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Does Students' Learning Environment Choice (Online, Hybrid, In-Person Options Within the Same Course Offering) Influence Academic Stress and the Learning Experience During the COVID-19 Pandemic?

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Abstract During the COVID-19 pandemic post-secondary courses transitioned from in-person to online learning environments, which came with challenges but also created opportunities to modify teaching and learning approaches that could continue upon the return to in-person learning. The purpose of this study was to determine the effect of students' ability to self-select their preferred learning environment/lecture format [online, in-person or hybrid (combined in-person and online learning)] on academic performance, overall stress, academic stress, learning approach (deep and surface learning approaches), and to gain insight into students' perceptions of online learning. During the Winter 2022 semester, courses were delivered online for the first 4 weeks, before the removal of COVID-19 restrictions. For the remaining 8 weeks, students in a fourth-year chronic disease pathophysiology course (n=210) were given the option to self-select their preferred learning environment/lecture format for the remaining 8 weeks of the semester, choosing between in-person (n=56, 26.7%), online (n=113, 53.8%), or hybrid (n=41, 19.5%) learning. Final grade and perceived stress levels did not differ between lecture formats; however, stress levels were inversely associated with final grades in the online ($r = -0.19$; $P=0.02$) and in-person ($r = -0.41$; $P=0.05$) lecture formats with no association in the hybrid format ($r = 0.03$; $P=0.85$). Further, academic stress was identified as the greatest source of stress experienced by 64% of in-person, 76% of hybrid, and 69% of online students. Students preferred learning requirements aligned with their self-selected learning format, wherein the main online learning challenges included i) needing more clarification, ii) difficulty interacting with professors, iii) feeling more distracted, iv) having lower comprehension, and v) experiencing difficulty with time management ($P<0.05$). These findings demonstrate that students' learning environment preferences influence their choice of lecture format; however, even when a preferred learning environment is selected, students' academic stress levels remain high and influence academic performance.

Keywords: *Lecture Format, Academic Stress, Learning Approach, COVID-19*

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1. Introduction

At many post-secondary institutions, the initial response to the COVID-19 pandemic was the abrupt transition of courses from the traditional face-to-face in-person learning environment into an online learning environment [1]. The educational experience in online learning environments can differ from in-person course instruction and can impact student learning [2,3]. During this period of online and remote learning during the COVID-19 pandemic, studies have reported students experiencing higher stress, anxiety, and depression levels [4-12], which coincided with social isolation and limited access to social coping mechanisms to alleviate stress, adversely impacting their mental health [4] [13,14,15]. There are benefits associated with online learning including increased flexibility [16,17,18,19,20], better access to resources [1,21], eliminating commuting times and associated expenses [22,23], and alleviating some anxiety in the learning environment [24,25,26,27]. Conversely, there are also challenges associated with online learning, including difficulties with technology,

such as user technology or digital literacy, internet connectivity or difficulties accessing online course resources (e.g., websites or virtual learning spaces) [27,28]. Some student attributes or characteristics are more likely to promote success in, and thus, satisfaction with online learning, including self-efficacy, self-regulation (including time management skills, active learning style, and self-discipline), motivation, time management, organizational skills, etc. [26,29]. Importantly, not all students' learning approach and/or personal characteristics are optimally suited for an online learning environment, and by extension, not all students adapt well to online learning [29]. A recent systematic review of studies assessing students' satisfaction with COVID-19-associated online learning reported that 36% of studies found that students were highly satisfied, 50% of studies reported moderate student satisfaction, and 14% of studies reported students were dissatisfied with the online learning format [16]. This degree of variability reflects the varied opinions regarding online learning that exist within the higher education student population and raises questions about the utility of continued online learning post-pandemic.

In addition to the challenges that students experience with online learning, instructors also experience challenges associated with shifting their pedagogical approach and adapting courses designed for in-person learning into an online learning environment [27]. Moreover, during the adaptation to online learning, instructors were also required to address the needs of students, in part, by finding new approaches and assessments to promote student engagement [27,30] in the attempt to counter students' social isolation during the pandemic. Of these approaches, group learning can be an effective method to increase engagement and promote active learning in both in-person and online lecture formats [31,32,33]. The inclusion of small online learning groups that function to connect students in an online learning format can help promote student engagement in course content application activities [34,35]. Group discussions are challenging in large in-person lectures where students may feel intimidated to openly engage in group discussions [36], whereas the smaller online learning group discussion activities have been shown to have higher student participation and provide students with more opportunities to apply their knowledge in this format [34]. Further, participation in online discussion activities allow students to build familiarity with one another and have been shown to stimulate active learning and understanding of course material, as well as improve collaboration and communication skills [31,32,34,37]. When combining group learning with a written discussion board format, students can benefit from the permanent record of the on-going discussion and have more time to formulate ideas, reflect, think critically, learn from their peers and respond to other students' posts, leading to a richer discussion, a greater exchange of ideas and comprehension of course concepts [34] [38,39,40]. The greater time frame for written discussion board interactions between students also provides more time to develop ideas, which can be limited in an in-person learning environment where discussion time may be limited by the instructor [36,37,38]. The implementation of active learning strategies such as discussion activities and the use of case-based learning or problem-based learning in online courses has been shown to mitigate some of the difficulties students report with online learning [31]. In this connection, scientific literacy skill development was effectively promoted during the COVID-19 pandemic in an online learning environment that utilized discussion board activities within online learning groups [41]. Moreover, scientific literacy skill development was as effective in the online learning environment as it was in the traditional in-person learning environment pre-pandemic [41], thereby demonstrating the utility of combined online learning groups and discussion board activities for engagement and critical skill development.

