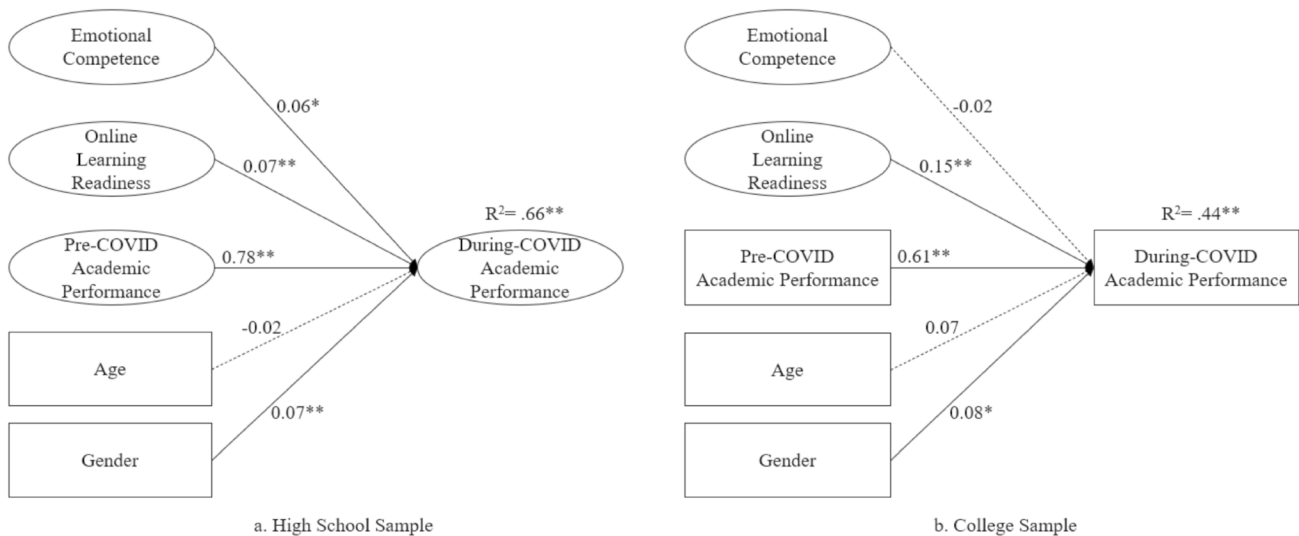
Note. * $p < .05$, ** $p < .01$.

M1-M5=measurement model 1-5, S=structural regression model, EC=Emotional Competence, OL=Online Learning Readiness, T1 score=Pre-COVID Academic Performance, T2 score=During-COVID Academic Performance.

Model fit information of M2-M4 in high school sample and M2 in college sample were not available, since there were only 3 manifest variables loading on 1 latent variable in each model and these models were just identified

models in both the high school and college samples generally supported our hypotheses. Consistent with Hypothesis 1, online learning readiness was associated with academic performance significantly for both high school students and college students (after controlling for their pre-COVID academic performance). However, there were some nuanced differences in the association between emotional competence and academic performance in the two samples. Partially consistent with Hypothesis 2, emotional

competence was significantly associated with high school students' academic performance, but such an association was not significant for college students. This finding also shed light on our second exploratory research question about the potentially different patterns of association among these constructs during adolescence (high school sample) and young adulthood (college sample). The association between online learning readiness and online academic performance was consistent across the two samples,



Note. * $p < .05$, ** $p < .01$.

Fig. 1 The Associations of Emotional Competence, Online Learning Readiness, and Academic Performance. All predictors were correlated with each other. Residuals were allowed to correlated according to modification indices

but the association between emotional competence and online academic performance during COVID-19 was different.

The findings for online learning readiness were consistent with previous research (e.g., Cigdem & Ozturk, 2016; Horzum et al., 2015) and highlighted the vital role of online learning readiness in the high school population. Both high school students and college students who are more ready to learn online had better online learning academic performance. Specifically, high school and college students who have confidence in using Microsoft Office programs, managing software, and using the search engines (e.g., Google and Yahoo) were more likely to have higher academic performance (Tsai & Lin, 2004). Moreover, as in previous studies (Roper, 2007; Yilmaz, 2017), students who could direct their own learning online, avoid online distractions (e.g., instant messages or surfing the Internet), and communicate effectively with peers or instructors online demonstrated stronger academic performance during COVID-19.

All these findings are in line with classical developmental psychology theories, especially Bandura's (1969, 1977) interactive triangle of personal factors, personal behaviors, and environmental factors and Vygotsky's (1978) social learning theory. A change in social and learning environment could influence students' learning significantly, and how well students' responses fit the environment are key factors of the learning outcome. Online learning and the pandemic are foreign for both high school and college students; the more ready students are, or the more quickly they can adjust to the new environment, the better their learning outcomes will be (Tu, 2002).

