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Nursing student's perspectives and academic performance in anatomy and physiology before, during and after a stability period of COVID-19

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ABSTRACT

The Coronavirus disease 2019 (COVID-19) has dramatically disrupted medical, allied health, and nursing education worldwide. It has created challenges for students and educators by requiring a sudden shift to online teaching and learning activities from didactic, passive teaching and learning. The objective of the present study was to evaluate the impact of these modes of teaching and learning before, during, and after the transition through COVID-19 on the class average and Grade Point Average (GPA) of nursing students taking anatomy and physiology in the first year of nursing. Using the virtual teaching and learning modality, the present study demonstrated that the mean class average of anatomy and physiology midterms and final examinations during COVID-19 (synchronous online teaching) was significantly higher ($P<0.001$) compared with the pre-COVID-19 (face-to-face (F2F) teaching) class average. However, the class average and GPA were not different between pre-COVID-19 (F2F teaching) and post-COVID-19 (hybrid/flex teaching). Virtual teaching of these subjects also significantly ($P<0.001$) increased the students' GPA in anatomy and physiology during COVID-19 compared to before and after the stability of COVID-19. Students' perspectives on teaching and learning these courses using these teaching modalities indicated that nursing students prefer a synchronous, hybrid mode of learning in anatomy and physiology. The present study demonstrates nursing students' preference for a synchronous, online and hybrid mode of teaching and learning anatomy and physiology in case of the re-emergence of a new strain of coronavirus after Omicron variant in future lockdown due to the COVID-19 pandemic.

1. Introduction

Human anatomy and physiology are considered the foundational courses that serve as prerequisites for the subsequent years and clinical courses for medical, allied health and nursing disciplines.[1,2] Adequate knowledge of these courses is essential for students in these disciplines to become successful professionals after graduation.[3,4] However, the teaching and learning of these courses have been impacted by several factors that include, but are not limited to, fewer contact hours between students and faculty,[5,6] increased student enrolment, fewer dedicated anatomy and physiology faculty members, increased cost and limited access to cadavers and prosections, and adoption of new teaching technologies.[6–8]

However, for the last three years, one of the most prominent factors impacting the teaching and learning of these courses was Coronavirus disease (COVID-19). Reported for the first time in China in 2019 and then declared a pandemic by the World Health Organization (WHO)[9] on March 11, 2020, COVID-19 spread rapidly to 183 countries, affecting more than 1.5 billion educators and students globally[9,10] by sending many into isolation, compromising their well-being and mental

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health.[11] Students experienced high anxiety, fear[12] and concerns about their education and academic performance during the COVID-19 pandemic.[13–16] As a result of the closures of educational institutions worldwide,[17] many passive, didactic and active learning activities used in the classroom before COVID-19 were no longer used.[18,19] This compelled educators and students to quickly adapt to fully virtual, e-learning and long-distance modes of teaching and learning in an extremely short period of time.[20–22] It forced them to learn a plethora of teaching and learning modalities, including video conferencing software, social media, pre-recorded lectures and new teaching technologies.[17,19,21–23] During COVID-19, many anatomy educators and students had limited access to cadavers, anatomical models, prosections, and students had decreased face-to-face (F2F) interactions with faculty and peers.[21] However, from the beginning of the pandemic until now, numerous studies conducted on the impact of COVID-19 focused on the perceptions of medical and allied health students and educators on teaching and learning,[16,22,24–26] except for a few studies on the impact of COVID-19 on their academic performance only before and during the pandemic.[27] Therefore, the students' and educators' perspectives, experiences and academic performance before, during and after a stability period have not yet been assessed.

In Canada, the first COVID-19 case was reported on January 27, 2020. By mid-March, all Canadian provinces declared an emergency and imposed mandatory isolation for Canadians with the immediate closure of all educational and government offices.[28] To date, the total number of COVID-19 positive cases reported in Canada was approximately 3.93 million, totaling 41,763 deaths (Government of Canada COVID-19 Epidemiology Update, June 21, 2022). The province of Alberta, where this study was conducted, reported approximately 586,000 COVID-19 positive cases with 4,591 deaths (Government of Canada COVID-19 Epidemiology Update, June 21, 2022).