Overall, there is variability in both students' perceptions of and attitudes toward online learning [42,43] and the academic stress that is associated with the online learning format [44]. Despite the requirement for all students to adapt to an online learning environment at the start of the COVID-19 pandemic, students and instructors may prefer the continuation of the online learning format either remaining completely online or in a hybrid environment combining both online and in-person learning options within courses post-pandemic [16,45]. Some of these benefits may include increased flexibility [16,17,18,19,20], increased accessibility [21], reduced commute time to attend in-person lectures [16] [22,23] [46], and access recorded lectures to facilitate learning and concept review [16,47,48]. With the ongoing transition out of online learning and the return to in-person learning, it will be beneficial to retain certain elements of online learning and to determine if continued online learning lecture formats are preferred by or optimal for some students. Phenomenology studies [49] can provide insight into students learning experiences in concurrent in-person, online and hybrid learning environments associated with the COVID-19 pandemic, which may help inform either instructor or institutional decisions regarding continuation of online learning post-pandemic. It is important to consider the student learning experience and to make evidence-informed decisions regarding the types of learning environments (in-person, hybrid or online) that are offered to students, as not all students are optimally suited for every learning environment [29]. Furthermore, elevated student academic stress and anxiety has been reported during the COVID-19 pandemic [5-11] [18] [50,51], which may be due, in part, to challenges associated with the online learning format. Identifying strategies to limit academic stress post-pandemic are needed in higher education. The present study was conducted in the Winter 2022 academic semester wherein courses started in an exclusively online learning environment for the first 4 weeks of the semester; however, COVID-19 physical distancing restrictions were lifted at the start of week 5. For the remainder of the semester (weeks 5-12) students were allowed to select their preferred learning environment and could remain online, return to in-person lectures or choose a hybrid learning environment (a combination of in-person and online lectures). The objectives of this study were to determine how the opportunity for students to self-select their preferred learning environment/lecture format

influenced their i) perceptions of online learning and the return to in-person lectures/learning environment, ii) learning approach, iii) academic stress, and iv) academic performance. The research questions we sought to address, within the context of our study, were the following: 1) What factors influence students' choice of learning environment? 2) Does the ability for students to self-select their preferred learning environment (in-person, online or hybrid) influence their academic performance and learning approach (i.e., deep versus surface learning approaches)? 3) How does the ability to self-select the learning environment influence students' academic stress experience?

2. Methods and Materials

2.1. Lecture Format and Students' Selected Learning Environment: In-Person, Online or Hybrid

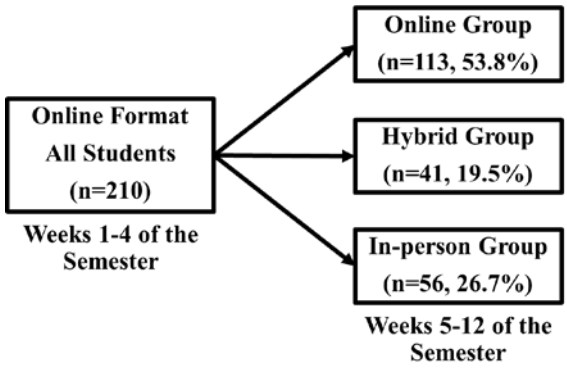

Figure 1. Study Design Diagram. Classes were delivered synchronous online format using Zoom during weeks 1 to 4 of the semester. During weeks 5 to 12 of the semester in-person lectures were permitted and were synchronously recorded over Zoom. All recorded lectures were available to all students throughout the semester. During weeks 5 to 12 students self-selected to attend lectures either entirely in-person (In-Person Group, 26.7% of the class), remain online (Online Group, 53.8% of the class) or a combination of in-person and online lecture attendance (Hybrid Group, 19.5% of the class)

The research context for this study involved undergraduate students in a health science major enrolled in a fourth-year nutrition and chronic disease pathophysiology course (n=210) during the Winter 2022 semester at a research-intensive university during the semester when COVID-19 physical distancing restrictions were ended at the university. As a result of the COVID-19 pandemic the first 4 weeks of lectures in the 12-week course were delivered online via two 90-minute synchronous lectures per week held on Zoom (Zoom Video Communications, San Jose, California, USA). The synchronous online lectures were also recorded and posted to the course website for students to review at any time during the semester. At the start of week 5 of the semester COVID-19 restrictions were removed and in-person lectures were permitted again at the institution. Despite the return to in-person learning the decision was made to continue recording lectures using Zoom, therefore, at this juncture in the course students could self-select what lecture format/learning environment they preferred to access to complete the course. Thus, between weeks 5 and 12 (8 weeks total) of the semester students chose between learning environments and reported at the end of the semester which of the 3 options they ultimately engaged in (as shown in Figure 1): in-person (n=56 or 26.7% of students in the course), online (n=113 or 53.8% of students in the course) or hybrid (combination of attending in-person and online lecture formats; n=41 or 19.5% of students in the course).

2.2. Inclusion of Online Learning Groups

Students were randomly assigned to an online learning group consisting of 10 students per group at the start of the semester and these online learning groups continued for the duration of the semester. Thus, after in-person lectures were possible starting in week 5 of the semester, these groups contained a mix of students engaging with the course in the in-person, online and hybrid formats. The intention of the online learning groups was to help foster a sense of community in the course and connect students together while learning remotely during the COVID-19 pandemic. Previously, students engaged in online discussions with their online learning group members have been shown to improve their critical thinking skills and utilize a deep learning approach [52]. Students were required to engage in online discussions within their online learning groups using the discussion board on the course website, wherein each online discussion activity or topic was worth 2% of their final grade for a total of 10% (i.e., 5 online learning group discussion assignments during the semester in weeks 2, 5, 8, 10 and 12). Online learning group discussions focused on course content and included case studies with application questions, knowledge translation activities related to cellular and molecular mechanisms, accessing the scientific literature to relate course concepts to diseases not discussed in lecture, and learning reflection.

2.3. Online Surveys

Two identical online surveys were conducted during the 12-week semester using the Qualtrics Insight Platform (Provo, UT, USA), distributed using private link sent to students' university email address. The first survey (Survey 1) was available to students during week 1 of the course (when all students were in an online learning environment) and the second survey (Survey 2) was available during week 12 of the course (at the end of the academic semester) for all students (in-person, online, and hybrid). Survey questions assessed students' learning approaches, perceived stress, and perceptions of the online learning environment in comparison to in-person learning. Specifically, learning approach (i.e., surface versus deep approaches) reflect students' engagement and their underlying motives and strategies employed during the learning process was assessed using the 20-item validated two-factor Revised Study Process Questionnaire (RSPQ2F) [53]. Students that use a surface learning approach tend to have minimal engagement in learning, rely on rote memorization, and have limited knowledge application capabilities, whereas students utilizing a deep learning approach tend to be highly engaged in learning, motivated

to learn and seek a deeper understanding and integration of course concepts [53,54,55]. Perceived stress levels were assessed using the validated 14-item Perceived Stress Scale (PSS) [56] that evaluates stress intensity from all sources, both academic and non-academic sources. Students' perceptions of online learning in comparison to their prior experiences during traditional in-person learning was evaluated using researcher-generated questions adapted from [57] that have been published previously [58]. This included students' perceptions of challenges associated with navigating the online learning environment including, but not limited to, organizing a schedule, accessing instructor support/asking questions, and the influence of online learning groups on engagement and course content comprehension. Additionally, on Survey 2 (at the end of the semester) students were asked additional seven researcher-generated questions about their overall experience with online learning groups and their influence course engagement and comprehension of course concepts [58]. Finally, on Survey 2, students were asked an open-ended text-based question to identify the factor(s) that influenced their decision to select engaging with the course lectures in either the in-person, online, or hybrid formats during weeks 5-12 of the course. A thematic analysis was conducted on students' text responses that informed their selection of learning environment that fell into the categories of i) exposure to COVID-19, ii) learning environment preferences, and iii) logistical factors.

