International Journal of Educational Research Open 6 (2024) 100332

Contents lists available at ScienceDirect

International Journal of Educational Research Open

journal homepage: www.elsevier.com/locate/ijedro

Sudden transition to online learning: Exploring the relationships among measures of student experience

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ARTICLE INFO

Keywords:
Online learning anxiety
Math anxiety
COVID-19 anxiety
Self-perceived performance
Higher education

ABSTRACT

Online learning anxiety might be related to how university students perceived their learning and performance during the COVID-19 pandemic, and in course modules with mathematical content, math anxiety may also have come into play. The aim of this study was to examine the relationships between these types of anxiety, as well as to explore other possible factors associated with students' experience of sudden transition to online learning in a module with high mathematical content. Participants were 125 psychology undergraduates enrolled in a Research Design module. The main results showed that students reporting greater online learning anxiety found online materials less useful and suffered from greater math anxiety; their self-perceived performance was also worse. In the year following lockdown, online learning anxiety was lower and the perceived usefulness of online material was greater than during lockdown. Finally, analysis of the association between psychological state in the use of e-learning tools during COVID-19 and online learning anxiety revealed that online learning readiness played a mediating role in this relationship. The paper concludes with a series of recommendations regarding how universities might better prepare for future unforeseen disruptions to face-to-face teaching. In particular, there is a need to improve students' readiness for online learning and to ensure that online materials are perceived as useful.

1. Introduction

The year 2020 will go down in history due to the global COVID-19 pandemic. In response to such a critical health situation, governments across the world implemented lockdowns and ordered the cessation of all non-essential activity for several months. During this period, social isolation, the effects on the economy, fears about the COVID-19 outbreak and uncertainty about what might happen had a negative impact on people's mental health, leading to an increase in symptoms of anxiety, depression, post-traumatic stress, psychological distress and stress (see, for example, the meta-analysis by Xiong et al. (2020; for Spain, see Ozamiz-Etxebarria et al. 2020). The impact was also felt in the academic context, insofar as both students and teachers had to switch immediately from face-to-face to online instruction. Learning thus became entirely mediated by technology, and by having to study remotely and individually at home, students were deprived of the opportunity for traditional classroom socialization.

In the context of higher education, several meta-analyses have reported a high prevalence of anxiety, depression and stress among students during the COVID-19 health emergency (Chang et al., 2021; Deng et al., 2021; Li et al., 2021; Wang et al., 2021). Psychological unease about the public health crisis may have negatively affected students' learning, which might have been further undermined by difficulties related to online teaching and assessment (e.g. worries about their education, examinations, problems accessing technology, unreliable internet connection, etc.). In the case of course modules with high mathematical content (i.e. those in which mathematical or statistical reasoning is a core requirement for students), math anxiety may also have had an important impact on their learning process, as it is a factor often associated with low academic achievement in maths courses (e.g. Núñez-Peña et al. 2015).

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https://doi.org/10.1016/j.ijedro.2024.100332
Received 18 October 2023; Received in revised form 5 February 2024; Accepted 5 February 2024
Available online 9 February 2024

1.1. Anxiety and online learning during the COVID-19 pandemic

Several studies have reported anxiety-related learning deficits during the COVID-19 pandemic. For example, academic delays were found to be positively associated with anxiety symptoms among Chinese college students (Cao et al., 2020). A study of Spanish university students during lockdown found that higher levels of both state and trait anxiety were associated with lower perceived academic self-efficacy (Alemany-Arrebola et al., 2020). High rates of anxiety in university students during the first months of the pandemic, concentration difficulties, difficulty in managing the academic workload and the need to perform well in online learning have also been documented (Fitzgerald & Konrad, 2021). Similarly, students with high levels of anxiety and stress were found to score lower on concentration, motivation and performance following the sudden transition to online teaching; these students showed a lower level of learning, more attentional difficulties and more motivational deficits (Besser et al., 2020). According to attentional control theory (ACT; Eysenck et al., 2007), anxiety interferes negatively with cognitive tasks precisely because it reduces attentional control, and this could explain why anxiety and concentration difficulties manifested together during the pandemic, decreasing study efficiency and undermining academic performance.

As for the negative impact that online teaching during the COVID-19 crisis might have had on learning, research prior to the pandemic had already shown that spending a lot of time in front of the computer poses an increased risk of anxiety and depression (Feng et al., 2014). It has also been suggested that negative psychological reactions to the COVID-19 pandemic could have reduced students' willingness to acquire knowledge through virtual means (Xie et al., 2020). Therefore, if both the pandemic and the transition to online instruction produced anxiety, they might have combined to have a potentially negative impact on the ability of students to advance in their learning. In situations such as this, it is crucial that teachers support students and provide them with online materials that facilitate their learning. Importantly, Fitzgerald and Konrad (2021) found that students who reported receiving good support from instructors had fewer sources of anxiety.