Regarding teaching and learning in nursing education worldwide during the COVID-19 pandemic, there have been very few studies conducted in nursing education.[29] compared to medical, allied health and science disciplines.[26,30] Most of these studies have either focused on qualitative analysis of data collected on the various teaching and learning of anatomy and physiology teaching themes adopted during the pandemic. These themes included but were not limited to students' and faculty members' perspectives on teaching and learning, their satisfaction with the technology used, various teaching modality preferences, advantages, challenges and recommendations[29–31] or the impact on the student's and educator's mental health during COVID-19.[32] None of these studies has used quantitative data to assess nursing students' academic performance and their experience and perspectives on teaching and learning these subjects in response to various teaching modalities such as synchronous online, hybrid/flex and F2F.[23] Also, most of these studies have assessed the impact of these modalities in gross anatomy, with few exceptions in physiology.[30,33]

In the faculty of Nursing at MacEwan University, from early March 2020 until the Winter of 2021, COVID-19 caused the emergency pedagogical transformation of nursing curricula, rapidly switching from F2F classroom teaching to an online, virtual platform. As a result, many active learning modalities, such as the use of technology, labs, in-class exams, and in-person contact with students, were moved to an online, virtual learning environment. This forced students to adopt self-directed learning approaches.[34] As the Delta variant cases slowly declined in the Fall of 2021, MacEwan University announced a hybrid/flex mode of delivery (i.e., the combination of virtual online and in-person classes) of courses across the campus. In November of 2021, the emergence and spread of another COVID-19 variant, Omicron, forced classes back online until February 28, 2022. As the Omicron variant cases slowly declined, MacEwan University then announced in-person classes until the end of Winter 2022. However, the impact of this shift from active learning strategies to virtual, online, hybrid/flex and in-person during COVID-19 periods on students' experience and perspectives and academic performance in nursing students taking anatomy and physiology has not yet been investigated.

This study aimed to assess qualitative data on the perspectives and experiences of nursing students after the pedagogical transformation and post-acute COVID-19 era and compare their academic performance before, during and after a stability period of COVID-19.

2. Materials and Methods

This article aimed to explore the qualitative and quantitative analysis of nursing students' perspectives, perceptions and experiences and academic performance before, during and after a stability period of COVID-19.

2.1. Before COVID-19 (Fall 2019)

In Fall 2019, the first-year nursing students taking anatomy and physiology were taught for 13 weeks with active learning strategies which included, but were not limited to, lectures, classroom discussion, in-class quizzes, content reinforcement using a game-based quizzing platform (Kahoot Inc., Oslo, Norway) and sample practice questions including short answer, matching, true and false and fill-in-the-blanks questions without an answer key, and the use of the modern and cutting-edge teaching technology and a three-dimensional (3D) virtual human dissection table (Anatomage, San Jose, CA) for gross human anatomy.[9] There was no laboratory component for either course.

2.2. During COVID-19 (Winter 2020, Fall 2020, Winter 2021 and Winter 2022)

The human anatomy and physiology courses were switched from F2F to an online platform because of the lockdown. The classes met for one hour and 20 minutes in the synchronous mode two days per week, along with two virtual office hours immediately before each synchronous session. A learning management system (Blackboard) was used to communicate with students, for post-course content, to allow discussion, to conduct computerized exams, and maintain a grade book.

Following the announcement of COVID-19 as a pandemic on March 11, 2020, by the World Health Organization (WHO) due to an outbreak of the original variant, a province-wide closure of educational institutions led MacEwan University to announce shifting of in-person classes to virtual, online teaching and learning from March 13, 2020, until Winter 2021, and from January to February 28 in Winter 2022 (due to the Omicron peak). As a result, many in-person activities described above were no longer adopted, except for Kahoots and sample practice questions. Before the Pre-COVID era, the principal author of this study was holding study sessions to review contents for mid-terms and final exams. Due to the sudden shifting of in-person face-to-face (F2F) classes to virtual online learning, detailed reviews of the exams, including contents per chapter with several marks assigned to each content, were posted on the Blackboard course page 2-3 weeks before each mid-term and final exam.

2.3. After a Stability period of COVID-19 (Fall 2021)

In the Fall of 2021, the number of Delta variant cases slowly declined, and all educational institutions, including MacEwan University, announced the hybrid/flex mode of teaching and learning, where one class was delivered virtually online and another in person. As a result, limited teaching strategies such as the use of the Anatomage Table and in-class quizzes and content reinforcement that were used before COVID-19 were re-instated in the teaching in this period.