Students provided their informed consent prior to completing either online survey and only students who completed both Survey 1 and Survey 2 were included in the analysis. Students who completed Survey 1 received a 2% participation bonus added to their midterm exam grade and students who completed Survey 2 received a 2% bonus added to their final exam grade. Alternative assignments were available for any students who did not complete the online surveys but still wanted to earn the participation bonus grades. Out of the 231 students originally enrolled in the course, 210 completed both online surveys, reflective of 90.9% of students originally registered in the course choose to participate in the study and the remaining 9.1% did not participate or completed only Survey 1 and dropped the course (therefore their incomplete data was not used in the analysis). This study was approved by the institutional Research Ethics Board (REB#20-10-026).

2.4. Statistical Analysis

Statistical analyses were conducted using GraphPad Prism software version 9.3.1 (San Diego, CA, USA). The predefined upper limit of probability for statistical significance was $P \leq 0.05$. Values are presented as mean values with the standard error of the mean (SEM). Learning approach and PSS score were analyzed by two-way ANOVA [main effects: lecture format group (i.e., In-Person, Hybrid and Online Groups) and time (i.e., Survey 1 and Survey 2)] followed by Tukey's range test. Data for academic stress, online learning challenges, and perceptions of online learning groups were collected only on Survey 2 on a Likert scale and differences between lecture format groups were determined using one-way analysis of variance (ANOVA) followed by a Kruskal-Wallis test. Pearson correlations were conducted to determine the association between students' learning approach scores, perceived stress levels and final grades.

3. Results and Discussion

3.1. Factors Influencing Students' Self-Selection of the Lecture Format/Learning Environment

Table 1. Factors Influencing Students' Choice of Lecture Format[1]

	In-Person % (n)	Hybrid % (n)	Online % (n)
Exposure to COVID-19			
Concerned about COVID-19 exposure	44.6 (25)	41.5 (17)	38.9 (44)
Not concerned about COVID-19 exposure	26.8 (15)	9.8 (4)	6.2 (7)
Did not identify COVID-19 exposure or risk as a factor in choosing a course format	28.6 (16)	48.8 (20)	54.9 (62)
Learning Environment Preferences			
Prefer in-person lectures versus online	51.8 (29)	24.4 (10)	18.6 (21)
Easier to concentrate in-person versus online	50.0 (28)	24.4 (10)	29.2 (33)
Easier to ask questions or communicate with the instructor in-person versus online	33.9 (19)	26.8 (11)	11.5 (13)
Missed the social aspect of in-person lectures	53.6 (30)	22.0 (9)	20.4 (23)
Missed the in-person learning environment during COVID-19-associated online learning	82.1 (46)	34.1 (14)	36.3 (41)
Concerned about the technical difficulties of online learning	19.6 (11)	12.2 (5)	4.4 (5)
Logistical Factors			
Challenges with commuting to campus for lectures	28.6 (16)	26.8 (11)	26.5 (30)
My other classes were in-person	14.3 (8)	9.8 (4)	8.8 (10)

[1]Proportion of students (expressed as % and n) who identified each factor that influenced their decision to select either the in-person, online or hybrid lecture formats during weeks 5 to 12 of the academic semester.

During weeks 5 to 12 of the semester students self-selected their preferred lecture format/learning environment for engaging with the lectures in the course (either exclusively in-person, exclusively online, or a hybrid approach with the combination of attending some lectures in-person and viewing other lectures online). At the end of the semester (i.e., on Survey 2), students were asked to explain the factor(s) that influenced their decision to engage with the course lectures in either an in-person, online or hybrid format. A thematic analysis determined three main categories of factors that influenced students' lecture format decision, which included risk of exposure to COVID-19, learning environment preference, and logistical factors, as shown in Table 1. For context, at this university, in-person courses were emergency shifted to an online format in March 2019 and all courses remained online until the end of week 4 of the academic semester (in February 2022), when in-person lectures were permitted to resume at the start of week 5. The impact of COVID-19 exposure on students' lecture format/learning

environment selection was identified by 71.4% of students in the In-Person Group (44.6% concerned; 26.8% not concerned), 51.3% of students in the Hybrid Group (41.5% concerned; 9.8% not concerned), and 45.1% of students in the Online Group (38.9% concerned; 6.2% not concerned). Learning environment preference and logistical factors also impacted students' selections. Not unexpectedly, a higher percentage of students who selected to resume in-person learning identified more benefits of this learning environment compared to students in the Hybrid and Online Groups. Specifically, 51.8% of students in the In-Person Group reported a preference in-person learning versus online learning.

Within the In-Person Group, 82.1% of students missed the in-person learning environment that was not permitted during the COVID-19 pandemic and 53.6% reported missing the social aspects of in-person learning. Additionally, 50.0% of In-Person Group students reported that it was easier to concentrate and 33.9% found it easier to ask questions or communicate with the instructor in person versus during online learning. Associated online learning 50.0% reported finding it easier to concentrate in an in-person learning environment. Interestingly, concerns about technical difficulties experienced during online learning was identified by only 19.6% of students in the In-Person Group and by an even lower percentage of students in the Hybrid and Online Groups (12.2% and 4.4%, respectively). Not unexpectedly, the percentage of students within the Hybrid and Online Groups that identified a preference for the in-person learning environment over an online learning environment were lower compared to the In-Person Group (51.8%), wherein the Hybrid Group students reported an intermediate percentage (24.4%), and the Online Group reported the lowest percentage (18.6%). All other students reported no specific preference for in-person lectures. Logistical factors played a lesser role in influencing students' selection of their learning environment/lecture format. Specifically, commuting to campus for lectures and the influence of other classes students were enrolled in also being held in-person was similar across lecture format groups. Thus, during the COVID-19 pandemic there were diverse factors that were considered in the decision to return to in-person/onsite learning or to remain in online learning, as this perspective has been reported elsewhere [59]. Furthermore, an understanding of the challenges students experience during online learning that inform their choice of learning environment was not assessed herein, which is a limitation, particularly since technology challenges and discomfort being viewed on camera in an online learning environment has been reported during the pandemic [51]. Collectively, this data provides insight into the reasons why students in this study self-selected a particular lecture format/learning environment, which may be relevant post-pandemic as instructors make decisions regarding the continuation of online learning now that in-person learning has resumed.