1.2. Math anxiety

Another relevant factor related to academic achievement in course modules with high mathematical content is math anxiety (for a review, see Suárez-Pellicioni et al. 2016). Math anxiety is defined as "feelings of tension, apprehension or even dread that interfere with the ordinary manipulation of numbers and the solving of mathematical problems" (Ashcraft & Faust, 1994, p. 98). The negative impact of math anxiety on academic achievement has been observed across all levels of education, from children in primary school through to university students (Barroso et al., 2021). In the higher education context, Núñez-Peña et al. (2013) found that highly math-anxious undergraduates obtained lower grades in a course module with high mathematical content than did their low-math-anxious classmates, and they also reported lower levels of math enjoyment, motivation and self-confidence (see, also, Núñez-Peña et al. 2015). More recently, Núñez-Peña and Bono (2019) reported that math anxiety is the main emotional factor (among other types of anxieties that learners experience in academic settings) that is negatively related to undergraduates' performance in courses of this kind.

As for the negative relationship between math anxiety and math performance, two explanations have been proposed based on cognitive theories of anxiety. Ashcraft and Kirk (2001), Ashkraft and Krause (2007) proposed that when highly math-anxious individuals perform a math task, math related intrusive thoughts and ruminations on poor performance, as well as worrying about mistakes, would occupy the limited working memory (WM) resources. This overload of WM resources would lead highly math-anxious students to perform poorly in mathematics, because they would not have enough cognitive resources to carry out tasks properly. This proposal has been referred to as the *disruption account* (Ramirez et al., 2018) and it is based on processing efficiency theory (PET; Eysenck & Calvo, 1992). Another recent proposal, based on ACT (Eysenck et al., 2007), claims that the low math achievement of highly math-anxious individuals may be due to their reduced attentional control (e.g. González-Gómez et al. 2023, Suárez-Pellicioni et al. 2015). Specifically, it is suggested that these individuals might have impairments in the shifting (González-Gómez et al., 2023) and inhibition (Suárez-Pellicioni et al., 2015) functions of the central executive system. Executive functions are fundamental to the correct solving of math tasks (e.g. Vosniadou et al. 2018), and hence these impairments would undermine math achievement in highly math-anxious students.

1.3. The current study

The aim of the present study was to explore which factors were associated with students' experience of online learning during the COVID-19 crisis. We focused specifically on a compulsory psychology degree module with high mathematical content, with data being gathered at two time points: during lockdown in the spring semester of the 2019–2020 academic year and one year later (in the spring semester of the 2020–2021 academic year). Lockdown in Spain began in March 2020 and for several months involved strict restrictions on leaving the home, with only essential services being maintained. Accordingly, online learning had to implemented with immediate effect for all students. Although some social restrictions had been lifted by the spring semester of 2021, classes continued to be taught online due to the ongoing situation with COVID-19. Several questionnaires were administered to undergraduates at both these time points to measure their anxiety or fear about COVID-19, their online learning anxiety, the perceived usefulness of online material, math anxiety, trait anxiety and self-perceived performance. We were interested in studying relationships between these factors and how the factors and their inter-relationships changed over the first year of the pandemic. Furthermore, although the study was merely exploratory, we sought to answer a number of specific research questions. Because anxiety is a common human emotional response to the anticipation of threat, especially under circumstances in which there is a high level of uncertainty (e.g. Grupe & Nitschke 2013), we wanted to explore whether anxiety about COVID-19 and online learning anxiety were initially unrelated to the personality disposition to experience anxiety (i.e., trait anxiety), given the extraordinary nature of the situation and the high level of threat and uncertainty. A related question to consider was whether individuals who still experienced anxiety about COVID-19 one year on (when knowledge of the pandemic situation was greater) were those with higher levels of trait anxiety. As for online learning anxiety, we aimed to explore whether this type of anxiety was related or not to trait anxiety after one year of online teaching. To gain more knowledge about other factors related to online learning anxiety and students' online learning experience, their psychological wellbeing in the use of e-learning tools during the COVID-19 pandemic, as well as their online learning readiness, math attitudes and level of depression were also assessed in the spring semester of the 2020–2021 academic year.

It is essential for universities to learn from student experiences during the COVID-19 pandemic so as to be better prepared for dealing with future unforeseen disruptions to face-to-face teaching.