2.4. Student's perspectives and experience on teaching and learning during COVID-19

The University's announcement on March 13, 2020, of the sudden shifting of in-person classes to virtual online teaching created anxiety, stress and confusion among faculty members and students in terms of which teaching modalities, teaching styles, types of technologies and modes of virtual online delivery would work best for them. For faculty members, several options were available to pre-record lectures using three different types of technology, i.e. Blackboard collaborate, Screencast-O-Matic and Kaltura Space. Lectures could be presented using one of two modes of online teaching, e.g., synchronous vs synchronous teaching. To assess the students' preference for teaching and learning technology, a first Google survey comprising of a multiple-choice close-ended questionnaire regarding their opinion on virtual classes was designed, and feedback was collected from the students.

2.5. Student's perspectives and experience on teaching and learning after a stability period of COVID-19

To evaluate what worked best in improving understanding and knowledge of anatomy and physiology, students were taught with selected modalities, styles and technologies during COVID-19 (Winter 2020, Fall 2020 and Winter 2021). The second Google survey comprised approximately 14 close-ended questions scored on a 5-point scale ranging from 1 being very satisfied to 5 being very dissatisfied. Data were collected via a Google survey link on the students' experience and perspectives after the Winter 2022 semester ended (April 2022).

The questions from both Google surveys were reviewed and validated by both authors. Students' responses were collected and presented in Table 2.

2.6. Recruitment of participants and student demographics

The study participants were first-year anatomy and physiology students enrolled in the Bachelor of Science in Nursing (BScN) program in the Faculty of Nursing of MacEwan University in Edmonton, AB, Canada. Approximately 70-80 anatomy students in the Fall 2020 semester (before COVID-19) were females (84.5%) and (15.5%) were males with a mean age of 21.4±2.63 years (n=80), whereas, 81.5% of the physiology students were female and 18.5% were male with a mean age 21.6±5.37 years (n= 65). During the COVID-19 period, i.e., Winter 2020, Fall 2020, and Winter 2021, of approximately 223 anatomy students, 75.4% were female, and 23.1% were male, with a mean age of 20.5±1.87 years (n= 223); for the same period, of approximately 160 physiology students, 75.9% were female, and 23.4% was male, with a mean age was 21.7±2.56 years (n=160).

For Fall 2021, for the 72 students enrolled in the hybrid/flex classes in anatomy, 77.66% were female, and 21.4% were with an average age of 21.0±2.16 years (n=72); for the 45 physiology students enrolled during the same time period, 73.3% of the students were female, and 26.7 were male, with an average age of 21.8±2.8 years (n=45). The female to male ratio for anatomy students after a stability period (Winter, March and April 2022 was 73.3:25.2 with an average age of 21.5±2.49 years (n=81), and for physiology, the female to male ratio was 69.1:29.4 with an average age was 21.7±2.44 years (68).

2.7. Data collection

The first author of the current study collected the data on class average and GPA and consulted Dr. Karen Buro, Professor, Department of Mathematics and Statistics, MacEwan University, for statistical evaluation of the quantitative data of this study. The second author of this study conducted similar student responses from the first-year medical students at the University of Malta, Malta, during COVID-19[26] and, therefore, provided help with the statistical evaluation of the qualitative data on nursing students' responses.

2.8. Data analysis

For quantitative data analysis, the differences in percent (%) class average and the GPA from three mid-terms and final for anatomy and two mid-terms and finals for physiology before, during and after a stability period of COVID-19 were pooled for statistical analysis. Data were analyzed using the SPSS II statistical software, version 25.0 for Windows (IBM Corp., Armonk, NY, USA) to determine the mean scores and standard deviation (+SD). For the statistical differences between before, during and after COVID-19 and between anatomy and physiology, a 1-way ANOVA was used, whereas a two-way ANOVA was used for class average and the Grade Point Average (GPA). A P-value less than 0.05 was considered statistically significant, followed by Cohen's "d" to assess the level of difference for each mid-term and final exam for anatomy and physiology. Cohen's "d" values for the present study were between 0.1 to 0.3.[5] Microsoft Excel spreadsheet for Windows 10 (Microsoft Corp., Redmond, WA, USA) was used for generating graphs showing means and standard deviations.