3.2. Association Between Students' Self-Selected Lecture Format/Learning Environment and Final Grade, Learning Approach and Perceived Stress Levels

Final course grades did not differ between the three lecture format groups (Figure 2A). Grades are the most common determinant of student success across course delivery modes [60,61,62] and previous studies have shown no difference in academic performance between online and traditional in-person lecture formats [63,64,65].

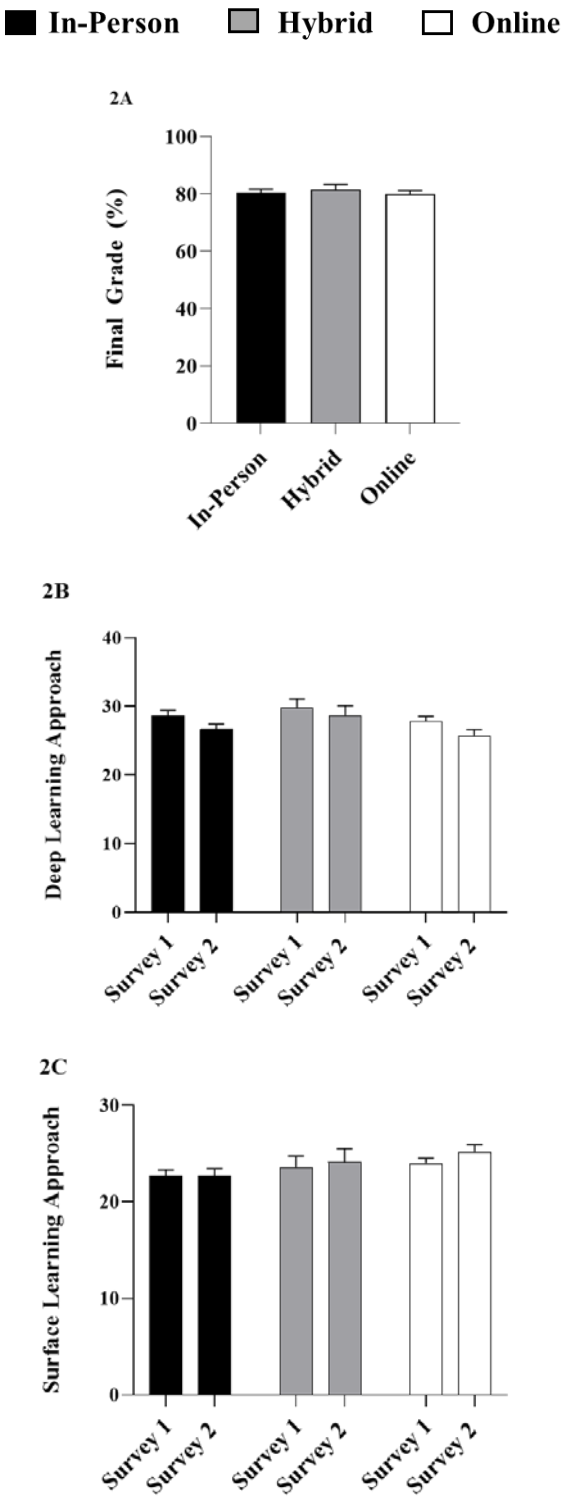

Figure 2. Effect of course format on students' final grade (A), deep and surface learning approach scores (B, C). Data are presented as mean values ± SEM and were analyzed by two-way ANOVA (main effects: lecture format group and time) followed by Tukey's range test. In-Person Group (black bars), Hybrid Group (grey bars) and Online Group (white bars).

Learning approach scores are divided into surface and deep scores, that reflect students' engagement, and their underlying motives and strategies employed during the learning process [53]. Therefore, students that utilize a deep learning approach are typically highly engaged, motivated and interested in the topic of study, seek a deeper understanding of course content leading to higher comprehension and integration of concepts and exhibit greater self-regulation in learning [53,54]. Conversely, students that utilize surface learning approaches tend to have minimal engagement in learning, limited knowledge application capabilities, and rely on repetitive memorization techniques [53,55]. Students' learning approach scores, both deep (Figure 2B) and surface (Figure 2C) learning approaches, did not change over time (i.e., between Survey 1 and Survey 2, $P>0.05$) and there were no statistically significant differences between lecture format groups in students learning approach scores at either the start (Survey 1) or end (Survey 2) of the semester ($P>0.05$). This indicated that students' favoring either deep or surface learning approaches exhibited no preference for a particular lecture format/learning environment. When students are actively involved in the learning process, reflective of a deep learning approach, they are more successful academically and will retain more information [66]. However, in the current study correlative analyses determined that there was no association between deep learning approach score and final grade in the course in any of the three lecture format groups (In-Person: $r = -0.17$, $P = 0.21$; Hybrid: $r = -0.02$, $P = 0.92$; Online: $r = 0.11$, $P = 0.28$). Similarly, there was also no association between surface learning approach score and final grade in any of the three lecture format groups (In-Person: $r = -0.02$, $P = 0.93$; Hybrid: $r = 0.08$, $P = 0.62$; Online: $r = 0.02$, $P = 0.87$).