2. Method

2.1. Participants

Participants were 125 psychology undergraduates enrolled in a second semester Research Design module at the University of Barcelona during either the 2019–2020 or 2020–2021 academic year. They were selected on the basis of their availability and willingness to take part in the study. The sample from the 2019 to 2020 year consisted of 73

students (83.6 % female; mean age 25.5 years, SEM = 1.02), representing 28 % of total enrolment, while that in 2020–2021 comprised 52 students (82.7 % females; mean age 23.9 years, SEM = 1.07), representing 20 % of total enrolment. All students in the sample attended online classes regularly and were informed about the study procedure and gave consent to participate before data collection. The Research Design module was taught online in both academic years, in contrast to the face-to-face format that had traditionally been employed. The content covered a diverse range of topics, including observational, experimental, quasi-experimental, longitudinal, and single-case designs, along with their respective statistical analyses. The module lasted four months, and the teaching staff and content were the same in both academic years.

2.2. Materials

Students were administered the following questionnaires (the first three at the end of the spring semester of the 2019–2020 academic year, and all the questionnaires listed at the end of the spring semester of the 2020–2021 academic year).

2.2.1. Questionnaire about the Research Design module (ResDesQ)

In the 2019–2020 academic year, students were administered an *ad hoc* questionnaire designed to assess their anxiety about COVID-19 (items 1 and 2 in Table 1) and their experience of online learning in the Research Design module (items 3 to 10 in Table 1). In the 2020–2021 academic year, items 1 and 2 were removed from the questionnaire because students' anxiety about COVID-19 was assessed instead by the Fear of COVID-19 Scale (Ahorsu et al., 2020). In addition, two new items about study space and internet connection (items 11 and 12 in Table 1) were included. All items were rated using a 5-point Likert-type scale (from 1 'strongly disagree' to 5 'strongly agree').

To determine the dimensionality of the ResDesQ, which was created ad hoc, we performed a cluster analysis using the affinity propagation technique (Frey & Dueck, 2007) and the R apcluster package, as well as a principal components analysis using SPSS 27.

The cluster analysis of the ResDesQ administered in the 2020–2021 academic year yielded two groups of items: 3, 5, 9, 10, 12, and 4, 6, 7, 8, 11 (see Table 1). The first group included (with the exception of item 12) items related to online learning anxiety, that is, concern about being able to learn the subject online, difficulty relaxing and concentrating, and concern about the online assessment. The representative (or exemplar) item of this group was item 5. The second group included (with the exception of item 11) items referring to perceived usefulness of online material, that is, weekly planning in the virtual campus, availability of online material, solutions to exercises and online classes. The representative (or exemplar) item of this second group was item 6. Items 11 and 12 were more related to practical aspects, namely the study space and internet connection.

Table 1
Questionnaire about the Research Design module (the ResDesQ).

Items
1. I feel anxious because of the exceptional situation caused by the COVID-19 pandemic.
2. During the first days of lockdown, I felt more nervous than usual.
3. I am concerned about learning this subject online.
4. The weekly planning in the virtual campus has helped me to worry less about learning this subject online.
5. I've found it difficult to relax while following the weekly planning of this subject in the virtual campus.
6. I've found the material available in the virtual campus to be useful for learning this subject.
7. The solutions to the different exercises, which are available in the virtual campus, have helped me to self-assess.
8. I've found the online classes to be useful for learning this subject.
9. I've found it difficult to concentrate when studying this subject.
10. I am concerned about the online assessment of this subject.
11. My study space is good enough for studying this subject online.
12. My internet connection is good enough for studying this subject online.

Based on the Pearson correlations between items, the principal component analysis indicated the existence of three components that explained 63.8 % of the total variance. The rotated loadings of the items confirmed that items 4, 6, 7 and 8 formed one group (with loadings between 0.61 and 0.87 on the first component, 26.7 % of the variance), items 3, 5, 9 and 10 formed another (with loadings between 0.58 and 0.81 on the second component, 23.3 % of the variance) and items 11 and 12 a third group (with loadings between 0.81 and 0.78 on the third component, 13.8 % of the variance).

In the cluster analysis of the items administered in the previous academic year (2019–2020), the same groups or factors were found: anxiety vs. elements that help to reduce it. The first group included the items referring to online learning anxiety (items 3, 5, 9 and 10 in Table 1), plus items 1 and 2 about anxiety towards COVID-19. The second group included the items related to the reduction of anxiety through the perceived usefulness of online material (items 4, 6, 7 and 8 in Table 1).