For qualitative data on student responses to various teaching modalities and strategies during COVID-19 and after a stability period of COVID-19 (Winter 2022), the questionnaire was made available online using Google Forms® (Alphabet Inc., Mountain View, CA). The link for the online questionnaire was posted on the Blackboard, and students were reminded to complete the surveys. The authors analyzed their comments following a thematic analysis (Table 2). Three themes used by Cuschieri and Agius[26] were followed and were categorized as: (1) perspectives on virtual online teaching and learning; (2) experiences gained from the shift to virtual online teaching and learning; and (3) perspectives before, during and after a stability period and its impact of teaching and learning of anatomy and physiology. Both authors discussed and analyzed the data, and the student's comments were categorized following the three themes stated above.

2.9. Research Ethics

All participants were informed about the details of the study. Participation in the study was voluntary, and students could withdraw from the study at any time. Their anonymity was affirmed. The research and the data from the student survey used in this article were approved by MacEwan University's Research Ethics Board (REB), File No. 101862.

3. Results

3.1. Impact of COVID-19 on Class average and GPA

Teaching and learning anatomy and physiology have been greatly affected by the COVID-19 pandemic over the last three years. The sudden shift from F2F to synchronous online teaching and learning of anatomy resulted in a highly significant increase in the percent class average for anatomy for mid-terms 1, 2 and 3 (P<0.001) and the final exam (P<0.001). However, there were no significant differences in class average between F2F (before COVID-19) and hybrid/flex teaching and learning for three mid-terms and final exams (Figure 1). Compared to F2F teaching and learning, synchronous online teaching and learning significantly (P<0.001) increased the GPA. No significant differences in GPA were found between F2F and hybrid/flex teaching and learning (Figure 3).

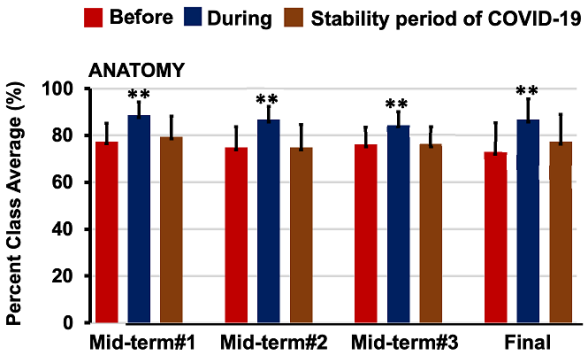

Fig. 1:

Synchronous online teaching and learning resulted in a significant (P<0.001) increase in class average for physiology mid-term 1 and 2 and the final exam (P<0.001) (Figure 2). Compared to F2F teaching and learning, the GPA was significantly increased during synchronous online teaching and learning. No significant differences in class average and GPA were found between F2F and after a stability period of COVID-19 (Figure 3).

3.2. Student's experience and perspectives during COVID-19

Most students preferred asynchronous (62.3%) over synchronous classes, while 64.6% preferred synchronous

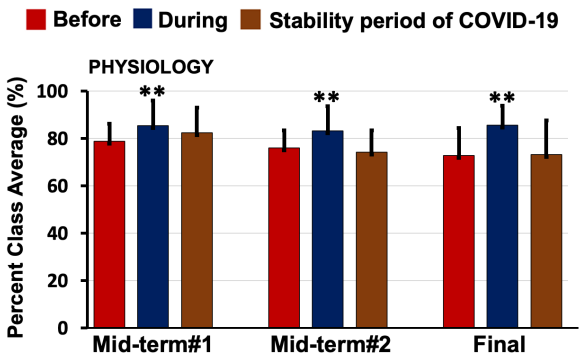

Fig. 2:

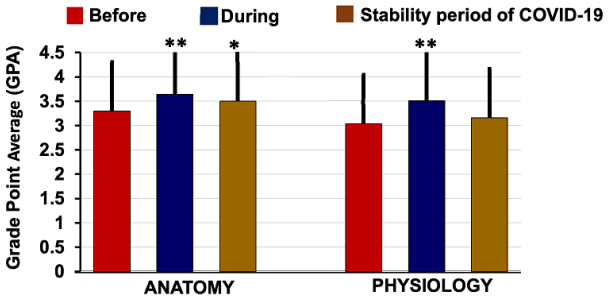

Fig. 3:

classes if the pre-recorded lectures were posted before classes. 93.2% of students strongly preferred a detailed exam review posted on Blackboard synchronous classes. (Table 1). While 70.3% of students preferred 15 minute long pre-recorded videos versus 30-40 minute-long videos (29.7%), the students strongly favoured (95.3%) pre-recorded lectures recorded with audio and video compared to audio recording only; in addition, 47.5% and 45.4% of students preferred video recorded in Blackboard Collaborate and Screencast-O-Matic software, respectively, compared to video recorded in Kaltura (Table 1).