This is in alignment with previous research demonstrating that students with established academic behaviours or study habits that result in a desired level of academic success will continue to employ the same approaches regardless of the course delivery mode [67]. Previous studies conducted during COVID-19 pandemic-associated online learning have shown that higher deep learning approach scores are positively associated with academic performance (i.e., final grades) [58], perceived capabilities in scientific literacy [41,68], and core employability skills including problem solving, oral communication, leadership, and organization/time management [69]. Conversely, higher surface learning approach scores have been shown to be negatively associated with final grades [68], scientific literacy capabilities [41,68], organization/time management skills [69]. Learning approach scores can also be interpreted to reflect engagement in learning [53] and assessments of students' attitudes toward learning while in an online learning environment have shown that students with higher surface learning approach scores are less engaged and experience less enjoyment and more anger and boredom in learning [68]. While students utilizing a deep learning approach experience more enjoyment and less anxiety, anger and boredom in learning [68]. When students are actively involved in the learning process, reflective of a deep learning approach, they are more successful academically and retain more information [66]. The online learning environment can support a deep learning approach [70], however, there are conflicting findings regarding learning approach scores in online learning with some outcomes showing a reduction in deep learning approach scores [58,71,72] versus those demonstrating that most students adopted a deep approach in an online learning environment [73]. Since students in the current study were able to select their preferred learning environment/lecture format, it is expected that their engagement and learning approaches did not differ. What is unknown is how their learning approach may change between courses that are offered in different lecture formats where choice of preferred learning environment was not permitted. Importantly, the learning approach scores reported herein reflect the typical learning approach scores associated with online learning assessed during the COVID-19 pandemic [41,58,68].

Elevated levels of stress and anxiety have been reported during COVID-19-associated online learning [5,6,7,8,9] [11] [50,74]. Perceived stress levels, including academic and non-academic sources of stress, were not different between lecture formats as the start or end of the semester (Figure 3A). The level of stress observed at both the start and end of the semester on the perceived stress scale is not indicative of elevated perceived stress levels [56]. Interestingly, the association between students' perceived stress levels and their final grade in the course was dependent upon the lecture format. Specifically, there was an inverse statistically significant association between final grade and perceived stress levels in the Online Group ($r = -0.41$, $P = 0.02$; Figure 3B) and In-Person Group ($r = -0.19$, $P = 0.05$; Figure 3C); whereas in the Hybrid Group there was no statistically significant association between final grade and perceived stress levels ($r = 0.03$, $P = 0.85$; Figure 3D). This indicates that students in the Online and In-Person Groups who were experiencing higher stress levels achieved lower final grades in the course, whereas this association did not exist in the Hybrid Group. It is possible that the flexibility permitted in a hybrid learning environment allowed students to better manage their stress levels by embracing the benefits of engaging with a course in a hybrid learning environment, although further study is required.

3.3. Association Between Students' Self-Selected Lecture Format/Learning Environment and Academic Stress Frequency and Intensity

Despite no statistically significant difference in overall perceived stress levels (from all sources, Figure 3A), 64% of In-Person students, 76% Hybrid students, and 69% Online students identified academic stress as the greatest source of stress experienced. The proportion of students identifying academic stress as their main source of stress experienced did not differ between lecture format/learning environment groups ($P=0.54$). Therefore, since students were able to select their preferred learning environment, there was no lecture format/learning environment where students experienced higher academic stress, thereby highlighting the importance of students being able to choose their optimal learning environment.

The distribution of students self-reported academic stress frequency and intensity is shown in Figure 4.

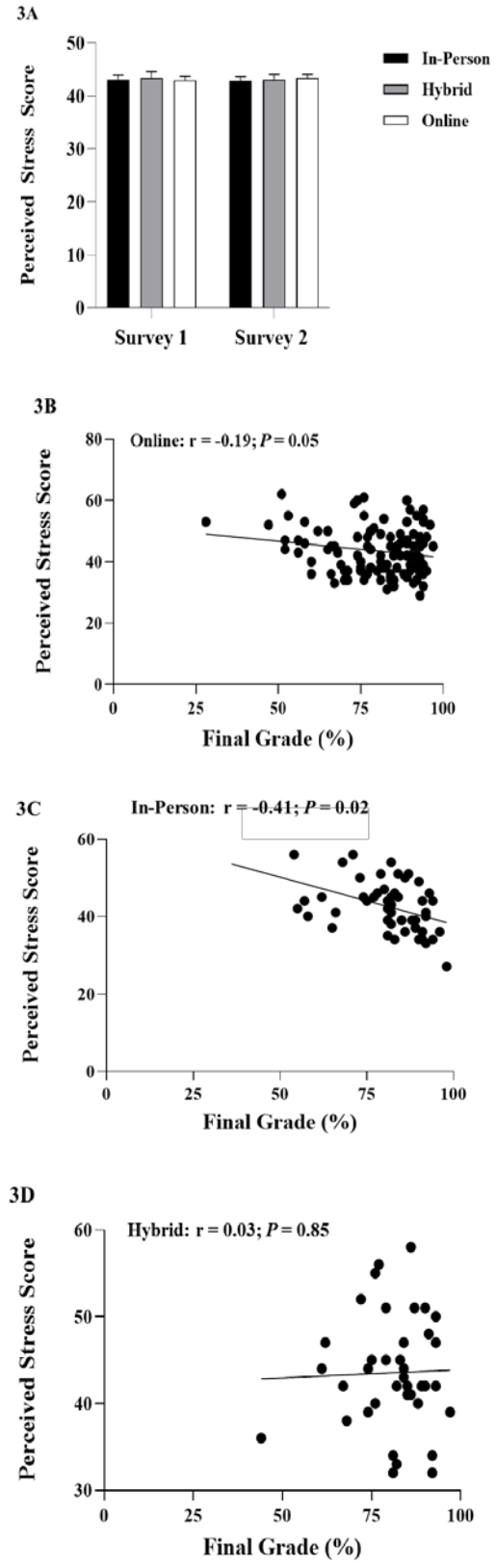

Figure 3. Changes in students' perceived stress (A) and correlations (Pearson correlation coefficient (r) and P-values) between perceived stress score and final grade in the Online Group (B), In-Person Group (C) and Hybrid Group (D). Data Figure 3A are presented as mean values ± SEM and were analyzed by two-way ANOVA (main effects: lecture format group and time) followed by Tukey's range test.