2.2.2. Shortened Math Anxiety Rating Scale (sMARS; Alexander & Martray, 1989)

The sMARS is a 25-item scale on which each item describes a situation that may cause math anxiety. Respondents must indicate the level of anxiety that each situation would cause them, using a 5-point Likert-type scale (from 1 'no anxiety' to 5 'high anxiety'). The total score reflects a person's general level of math anxiety and ranges from 25 (low math anxiety) to 125 (high math anxiety). The sMARS measures three dimensions of math anxiety, two related to the anxiety that is experienced within academic contexts and one that refers to other settings: (1) maths test anxiety (i.e. worry when sitting a maths test or about maths examination grades), (2) maths course anxiety (i.e. worry during a maths-based course module), and (3) numerical task anxiety (i.e. worry when performing numerical operations). In the present study we used the Spanish adaptation of the sMARS (Núñez-Peña et al., 2013), which showed good psychometric properties in terms of 7-week test-retest reliability (r = 0.72) and internal consistency (Cronbach's α of 0.94 for total scale scores).

2.2.3. State-trait anxiety inventory – Spanish adaptation (STAI; Guillén-Riquelme & Buela-Casal, 2013)

A brief version of the Spanish adaptation of the STAI (Guillén-Riquelme & Buela-Casal, 2013) was used in the present study, specifically its trait anxiety subscale. This subscale comprises six items referring to different emotions that a person feels in general, with each item being rated on a 4-point Likert-type scale (from 0 'almost never' to 3 'almost always'). The total score ranges from 0 (low anxiety) to 18 (high anxiety) and measures the predisposition to perceive situations as threatening. A moderately good internal consistency (Cronbach's α of 0.69) has been reported for this scale.

2.2.4. Fear of COVID-19 scale (FCV-19S; Ahorsu et al., 2020)

The FCV-19S consists of seven items related to how a person feels when dealing with certain situations in which COVID-19 is involved. Items are rated using a 5-point Likert-type scale (from 1 'strongly disagree' to 5 'strongly agree'), and hence the total score, which reflects the person's level of fear about COVID-19, ranges from 7 (low fear) to 35 (high fear). The Spanish version of the FCV-19S (Martínez-Lorca et al., 2020) was used in the present study and showed good internal consistency (Cronbach's α of 0.86). Concurrent validity was supported by significant positive correlations with scores on state anxiety (r = 0.50) and trait anxiety (r = 0.26).

2.2.5. Psychological wellbeing in the use of E-learning tools during COVID-19 questionnaire (Haider & Al-Salman, 2020)

For the present study we used a Spanish translation and adaptation of

the psychological wellbeing in the use of e-learning tools during COVID-19 questionnaire (Haider & Al-Salman, 2020), including the following dimensions: (1) social interaction, (2) psychological state, and (3) academic performance. These three dimensions comprise a total of 13 items, each rated using a 5-point Likert-type scale (from 1 'strongly disagree' to 5 'strongly agree'). The total score therefore ranges from 13 to 65, with higher scores indicating a greater negative impact of e-learning and prolonged use of digital tools on students' social, psychological and academic wellbeing. Haider and Al-Salman (2020) did not analyze the psychometric properties of this questionnaire. However, before designing it, they examined different questionnaires constructed for similar purposes and also consulted a panel of three experts for their feedback. The experts' suggestions were incorporated into the questionnaire, and a test-retest was conducted.

2.2.6. Online learning readiness scale (OLRS; Chung et al., 2020)

A Spanish translation and adaptation of the OLRS (Chung et al., 2020; OLRS adaptation from Hung et al. 2010) was used in the present study to assess participants' online experience and satisfaction. This adaptation includes 15 items referring to four dimensions: self-directed learning (i.e. able to carry out own study plan and set up personal online learning goals), learner control (i.e. manage own online learning progress), motivation for learning (i.e. open to new ideas when learning online and motivation for online learning) and online communication self-efficacy (i.e. feel confident in using online tools to communicate thoughts and post questions). These items are rated using a 5-point Likert-type scale (from 1 'totally disagree' to 5 'totally agree'). The OLRS also includes three items examining overall online learning satisfaction (response options are 'I am not satisfied' or 'I am satisfied'), overall online learning experience ('bad' or 'good') and intention to continue using online learning ('disagree' or 'agree'). Internal consistency for the aforementioned dimensions was 0.86, 0.85, 0.87 and 0.88, respectively, while coefficients for the other three items (online learning satisfaction, online learning experience and intention to continue using online learning) were 0.76, 0.79 and 0.83, respectively (Chung et al., 2020).