3.3. Student's experience and perspectives after a stability period of COVID-19

When students were asked about their concerns over nursing education during COVID-19, 70.9% of anatomy and 76.5% of physiology students expressed concerns. When asked preference for virtual online teaching versus F2F teaching, 92.1% of anatomy and 85.2% of physiology students were satisfied with virtual online teaching. Approximately 97.6% of anatomy students and 91.2% of students were very satisfied with the instructor's knowledge of teaching technologies such as Blackboard Collaborate, Screencast-O-Matic, as well as the use of plastic models, bones and drawing tablets to explain

Table 1: Teaching modalities preferences by nursing students during COVID-19 and hybrid/flex periods

Teaching modalities	Student Responses	Percent (%) response rate
Modes of Classes	Synchronized	37.7%
	Unsynchronized	62.3%
Modes of lectures	Pre-recorded lectures only	35.4%
	Pre-recorded lectures followed by synchronized classes	64.6%
Modes of lecture delivery	Pre-recorded lectures posted before classes	93.2%
	Pre-recorded posted lectures after synchronized classes	6.8%
Exam reviews	Exams reviewed by Professor	33.6%
	Exams review posted on the Blackboard	66.4%
Length of Pre-recorded Lectures	Short pre-recorded lectures (15-mins)	70.3%
	Pre-recorded lectures (30-40 mins)	29.7%
Technology used for video recording	Screencast-O-matic	45.4%
	Blackboard collaborates	47.5%
	Kaltura space	7.1%
Modes of Lecture Presentations	Only audio presentation	4.7%
	In both audio-video presentation	95.3%

physiology concepts virtually. 96.8% of anatomy students and 97.0% of physiology students were satisfied with instructor support online and offline, and 97.6% of anatomy students and 98.5% of physiology students were satisfied with the instructor communicating with students through the Blackboard announcements. 97.6% and 97.1% of anatomy and physiology students, respectively, strongly felt that mid-term and final exam reviews posted on Blackboard were content focused and helped them prepare for mid-terms and final exams. 48.8% of anatomy and 27.9% of physiology students responded "yes" to synchronous online teaching and learning, whereas 43.3% of anatomy students and 46.6% of physiology students responded "no". The remaining 7.9% of anatomy and 25.5% of physiology stayed neutral. When asked if they preferred hybrid/flex mode of teaching over F2F teaching, 42.5% of anatomy students and 61.8% of physiology students responded: "yes" compared to 39.4% of anatomy students and 29.4% of physiology students who responded "no" (Table 2). In comparison, 18.1% of anatomy and 8.8% of physiology students stayed

neutral. When asked if their understanding and knowledge of anatomy and physiology was greater during synchronous online teaching than hybrid/flex and face-to-face teaching, 36.2% of anatomy students and 35.5% of physiology students responded with "yes". In contrast, approximately 42-47% of anatomy and physiology students responded "no". When asked if their knowledge and understanding of anatomy and physiology was greater during face-to-face teaching and learning over synchronous and hybrid/flex teaching and learning, 49.6% of anatomy students and 50.0% of physiology students responded "yes" whereas 33.9% of anatomy and 30.9% of physiology students responded "no". Finally, when they were questioned about which mode of learning they would prefer if allowed to learn anatomy and physiology in the future, 40.9% of anatomy students and 54.4% of physiology students highly preferred the hybrid/flex modes of learning over fully in-person (35.4% of anatomy students and 25.0% of physiology students); 23.6% and 20.6% of anatomy and physiology students, respectively, preferred a fully synchronous mode of teaching and learning (Table 2).