Overall, there was no difference between lecture formats in students' frequency (P=0.36) or intensity (P=0.52) of experiencing academic stress. Both the Online and In-Person Groups had the higher percentage of students experiencing academic stress at a frequency of 1-3 days/week (42.9% and 37.8%, respectively). In contrast, the highest percentage of students in the Hybrid Group (43.9%) reported experiencing an academic stress at a frequency of 7 days/week. The intensity of students' self-reported academic stress experience was similar between learning environment groups, wherein the intensity of academic stress was identified as extremely stressful by the majority of students (ranging from 61.9% - 68.3% across the three lecture format groups). Experiencing academic stress is not avoidable in higher education, particularly the stress associated with transitioning from in-person to an online learning environment during the COVID-19 pandemic [5-9] [11,18] [41,50] [74]. The data from

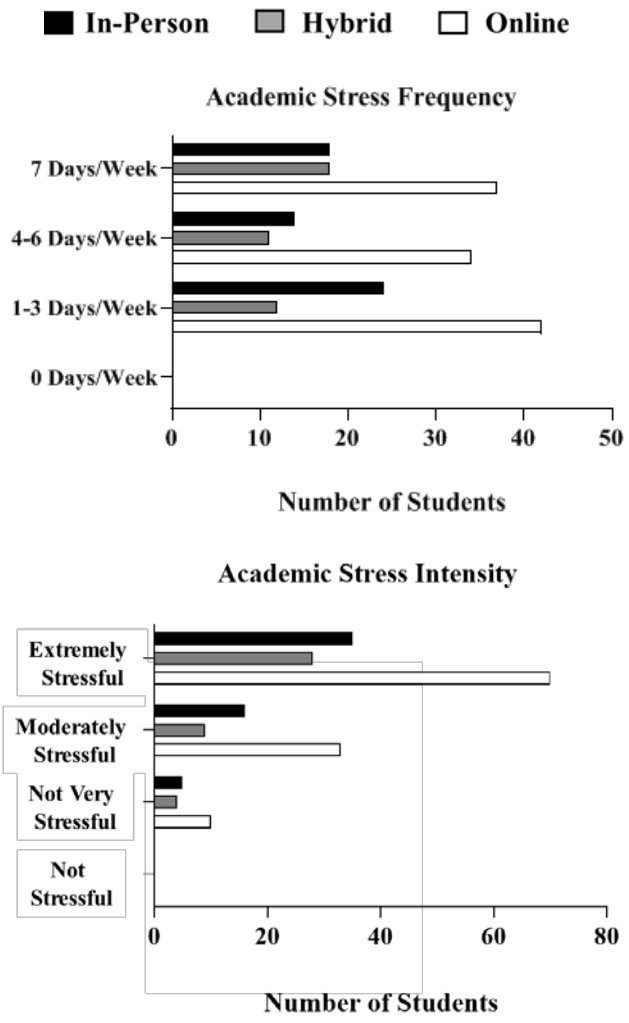

Figure 4. Distribution of students' experience of academic stress frequency and academic stress intensity. Academic stress frequency was self-reported as the number of days experienced per week. Academic stress intensity was self-reported as the level of intensity on a 4-point Likert scale ranging from not stressful to extremely stressful. Bars represent the number of students within each lecture format/learning environment experiencing each category of academic stress frequency and intensity. In-Person Group (black bars), Hybrid Group (grey bars) and Online Group (white bars).

The data from the current study highlights that the academic stress experience is not exacerbated by the learning environment/lecture format when students are provided the opportunity to select which learning environment is optimal for their needs, which is of importance as learning environments have returned to traditional face-to-face in-person learning.

3.4. Students' Perceptions of Academic Stress and Other Challenges Associated with an Online Learning Environment

Students' perceptions of academic stress associated with online learning are shown are Table 2, which may have influenced their individual decisions when selecting which lecture format/learning environment to engage in during weeks 5-12 of the course.

Table 2. Students' Perceptions of Stress Experienced in an Online Learning Environment[1]

Compared to an in-person learning environment…	In-person	Hybrid	Online	P-Value
The online learning environment is more stressful	2.00 ± 0.11^{a}	1.81 ± 0.13^{ab}	1.46 ± 0.06^{b}	<0.001
I experience more stress associated with organizing and maintaining a schedule in online learning	4.65 ± 0.23^{a}	4.31 ± 0.36^{ab}	3.83 ± 0.21^{b}	0.050
I experience more stress associated with meeting academic workload demands/expectations in online learning	4.38 ± 0.15^{a}	3.93 ± 0.26^{ab}	3.63 ± 0.14^{b}	0.009
I experience more stress resulting from time management challenges in online learning	4.59 ± 0.22^{a}	4.00 ± 0.31^{ab}	3.75 ± 0.18^{b}	0.02
Having recorded lectures to refer to later helps me manages academic stress	6.46 ± 0.14^{a}	6.85 ± 0.07^{ab}	6.88 ± 0.03^{b}	0.010

[1]Values presented are mean values ± SEM. Analysis was conducted using one-way ANOVA followed by Kruskal-Wallis test. For each question, values not sharing a lower-case letter differ (P<0.05). Responses to each statement were provided on a Likert scale (1 to 7, wherein 1 represented the lowest level of agreement and 7 represented the highest level of agreement). Responses were collected at the end of the academic semester (i.e., Survey 2).

Relative to the students in the Online Group, students in the In-Person Group reported experiencing significantly higher academic stress while in the online learning environment compared to in-person learning (P<0.05), whereas the Hybrid Group did not differ from either the In-Person or Online Groups. Similarly, significantly higher academic stress was experienced in an online learning environment by students in the In-Person Group (i.e., those who chose to return to in-person lectures/learning) compared to students in the Online Group (i.e., those who chose to remain in an online learning environment), whereas outcomes in the Hybrid Group remained intermediated between the In-Person and Online Groups as shown in Table 2. Specifically, students in the In-Person Group reported experiencing significantly higher academic stress associated with online learning compared to the Online Group with respect to i) organizing and maintaining a schedule in online learning, ii) meeting workload demands/expectations, and iii) challenges with time management (P<0.05). This data provides insight into some of the underlying reasons why students experience stress in an online learning environment [5-9] [11,18] [50,58] [74] and why some students would prefer to return to in-person lectures when first given the opportunity.