2.2.7. Math attitudes questionnaire (MAQ; Núñez-Peña et al., 2013)

This questionnaire includes three questions about maths: enjoyment (*How much do you enjoy mathematics?*), motivation (*How much motivation do you have towards mathematics?*) and self-confidence (*How self-confident are you with regard to mathematics?*), each answered using a 5-point Likert-type scale (from 1 'not at all' to 5 'very much'). The MAQ was administered in previous studies to undergraduates enrolled in a Research Design module (Núñez-Peña et al., 2013, 2015).

2.2.8. Depression, anxiety and stress scales (DASS-21; Lovibond & Lovibond, 1995)

For the present study we used the depression scale of the DASS-21, which comprises seven items that explore how respondents have felt over the past week. Each item is rated using a 4-point Likert-type scale (from 0 'did not apply to me at all' to 4 'applied to me very much or most of the time'), such that the total score, which represents the person's general level of depression, ranges from 0 to 21. The Spanish adaptation of the DASS-21 (Bados et al., 2005) that was used in the present study has shown good reliability (Cronbach's α of 0.84 for the depression scale).

2.2.9. Self-perceived performance

Students were also asked about their self-perceived performance (*What grade do you think you will get, approximately, in the Research Design module?*).

2.2.10. Multiple-choice examination

Students enrolled in the Research Design module sat an online multiple-choice examination at the end of the academic year. The exam consisted of a series of problems to be solved by performing statistical analyses using SPSS software. The questions concerned the type of analyses performed and the interpretation of results. In total there were 25 questions, each with four possible answers, and errors were penalized to correct for guessing.

2.3. Procedure

In both academic years, students were asked to answer the corresponding questionnaires before the end of the semester. Questionnaires were administered online through Qualtrics as a voluntary activity, and their completion required about 15 min. At the end of each academic year, students were assessed with the online multiple-choice examination. Only those students who both completed the questionnaires and sat the final examination were included in the present analysis.

2.4. Data analysis

The variables analysed in the 2019–2020 academic year were anxiety about COVID-19, online learning anxiety, perceived usefulness of online material, self-perceived performance (all with the ResDesQ), math anxiety (sMARS) and trait anxiety (STAI). The same variables were analysed in the 2020–2021 academic year (with the FCV-19S now being used to measure anxiety towards COVID-19), but in this case we also evaluated study space and internet connection (ResDesQ), students' psychological wellbeing in the use of e-learning tools during the COVID-19 pandemic, their online learning readiness (OLRS), math attitudes (MAQ) and depression (from DASS-21).

For each academic year, associations between the variables were examined by calculating Spearman correlations. Mediation models were also built to explore possible mediator variables. Finally, independent *t*-tests were computed to compare means for the group of items on online learning anxiety and the group of items on perceived usefulness of online material between the two academic years. Effect sizes were calculated using Cohen's *d* statistic. The correlational analysis and comparisons between academic years were performed using SPSS 27, while for the mediation analyses we used the PROCESS macro 4.0 for SPSS 27 (Hayes, 2018).

3. Results

3.1. Correlational analysis and mediation analysis

In this section we report only those relationships between variables that were significant in each academic year.

3.1.1. Academic year 2019–2020

In the 2019–2020 academic year, scores on online learning anxiety were negatively correlated with scores on self-perceived performance (r = -0.527; $p < .001$) and perceived usefulness of online material (r = -0.603; $p < .001$). By contrast, positive correlations were observed between scores on online learning anxiety and scores on anxiety about COVID-19 ($r = 0.377$; $p = .001$), total scores on the sMARS ($r = 0.246$; $p = .042$) and scores on the maths test anxiety dimension of the sMARS ($r = 0.284$; $p = .018$). Regarding anxiety about COVID-19, scores on this variable were negatively correlated with scores on self-perceived performance (r = -0.277; $p = .018$) and perceived usefulness of online material (r = -0.261; $p = .026$), and positively correlated with total scores on the sMARS ($r = 0.285$; $p = .018$) and scores on the maths test anxiety dimension of the sMARS ($r = 0.281$; $p = .019$). We also found that students who perceived greater usefulness of the online material also expected to obtain a higher grade in the course module ($r = 0.539$; $p < .001$). This relationship was mediated by online learning anxiety (direct effect $c' = 0.159$; $p = .006$ and indirect or mediated effect $a*b = 0.087$; $p = .023$). In addition, the perceived usefulness of online material acted as a mediator of the relationship between anxiety about COVID-19