Table 2: Student's perspectives on teaching and learning of anatomy and physiology before, during and after a stability period of COVID-19

Questionnaires		Courses	
		Anatomy Percent (%)	Physiology Student response
1. Were you concerned about your nursing education due to COVID-19?	Yes	70.9%	76.5%
	No	21.3%	14.7%
	Not sure	7.9%	8.8%
2. How satisfied were you with the online teaching and learning adopted due to COVID-19 measures?	Very satisfied	26.0%	17.6%
	Satisfied	66.1%	67.6%
	Dissatisfied	7.0%	11.8%
	Very dissatisfied	1.0%	3.0%
3. How satisfied were you with the instructor's knowledge of the use teaching technology during COVID-19	Very satisfied	47.2	33.8%
	Satisfied	50.4%	57.4
	Dissatisfied	2.0%	8.8%
	Very dissatisfied	0.40%	0.0%
4. How satisfied were you with the instructor's knowledge of the use teaching technology during COVID-19?	Very satisfied	47.2	30.9%
	Satisfied	50.4%	55.9%
	Dissatisfied	2.0%	11.8%
	Very dissatisfied	0.40%	1.4%
5. How satisfied were you with the instructor promptly and timely answering the emails and phone calls and clarifying anatomy and physiology concepts outside online teaching?	Very satisfied	55.1%	63.2%
	Satisfied	41.7%	33.8%
	Dissatisfied	3.2%	1.5%
	Very dissatisfied	0.0%	1.5%
6. How satisfied were you with your instructor communicating with you through the Blackboard announcements about teaching during COVID-19?	Very satisfied	60.6%	63.2%
	Satisfied	37.0%	35.3%
	Dissatisfied	2.4%	0.0%
	Very dissatisfied	0.00	1.5%
7. Were the mid-terms and final exams posted on the Blackboard were content focused and helped you to prepare for the exams	Yes	97.6%	97.1%
	No	0.00%	0.00%
	Not Sure	2.4%	2.9%
8. Were you satisfied with your instructor reducing online exam related anxiety and stress during COVID-19?	Yes	82.7%	73.5%
	No	7.9%	4.9%
	Not Sure	9.4%	20.6%
9. Do you prefer synchronous online teaching and learning?	Yes	48.8%	27.9%
	No	43.3%	46.6%
	Not Sure	7.9%	26.5%
10. Do you prefer flex/hybrid (combination of synchronous online and face-to-face teaching and learning?	Yes	42.5%	61.8%
	No	39.4%	29.4
	Not Sure	18.1%	8.8%

Continued on next page

Table 2 continued

11. Do you prefer 100% face-to-face (in-person) teaching and learning?	Yes	44.9%	42.6%
	No	40.2%	42.6%
	Not Sure	15.0%	14.7%
12. My understanding and knowledge of anatomy and physiology was much greater during synchronous online teaching and learning than in flex/hybrid (combination of synchronous online and face-to-face) learning?	Yes	36.2%	35.5%
	No	42.5%	47.1%
	Not Sure	21.3%	17.6%
13. My understanding and knowledge of anatomy and physiology was much greater during face-to-face teaching and learning than synchronous online and flex/hybrid (combination of synchronous online and face-to-face) learning?	Yes	49.6%	50.0%
	No	33.9%	30.9%
	Not Sure	16.5%	19.1%
14. Given an opportunity to teach and learn anatomy and physiology in the future, which mode of teaching and learning delivery methods will you prefer?	100% face-to-face	35.4%	25.0%
	100% synchronized	23.6%	20.6%
	Hybrid/Flex	40.9%	54.4%

4. Discussion

The COVID-19 pandemic resulted in a rapid pedagogical transformation, forcing students and educators worldwide into social isolation during the peak of the lockdown.[35–38] This rapid change caused anxiety and stress and affected students' mental health[39] and academic performance.[40,41] For anatomy courses, this sudden shift in pedagogy affected body donation and prosection programs at various institutions worldwide.[17,42] As a result, many educators were forced to quickly adapt to online, virtual teaching modalities while maintaining the same learning outcomes as before COVID-19.[43,44] Our results demonstrated that due to this sudden pedagogical transformation, faculty members and students at our institution were forced to adapt to various online learning platforms, teaching strategies and technologies adoptions.