Table 3. Perceptions and Challenges in Online Learning[1]

Compared to an in-person learning environment…	In-person	Hybrid	Online	P-Value
I find that I need more help and clarification in online learning.	4.59 ± 0.17^{a}	4.07 ± 0.24^{a}	3.05 ± 0.14^{b}	<0.001
I find myself more distracted in online learning.	5.74 ± 0.18^{a}	5.10 ± 0.25^{a}	3.80 ± 0.17^{b}	<0.001
I cannot interact as much as I need to with the professor in online learning.	4.88 ± 0.17^{a}	4.10 ± 0.21^{b}	3.32 ± 0.16^{c}	<0.001
I find there are fewer interruptions from other students in online learning.	4.14 ± 0.20^{b}	4.51 ± 0.25^{ab}	5.05 ± 0.15^{a}	0.002
I feel that I have more independence in online learning.	5.24 ± 0.15^{b}	5.98 ± 0.15^{a}	6.26 ± 0.09^{a}	<0.001
I feel it is difficult to ask questions and I understand course concepts less in online learning.	4.40 ± 0.15^{a}	4.37 ± 0.10^{a}	4.03 ± 0.08^{b}	0.014
I find organizing a schedule for attending lectures or studying to be easier in online learning.	3.76 ± 0.23^{b}	4.59 ± 0.28^{ab}	5.31 ± 0.17^{a}	<0.001
I find time management is more challenging in online learning.	4.82 ± 0.23^{a}	4.10 ± 0.32^{ab}	3.82 ± 0.20^{b}	0.01
I find online learning to be a better learning environment overall.	3.38 ± 0.17^{b}	4.00 ± 0.19^{ab}	4.63 ± 0.14^{a}	<0.001

[1]Data are presented as mean values ± SEM and were analyzed by one-way ANOVA followed by Kruskal-Wallis test. For each question, values not sharing a lower-case letter differ (P<0.05). Responses to each statement were provided on a Likert scale (1 to 7, wherein 1 represented the lowest level of agreement and 7 represented the highest level of agreement). Responses were collected at the end of the academic semester (i.e., Survey 2).

Some of the difficulties experienced in online learning can significantly increase students stress and anxiety levels [75], which was further investigated. First, an approach to alleviate students' academic stress levels can be to provide recorded lectures regardless of the learning environment. Prior to the shift to online learning due to COVID-19, students found lecture recordings to be valuable for the purpose of reviewing content [76-78] and learning at their own pace to optimize time spent studying [79-84]. In the current study, the percentage of students who reported accessing lecture recordings throughout the semester to support their studying of course content after the initial lecture was provided (either in-person or online) was similar in all lecture formats (68.5% of In-Person students, 71.9% of Hybrid students and 69.8% of Online students). It has been suggested that lecture recordings can be used as a tool to allow flexibility in studying [80,81,85,86] and support self-directed learning [83,87], which can enable students to practice more efficient

learning strategies [88,89]. Further, there was a high level of agreement in all lecture format/learning environment groups that having recorded lectures to refer to helped students manage their academic stress (Table 2), with the highest level of agreement apparent in the Online Group. Previously students have reported that better stress management is a benefit of recorded lectures [80,84,90]. For example, lecture recordings were found to be particularly useful to students when missing a class [82,91]. Taken together, the use of lecture recordings can increase students' knowledge acquisition, in part, because of the ability to revisit lecture topics as needed [80,81,90] and improve overall academic performance [91,92,93]. Continuation of lecture recording to facilitate learning in higher education post-pandemic may represent a benefit emerging from the adaptation of in-person courses to an online format during the COVID-19 pandemic. Further studies are required to assess if instructors are continuing this educational practice or reverting back to not recording classes upon the return to traditional in-person learning.

Students' overall perceptions of online learning compared to the traditional in-person learning are presented in Table 3. Students in the In-Person Group experienced greater challenges associated with online learning including i) the need for more help and clarification, ii) feeling more distracted, iii) difficulty interacting with the professor as much as they required, iv) more interruptions, vi) less independence, vi) more difficulty asking questions and understanding course concepts, vii) more difficulty organizing a schedule, and viii) more challenges with time management ($P<0.05$).

Consequently, these students opted to return to in-person learning once it was available. By incorporating flexible components (due dates, choice of assignments, different ways to participate) into the learning environment, instructors can help students adapt to the challenges of online learning, which have been shown to be beneficial during the onset of the pandemic [23,46,94,95]. Conversely, students in the Online Group had more positive perceptions of a learning environment and significantly differed from the In-Person Group by finding online learning associated with i) needing less help and clarification, ii) feeling less distracted, iii) less difficulty interacting with the professor as much as needed, iv) fewer interruptions, vi) more independence, vi) less difficulty asking questions and understanding course concepts, vii) less difficulty organizing a schedule, and viii) experienced fewer challenges with time management ($P<0.05$). Other advantages of online learning include reducing commute and transportation costs [96,97], increasing learning accessibility [1], schedule and learning flexibility, the ability for students to learn at a self-directed pace to optimize knowledge acquisition [23,46], and reducing academic-related anxiety and stress [24,25]. Therefore, as expected, students in the Online Group had a significantly more positive overall assessment of an online learning environment compared to students in the In-Person Group ($P<0.05$). An explanation for these results could be that students in the Online Group learning-associated attributes and preferences are better adapted for online learning, whereas students in the In-Person and Hybrid Groups were more aligned with a traditional learning environment/lecture format, or a blending of these learning environments, respectively. Furthermore, students that chose to remain in the online learning environment may also be more familiar with the tools necessary for online learning, and hence, are better suited for this type of learning environment. For example, computer science students reported similar or reduced stress levels during pandemic-associated online learning [98]. Consequently, online learning can promote the development of technological skills and learning methods [89], which can prepare students to better adapt to dynamic learning environments [99] and improve student achievement [100]. Thus, there are benefits associated with online learning that could still be retained, in part, through the adoption of hybrid learning that blends both in-person and online learning environments. Further, permitting students to engage with their courses in the manner that is optimal for their learning may foster better academic outcomes.

The perceptions of online learning in the Hybrid Group, who attended some lectures in-person and some lectures online during weeks 5-12 of the semester, shared many online learning perceptions as the In-Person Group including needing more help and clarification, experiencing more distractions and interruptions, having difficulty asking questions, understanding concepts, time management and organizing a schedule ($P<0.05$). Interestingly, the Hybrid Group perceptions of online learning differed from the In-Person Group with respect to having an adequate ability to interact with the professor in online learning and having more independence in this learning environment ($P<0.05$). Not unexpectedly, students in the Online Group identified online learning to be a better overall learning environment, which was significantly different from the lower perceptions of online learning identified in the In-Person Group ($P<0.05$). By combining the benefits of traditional in-person learning and online learning [23], hybrid teaching models can create a more flexible and engaging learning experience [101,102]. Compared to in-person learning, the performance of students in an online or hybrid [103] format have been shown to remain the same or improve both before [104-106] and after the pandemic [107,108]. Students have heterogeneous learning styles that align with different learning methods, and having flexibility within the learning environment (e.g., incorporating a hybrid approach or recording lectures) can provide equitable educational opportunities to optimally support academic success and achievement [109,110].