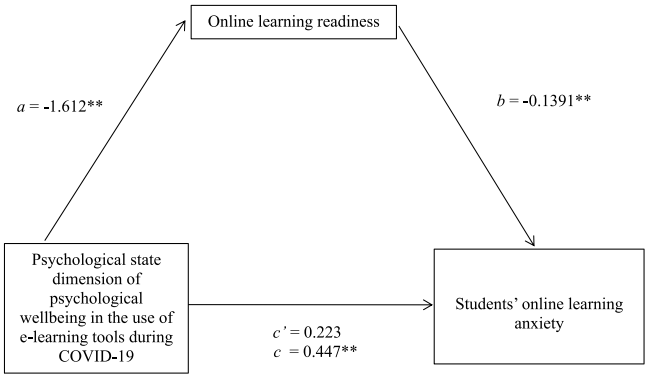
and online learning anxiety (direct effect c' = 0.392; p = .012 and mediated effect $a*b$ = 0.234; p = .049). Finally, total scores on the sMARS were negatively correlated with scores on self-perceived performance (r = -0.260; p = .031) and positively correlated with scores on trait anxiety (r = 0.328; p = .006). None of the variables analysed was correlated with the grade obtained in the multiple-choice exam.

3.1.2. Academic year 2020–2021

In the 2020–2021 academic year, scores on self-perceived performance were negatively correlated with scores on online learning anxiety (r = -0.362; p = .008), a relationship that was also observed in 2019–2020, and positively correlated with scores on the learner control dimension of the OLRS (r = 0.300; p = .031). As in 2019–2020, scores on online learning anxiety were negatively correlated with scores on perceived usefulness of online material (r = -0.341; p = .013). Scores on online learning anxiety were also negatively related to total scores on the OLRS (r = -0.536; p < .001) and to scores on each of its dimensions, namely self-directed learning (r = -0.541; p < .001), learner control (r = -0.473; p < .001), motivation for learning (r = -0.303; p = .029) and online communication self-efficacy (r = -0.405; p = .003). By contrast, scores on online learning anxiety were positively correlated with total scores on the sMARS (r = 0.333; p = .016) and with scores on its maths test anxiety (r = 0.358; p = .009) and maths course anxiety (r = 0.278; p = .046) dimensions; they were also positively correlated with a perceived negative effect of the use of e-learning tools during COVID-19 on psychological wellbeing (r = 0.403; p = .003) and with scores on the dimensions of this tool referring to psychological state (r = 0.425; p = .002) and academic performance (r = 0.377; p = .006). It can be seen in Fig. 1 that the association between the psychological state dimension of psychological wellbeing in the use of e-learning tools during COVID-19 and students' online learning anxiety (total effect c = 0.447; p = .003) was notably weaker when online learning readiness was introduced as a mediator variable (direct effect c' = 0.223; p = .132), with the mediating effect being significant (mediated effect $a*b$ = 0.224; p = .015). A positive correlation was also found between scores on perceived usefulness of online material and total scores on the ORLS (r = 0.277; p = .047) and scores on two of its dimensions, namely self-directed learning (r = 0.332; p = .016) and learner control (r = 0.291; p = .036).

Aside from the variables related to online learning, relationships were also observed among different types of anxiety and depression in the 2020–2021 academic year. Total scores on the sMARS were positively correlated with scores on trait anxiety (r = 0.457; p = .001), anxiety about COVID-19 (r = 0.598; p < .001) and depression (r = 0.360; p = .009). A positive correlation was likewise found between scores on anxiety about COVID-19 and scores on trait anxiety (r = 0.285; p = .041) and depression (r = 0.327; p = .018), and also between scores on trait anxiety and depression (r = 0.655; p < .001). Conversely, scores on anxiety about COVID-19 were negatively correlated with scores indicating a positive attitude towards maths (r = -0.329; p = .017), and the latter were negatively correlated with total scores on the sMARS (r = -0.547; p < .001).

Finally, among students in the 2020–2021 academic year, 67.3 % reported a good online learning experience, 57.7 % were satisfied with this approach to learning and 38.5 % said they would continue with online learning if given the choice. Regarding their study space and internet connection, the majority of students agreed or strongly agreed that these were good enough (73.1 % for study space and 86.6 % for internet connection).



**p < .01.

Fig. 1. Mediating effect of online learning readiness on the relationship between the psychological state dimension of psychological wellbeing in the use of e-learning tools during COVID-19 and students' online learning anxiety.

3.2. Comparative analysis of academic years

In the 2020–2021 academic year, online learning anxiety was lower (t(123) = 3.11, p = .002, d = 0.56) and the perceived usefulness of online material was greater (t(123) = 6.18, p < .001, d = 1.01), in comparison with 2019–2020 (Table 2). The results for 2020–2021 also showed a reduction in the negative correlation between online learning anxiety and both self-perceived performance (r = -0.527, p < .001 vs. r = -0.362, p = 0.008) and perceived usefulness of online material (r = -0.603, p < .001 vs. r = -0.341, p = 0.013). By contrast, no differences were observed in self-perceived performance between the two academic years (t(123) = 0.83, p = .408, d = 0.15).