The mounting evidence gathered over the last three years on the impact of COVID-19 on the teaching and learning of biosciences differed from institution to institution,[22,26] the type of survey questions asked to the students and faculty members, and whether the survey was carried out during or post-COVID era.[16,26,28,31] Results from Rafi et al.[25] based on student surveys on nursing students' preferences for online teaching modalities, teaching platforms[25] and length of pre-recorded PowerPoints showed that they appreciated the use of the online platform,[45] but preferred asynchronous virtual online classes. This may be due to the availability of pre-recorded lectures posted on their learning platform (the Blackboard). This allowed students to learn the topic at their own pace and enjoy the ability to browse, pause, rewind and view videos multiple times.[46]

Nursing students in the present study expressed a strong interest in having pre-recorded lectures before their synchronous classes. This agrees with the findings of Singh et al.,[45] which showed that medical students expressed a preference for pre-recorded lectures. Also, 70.0% of nursing students in the present study preferred to have pre-recorded lectures of 15 minutes in length posted prior to virtual classes. A shorter 10–20-minute-long video was found to optimize student interest and engagement better than a 60-minute lecture.[10,25] However, they showed an equal preference for pre-recorded lecture recording technologies such as Screencast-O-Matic and Blackboard Collaborate than Kaltura space to have pre-recorded lectures recorded. Students highly appreciated the faculty's support, both online and offline, and virtual online office hours.[47] They greatly appreciated having their mid-terms and final exam details reviews posted on Blackboard a few weeks before the exams rather than reviewing them online synchronously.[48] This may have helped them prepare for the mid-terms and final exams in advance.

After a stability period of COVID-19, the survey of students on their experience and perspectives on learning anatomy and physiology during the peak of COVID-19 showed that although 71-76% of nursing students were concerned about their nursing education due to the COVID-19 pandemic,[47] the majority of them were satisfied with their adaptation to online learning.[49] Almost 97.6% of anatomy students and 91.2% of physiology students acknowledged the main author's of this study's use and knowledge of teaching technology during the COVID-19 pandemic and highly appreciated his support and help through personal communications (offline), Blackboard announcements and his conduct in the virtual classroom.[49] Similar studies have demonstrated that the student-teacher interactions, the students' feedback and the instructor's meeting with students virtually were reported to be advantageous for medical students.[50] Almost 97.0% of anatomy and physiology students showed high satisfaction over the use of pre-recorded lectures, PowerPoint presentations, detailed mid-terms and final exam reviews, sample practice questions (multiple-choice questions, matching and short answer questions) and exam reviews posted on Blackboard, which helped them prepare for mid-terms and the final exam beforehand.[49]

However, students in the present study were divided over the modes of teaching and learning as well as synchronous versus asynchronous online teaching during and after a stability period of COVID-19. For instance, anatomy students preferred synchronous online teaching more than physiology students (48.8% vs.27.0%). In contrast, their preference for flex/hybrid teaching and learning was the opposite for physiology students (61.8% vs. 42.5%), while only 50.0% of anatomy and physiology students preferred F2F classes. Similarly, 41% of anatomy and 55.0% of physiology students would prefer flex/hybrid modes of teaching and learning when classes will be assumed F2F after the pandemic is over.[45,49] This strongly indicates that nursing students' preferences for teaching modes have changed due to the pandemic. This could be attributed to several reasons: firstly, they may have adapted to online learning at their own pace and had the flexibility to review the pre-recorded lectures as many times and any time as they wanted. Secondly, the flex/hybrid learning mode allowed them to avoid travelling to attend in-person classes, thus reducing their fear of being exposed to the pandemic. This agrees with the findings of Singh et al.,[45] as medical students in their study preferred the flex/hybrid learning mode. When given a choice between F2F classes and online learning, 50.9% of students preferred online learning and only 26.0% preferred F2F classes. In other studies, 47.0% of students favoured replacing F2F classes with online learning.[49,51,52] Numerous studies, mainly conducted during the peak of the COVID-19 pandemic, reported that online was as effective as didactic, passive teaching and learning due to its easy accessibility, self-directed evaluation and higher student engagement, in addition to the ease of receiving support from faculty members in the online

teaching modules [18,51,52] This indicates that an online virtual mode of teaching and learning can be seen as a future mode of teaching and learning if the pandemic re-emerges in the future. Moreover, blended (combination of synchronous online, flex/hybrid and active learning strategies) learning in nursing,[23] allied-health students [53] and medical students [39] improved their academic performance when taught online rather than in F2F classes; therefore, many suggested 'blended' approaches in the teaching of human anatomy and physiology during COVID-19.[54]