3.5. Students' Perceptions of Online Learning Groups Differ Based on their Preferred Lecture Format/Learning Environment

Online learning groups were utilized in the current study to help foster a sense of community in the course and connect students together while learning. Previous research has shown that students' anxiety was reduced when participating in group discussions in an online environment (versus larger in-person student group discussion) [23,46]. Online peer discussions amongst students in online learning groups have been demonstrated to improve scientific literacy skills [41], critical thinking

skills, and encourage a deep learning approach [52]. Further, higher engagement with online learning groups that utilize discussion board activities, similar to the current study, has been shown to be positively correlated with higher final grades and learning enjoyment [68]. Conversely, lower engagement with online learning groups was shown to be inversely correlated with surface learning approach and experiencing anger and boredom associated with learning [68]. In the current study, students' perceptions of the benefits experienced from engaging with online learning groups differed between their selected lecture format/learning environment, as shown in Table 4.

Table 4. Students' Perceptions of Online Learning Group Activities[1]

Being in an online learning group…	In-Person	Hybrid	Online	P-Value
Helped me meet new people with different perspectives from my own.	4.43 ± 0.32	4.77 ± 0.39	5.55 ± 0.26	0.43
Helped me feel more engaged in the course content.	4.65 ± 0.34^{b}	4.87 ± 0.37^{b}	6.31 ± 0.26^{a}	0.01
Improved my understanding of the course content.	5.67 ± 0.31^{b}	5.88 ± 0.35^{b}	7.42 ± 0.24^{a}	0.03
Helped me feel more connected to other students in the course when we are learning remotely.	4.93 ± 0.39	4.97 ± 0.39	5.95 ± 0.29	0.61
Helped me feel a sense of community within the course.	4.98 ± 0.36	5.20 ± 0.35	5.54 ± 0.27	0.63
Stimulated me to think about new ideas.	5.11 ± 0.30^{b}	5.86 ± 0.34^{b}	6.87 ± 0.25^{a}	0.05
Was a positive experience overall.	6.10 ± 0.38^{b}	6.71 ± 0.34^{b}	8.05 ± 0.22^{a}	0.02

[1]Data are presented as mean values ± SEM and were analyzed by one-way ANOVA followed by Kruskal-Wallis test. Values not sharing a lower-case letter differ ($P<0.05$). Responses to each question were provided on a Likert scale (1 to 10, wherein 1 represented the lowest level of agreement and 10 represented the highest level of agreement). Responses were collected at the end of the academic semester (i.e., Survey 2).

Overall, students expressed agreement that the experience of being in an online learning group was positive (78% of the In-Person Group, 87% of the Hybrid Group and 89% of the Online Group), however, students in the Online Group identified that the experience of being in an online learning group to be a significantly more positive compared to students in the In-Person and Hybrid Groups ($P<0.05$; Table 4). Furthermore, students in the Online Group also reported that online learning groups i) promoted feelings of being more engaged in the course content, ii) improved their understanding of the course content, and iii) stimulated thinking about new ideas ($P<0.05$; Table 4) to a greater degree than students in the In-Person and Hybrid Groups. These outcomes support the findings that online learning groups can improve student achievement [24,68,111] by increasing engagement [25,34,101,112,113]. Although online learning groups were intended to support student-student connections, there were no statistically significant differences between lecture format groups in their perceptions of online learning groups helping students meet new people with different perspectives, feeling connected to other students while working remotely, or feeling a sense of community within the course ($P>0.05$; Table 4). The utility of online learning groups is based on students' engagement and perception of the benefits associated with online learning groups [114,115], therefore, student buy-in is required to maximize the effectiveness of this teaching and learning strategy. The findings from the current study suggest that these benefits of online learning groups may be perceived as more valuable when students were exclusively in an online learning environment compared to when they are implemented during traditional in-person learning.

The shift to online learning during the COVID-19 pandemic was associated with many challenges for both students and instructors, including technology limitations and internet connectivity, inexperience with the technology required for online learning, time management, communication with instructors, additional preparation time, distractions in a home learning environment [16]. Additionally, multiple studies have reported elevated levels of stress and anxiety during COVID-19-associated online learning [5-9] [11,18] [50,51] [74]. However, some students reported benefits associated with online learning, such as flexibility in lecture schedules and the review of recorded lectures, time management, reduced financial costs, ease of communication, greater engagement and comprehension [16]. Based on these reported limitations and benefits, some students are better suited for and/or prefer an online learning environment, whereas others may prefer in-person learning. This suggests that success in higher education may be influenced by the learning environment and offering courses with flexible formats (i.e., hybrid formats) or providing access to online lecture recordings in in-person lecture formats that may better support student learning preferences and success. In the current study, when students were provided the opportunity to self-select their preferred learning environment the majority of students (73.3%) selected either an exclusively online or hybrid learning environment. The similar outcomes across learning environments/lecture formats with respect to overall academic performance, perceived stress, and learning approach reflects a positive impact of students engaging in the course within their preferred learning environment format, wherein differences in these outcomes would be anticipated to be exacerbated if students were required to engage in a lecture format that did not align with their optimal learning environment preference. The results from the current study indicate that flexible course designs that provide students with choice in how to best engage in higher education may alleviate student stress and better support academic achievement. The results in the current study were assessed within the context of a traditional lecture format science course and students' ability to self-select their learning environment may provide different outcomes in other disciplines or in seminar or laboratory-based course formats. Therefore, further study is required and the results from this study may not be broadly extrapolated to all course formats. Another limitation of this study is that it was conducted during the COVID-19 pandemic, and although it is important to assess the effectiveness of pandemic-associated teaching and learning approaches the findings may differ if this study was repeated post-pandemic (i.e., students could choose

their preferred learning environment) or if students were randomly assigned to a learning environment versus being given the autonomy to choose their preferred learning environment/lecture format. Therefore, it will be important to re-assess the outcomes of the current study in a post-pandemic setting where students are permitted to select their preferred learning environment when in-person, online and hybrid course options are concurrently available. Overall, the results from this study provide evidence that including flexible course delivery options and broadening the teaching and learning approaches to include online, hybrid, and/or in-person formats may allow students to experience the benefits of a balance between face-to-face learning and the flexibility of remote learning and should be considered as a means to increase accessibility and inclusion in higher education.

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Statement of Competing Interests

The authors have no conflicts of interest to disclose.

List of Abbreviations

RSPQ2F, revised study process questionnaire; PSS, perceived stress scale.

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