4. Discussion

The COVID-19 pandemic forced the teaching community to transition abruptly from traditional face-to-face education to an online learning model. Both students and teachers had suddenly to rely on new technologies and to change the way they interacted with each other. In this context, students' learning and performance may have been affected not only by established factors (e.g. math anxiety in course modules with high mathematical content) but also by anxiety about both COVID-19 and online learning and assessment. The aim of this study was to examine the relationships between these three types of anxiety in a course module with mathematical content and to study to what extent they are related to self-perceived performance and perceived usefulness of online materials. We studied these associations at two time points: during lockdown at the start of the pandemic in the 2019–2020 academic year, and one year later (during the 2020–2021 academic year), when teaching and assessment continued to be done online. We were also interested in studying whether these relationships changed between these two time points.

Results showed that, in both academic years, students with greater online learning anxiety expected to obtain a lower grade, perceived the online material to be less useful and presented higher levels of math anxiety, especially maths test anxiety. Besser et al. (2020) similarly showed that anxiety had a stronger negative impact on academic achievement during online teaching necessitated by the pandemic than during previous traditional face-to-face learning. Specifically, they found that students who received online teaching during the first months of the pandemic reported less learning and greater attentional difficulties. Interestingly, in the present study, a number of differences

Table 2
Means and SEM (in brackets) for the group of ResDesQ items referring to online learning anxiety and the group of ResDesQ items related to perceived usefulness of online material.

	2019–2020	2020–2021
Online learning anxiety (items 3, 5, 9 & 10)	16.00 (0.38)	14.12 (0.48)
Perceived usefulness of online material (items 4, 6, 7 & 8)	10.75 (0.33)	14.35 (0.51)

emerged when comparing the two academic years. Online learning anxiety was lower and the perceived usefulness of online material was greater in the spring semester of the 2020–2021 academic year compared with the same semester in 2019–2020. Furthermore, the negative association between these two variables, although still significant, was smaller in 2020–2021 than in 2019–2020. A possible explanation for this change could be the experience with online materials and learning that students had already gained during the first semester of the 2020–2021 academic year (all learning was exclusively online from the start of that academic year), as this may have helped them to adapt to the situation and gain confidence in this new learning format. Teachers would also have been more experienced in online teaching in the 2020–2021 academic year, and by this time they would have had the opportunity to refine their online materials and, therefore, be better able to support students' learning. This could be one reason why students in the 2020–2021 academic year perceived the online material to be more useful. Fitzgerald and Konrad (2021), who also observed a high prevalence of anxiety and difficulties in concentration at the start of the pandemic with the change to remote learning, found that students who felt well supported by instructors reported fewer symptoms.

Another interesting finding when comparing the two academic years was that in 2019–2020, students' fear of COVID-19 was negatively related to self-perceived performance and the perceived usefulness of online material, and positively related to online learning anxiety, whereas these relationships failed to reach significance in the analysis of data gathered one year later. It is worth noting that a positive relationship between fear of COVID and math anxiety was observed in both academic years. Negative associations between online learning anxiety and self-perceived performance, and between fear of COVID-19 and self-perceived performance at the beginning of the pandemic may be related to the fact that perceived self-efficacy decreases with anxiety (Alemany-Arrebola et al., 2020). Moreover, anxiety has the potential to sidetrack students in their academic studies, due to what Boals and Banks (2020) described as mind-wandering during a pandemic. Mind-wandering includes the constant need that students had to be informed about the latest news concerning the pandemic, concerns about the risk of family and friends falling ill, and worries about the economic impact of the pandemic. Attentional control theory (Eysenck et al., 2007) similarly proposes that anxiety causes intrusive thoughts (i.e. mind-wandering) that occupy the limited resources of working memory, making it difficult to focus attention on a task and, therefore, undermining its execution. Fitzgerald and Konrad (2021) found that mind-wandering correlated with worse academic performance, leaving students vulnerable to academic decline. Importantly, in our study, students reported difficulties concentrating on lessons and homework during the pandemic. However, these difficulties were less evident in the 2020–2021 academic year ($t(123) = 2.36$, $p = .020$, $d = 0.42$), an indication once again of students' ability to adapt to stressful situations. However, and unexpectedly, we observed no improvement in self-perceived performance when comparing the two academic years. This might be due to the ongoing impact of online learning anxiety and concentration difficulties on study ability and perceived self-efficacy, insofar as levels of online learning anxiety remained high in the spring semester of the 2020–2021 academic year, despite being comparatively lower than in 2019–2020. During the 2020–2021 academic year, students with greater online learning anxiety not only expected to obtain a lower grade and perceived the online material to be less useful than did their classmates low in online learning anxiety, but they also reported less readiness and a more negative experience of online learning in general.