During COVID-19, virtual online teaching became a substitute for didactic, in-person teaching, and many in-person teaching modalities were no longer used.[23] As for the impact of the COVID-19 pandemic on academic performance during COVID-19 and after a stability period of COVID-19, not much is known about nursing students compared to medicine, health-allied [31,41,47] and most of these studies focused on students and faculty members' experiences and perspectives; very few studies examined its impact on the academic performance of the students in these disciplines.[39,41] Nursing students in the present study achieved a significant increase in the class average and their individual GPA in anatomy and physiology in all midterms and finals taken during the COVID-19 pandemic compared to before and after a stability period of the COVID-19 pandemic. Limited studies on students' academic performance during COVID-19 are conflicting, and results vary from one study to another. For instance, medical students taking anatomy [39] and physiology students taking neuroscience and endocrine modules during F2F teaching obtained significantly higher test scores than in online teaching. This could be due to supervised in-person exams compared to nursing students writing mid-terms and finals unsupervised online. The significant improvements in academic performance in these subjects during COVID-19 are consistent with medical [55] and dental [52,56] students who reported a higher-class average in online teaching modalities.

The higher test results reported in nursing students in the present study may be due to many underlining reasons; firstly, based on qualitative data from a Google survey on their preferences, teaching was adjusted on synchronized online during COVID-19. Before their online classes, they were given access to pre-recorded lectures, practiced questions, a detailed review of mid-term and final examinations were posted, and regular virtual office hours were maintained to provide them with clarifications in case of questions.[49] Also, plastic models were used for anatomy teaching during online teaching, and a drawing tablet was used to explain physiological concepts. A regular online classroom discussion on certain anatomy and physiology topics was held. For every chapter taught online, Kahoot quizzes were conducted to assess students' knowledge. These collaborative activities and online class discussions were highly appreciated by students.[45,48]

It may also be that nursing students spent more time studying anatomy and physiology (Narnaware and Chahal, 2020), or that they were adapted to self-directed virtual online learning due to a strict lockdown, self-isolation and lack of social interaction with others.[34,48] As enumerated above and reflected in their Google Survey conducted during and after COVID-19, students likely benefited from the "close guidance" approach by the main author of this study which includes help and guidance during virtual online and offline.[50] As a result of the lockdown and shifting classes to online, all the mid-terms and final exams were conducted online during COVID-19. Therefore, students may have taken advantage of unsupervised online proctoring during online exams, which includes access to course material due to the non-blockage of the web browser.[47] However, this needs to be examined further.

5. Conclusion

This present study provides evidence for anatomy and physiology educators to understand the adoption of various teaching modalities and students' perspectives and preferences on specific modes of teaching and learning of these courses in light of the pandemic. It compared their understanding of these courses before (F2F), during (synchronous virtual teaching and learning) and after (hybrid/flex teaching) the pandemic on the academic performance of nursing students. Nursing students' preference for adopting a synchronous hybrid mode of teaching-learning allows them to undertake self-directed learning to have increased flexibility and to manage their study time compared with F2F teaching. However, the lack of online proctoring of their exams during online teaching raises the concern of whether their understanding and knowledge of these courses were compromised or whether they were adapted to this mode of teaching and learning, resulting in improved understanding and academic performance. But suppose they took advantage of the lack of online proctoring, in that case, the long-term consequences of retaining and applying the knowledge they gained during online teaching to future years of nursing may affect their ability to recall, retain and apply to their future nursing and clinical courses.

The world is not out of the woods yet regarding the pandemic, with recent travel bans from ten African countries to the USA, Canada, and the recent lockdown of one the major Chinese city and globally in response to increasing cases of Omicron. Moreover, to date, more than 2,625 Omicron cases in Canada and more than 980 in Alberta (Globe and Mail, Toronto, 2022) is a grim reminder that the pandemic is not yet over and done with. Therefore, readopting the synchronous flex/hybrid mode of teaching and other online teaching modalities adopted during the pandemic's peak may be crucial in case of the re-emergence

of a new strain of Coronavirus in the future.

6. Limitations

Student responses during COVID-19 on various teaching modalities and strategies during the COVID-19 and after a stability period were only collected from one group of students in Winter (March 2020) and during a stability period (March 2022). However, their responses may have differed if the surveys had been conducted each semester during COVID-19. Similarly, the data on the academic performance of nursing students during hybrid/flex was collected for only one semester (Fall 2021), whereas F2F learning was only conducted for five weeks after the university announced resuming F2F classes from February 28/2022.

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8. Conflict of Interest

The authors declare no conflict of interest.

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