Developmental differences were identified in the associations between emotional competence and academic performance. The association between emotional competence and during-COVID-19 academic performance in the high school sample confirmed the findings from previous research that high emotional competence could contribute to academic performance (Brackett et al., 2012; Garner, 2010). Adolescents who could identify, comprehend, regulate, and utilize their own or others' emotions performed better academically (Brackett et al., 2012; Durlak et al., 2011; Zins et al., 2007). Such findings are consistent with Pekrun's (2000, 2006) control-value theory of achievement emotion, which highlights the emotional arousal in academic settings elicited by academic achievement. Achievement emotion can influence cognitive, motivational, and regulatory processes associated with learning and achievement. Conversely, negative emotions consume energy that is essential for cognition and impair academic performance (Meinhardt & Pekrun, 2003). Therefore, adolescents who could better identify and regulate emotion achieved higher grades in the current study.

However, in the college sample, no association was identified between emotional competence and academic performance. This discrepancy in the association pattern between emotional competence and during-COVID-19 online academic performance is likely due to two factors: developmental differences and different measurements of academic performance. Developmentally, adolescents may have a harder time regulating emotions due to brain, body, and social relationship changes (Casey et al., 2019; Miller-Slough & Dunsmore, 2016), so emotional competence appears to be more critical for adolescents than young adults. The discrepancy might also be caused partially by the different measures of GPA (i.e., high school—Chinese, math, and English total grade; college—a single average score).

The current study has both theoretical and practical implications. The relatively large pooled sample sizes (15–25 years of age) enabled us to make more generalizable statistical inferences about both high school students (adolescents) and college students (young adults), at least in the Chinese student population. Theoretically, this study added to the limited literature on adolescents' online learning readiness (Tsai & Lin, 2004) and replicated prior work in the college population to emphasize the important role online learning readiness plays in online academic performance during young adulthood (e.g., Hung et al., 2010; Rafique et al., 2021). Moreover, our findings extended previous research on the impact of emotional competence on psychological development outcomes (e.g., Kotsou et al., 2011; Valiente et al., 2020) to highlight its crucial role in online academic performance, especially for high school students.

Practically, this study informed both high schools and higher education institutions that preparing students to learn online is as essential as preparing the institution to operate online (Habibu et al., 2012; Littlejohn & Pegler, 2007). Being ready to transition to an online learning environment and having high emotional competence could make adolescents more resilient to COVID-19-related challenges, such as social isolation and learning loss (Shanahan et al., 2020). Educational institutions not only need to provide instructions on how to use Microsoft Office software and online searching techniques but should also provide learning strategies like how to avoid online distractions (e.g., social media and video games) and how to communicate effectively with teachers and peers online. Such guidance would be especially beneficial for students who think they are not ready for online learning. Moreover, students' mental health issues need to be addressed by emotional competence-related interventions, especially for adolescents (Lau & Wu, 2012). Schools and universities should consider having interventions and training on emotional competence to promote students' mental health

and help them navigate the volatile, uncertain, complex, and ambiguous world (Hadar et al., 2020). Effective strategies of identifying, comprehending, regulating, and utilizing emotions should be offered via online instructions and activities, especially for high school students. Moreover, online counseling should be more accessible for adolescents (O'Connor, 2020; Wen et al., 2020).

Limitations

This study has some limitations that should be considered when interpreting its results. First, although pre-COVID academic performance has been controlled for from a longitudinal perspective, the directionality of the association between online learning readiness, emotional competence, and online academic performance during the COVID-19 pandemic could not be deduced due to the cross-sectional nature of the current data. The different measures of grade point average across the sample may have contributed to different findings for the groups. Second, self-reported data on emotional competence and online learning readiness unavoidably introduced bias into the measurements. Thirdly, this study did not account for demographic control variables such as socioeconomic status, which can be a key factor contributing to students' access to computers and the Internet or other resources. Moreover, the data collection intervals were different for high school and college students, being 2 months less for the latter group.

Future directions

Future studies that include students in small towns and rural areas will enrich the generalizability of our findings because our samples were predominantly students from cities. Rural or suburban students would likely have less access to online resources or learning resources in general (Lai & Widmar, 2021). Moreover, longitudinal research is needed to infer the associational patterns of emotional competence and online learning readiness with academic performance, considering the enduring and emerging nature of emotional competence during adolescence (including young adulthood) and their potential nuanced implications for academic performance trajectory. Regardless, this is one of the first studies, to our knowledge, that simultaneously considered cognitive and emotional factors associated with online academic performance across different developmental stages in adolescence during the COVID-19 pandemic.

Availability of data and material The authors do not have permission to share the data used in this study.

Declarations

Conflicts of interest/Competing interests On behalf of all authors, the corresponding author states that there is no conflict of interest.

Code availability Not applicable.

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the Beijing Normal University and Dalian Neusoft University of Information. We are in compliance with the 1964 Declaration of Helsinki and its later addenda.

Consent to participate Informed consent was obtained from all individual participants included in the study. For participants under 18 years old, parent and guardian consent were obtained.

Consent for publication Not applicable.

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