A further point to note here is that students also perceived that the prolonged use of e-learning tools during the COVID-19 pandemic had a negative impact on their psychological state and academic performance. Difficulties with online learning stemming from classroom closures is therefore another factor that could make students vulnerable to academic decline, leading them to maintain a perception of poor performance even one year later. In fact, students who reported greater readiness and a more positive experience of online learning expected to obtain higher grades and considered the online material to be more useful than did the rest of their classmates.

As expected, anxiety about COVID-19 and online learning was not, in the 2019–2020 academic year, limited to those students who scored high on trait anxiety, suggesting that, at that point in time, the circumstances surrounding lockdown and the abrupt switch to online learning were a source of anxiety even for those individuals who were not inclined to experience it. However, one year after the start of the pandemic (2020–2021 academic year), trait anxiety was associated with anxiety about COVID-19, although not with online learning anxiety. This suggests, as hypothesized, that once students became accustomed to the pandemic situation, only those with a stronger tendency to feel anxiety continued to have a high level of fear of getting COVID-19, which was not associated with greater online learning anxiety.

Finally, it should be noted that although more than half of students in the 2020–2021 academic year reported a good experience with online learning and felt satisfied with this approach, the majority still preferred face-to-face teaching.

4.1. Recommendations

During the pandemic, online learning was a challenge for most students, and in the case of subjects with mathematical content, the challenge was even greater for those with high math anxiety. The results of this study highlight the need to enhance students' readiness for online learning and to ensure that online materials are perceived as useful, as doing so may help to reduce the negative impact that online learning anxiety, as well as other sources of anxiety, can have on the acquisition of knowledge.

Given that online learning has become much more widespread as a result of the pandemic and that, according to our results, online learning anxiety can manifest independently of trait anxiety, further efforts are required to help students adapt to this approach, especially in those course modules that already posed challenges prior to the pandemic, for example, psychology degree modules with mathematical content (Núñez-Peña et al., 2013, 2015). Providing students with adequate resources, materials and support can increase their motivation and satisfaction, both of which are essential to improve online learning (Yan & Batako, 2020). In conclusion, it is important to continue investigating, identifying and applying strategies and resources that can reduce anxiety among students, especially in adverse contexts such as that generated by a pandemic. In particular, attention should be focused on how best to reduce online learning anxiety and increase students' readiness for online learning, as these are important factors both for the success of online learning in general and for ensuring that universities are better prepared to deal with future unforeseen disruptions to face-to-face teaching.

4.2. Limitations

This study has a number of limitations that must be acknowledged. First, the questionnaires were administered online and completed anonymously by a convenience sample of students. Second, the total number of participants was moderate and male students were underrepresented due to the gender imbalance among students enrolled in psychology courses, which may limit the generalizability of results. The small sample size could be due to the period in which the questionnaires were administered, which was at the end of the semester coinciding with the exam preparation period. Lastly, the multiple-choice examination at the end of the course module was also conducted online with limited proctoring, and hence there was an opportunity for dishonest behavior (i.e. cheating) among students (Hylton et al., 2016). This could explain why no relationship was found between the variables studied and the actual performance of students in the exam. We attempted to overcome

this limitation by also analysing self-perceived performance, a variable not susceptible to dishonesty of this kind.

5. Conclusion

Notwithstanding these limitations, the present study confirms previous research on the impact of different types of anxiety during the COVID-19 pandemic. The constant tension caused by the pandemic, coupled with both online learning anxiety and the possibility of math anxiety in a course module with high mathematical content, could have interfered with students' self-perceived performance. However, our results show that the perceived usefulness of online material and greater readiness for online learning can help to reduce students' anxiety towards online learning.

Funding

This work was supported by the Convocatòria d'Ajuts a la Recerca en Docència Universitària from the Institut de Desenvolupament Professional (IDP-ICE), University of Barcelona (Grant No. REDICE20-2520).

CRediT authorship contribution statement

Roser Bono: Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **María Isabel Núñez-Peña:** Conceptualization, Visualization, Writing – original draft, Writing – review & editing, Methodology. **Carlos Campos-Rodríguez:** Data curation, Investigation, Writing – original draft, Methodology. **Belén González-Gómez:** Conceptualization, Writing – original draft, Methodology. **Vicenç Quera:** Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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