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Preserving Safety while Upholding the Integrity of Medical Education and Practical Skills: The Impact of COVID-19 on Teaching Human Anatomy

Anna Cowan

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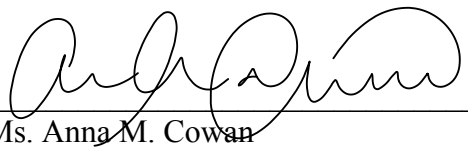
by
Anna M. Cowan



Ms. Anna M. Cowan 9/23/21
Date

Dr. Thomas Kwasigroch, Thesis Mentor **04/23/21**
Date

Mr. Robert M. Becker, Reader **04/23/21**
Date

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ABSTRACT

The global pandemic caused by COVID-19 placed constraints on several aspects of normal life, especially those of higher level education. While many programs moved to teaching in a strictly online format, there are some courses in which this structure was not appropriate. This study observed the outcome of the adapted course structure employed at Quillen College of Medicine during their Gross Human Anatomy course. Through a voluntary survey and multiple independent t-tests, it was demonstrated that the students who took the adapted course performed, on average, 2 points lower on each exam than previous classes. Also, this study showed that there was no statistically significant impact on student performance caused by the instituted safety measures, specifically quarantining. Finally, students had no distinct preference in regards to the structure of the course as it related to their learning experience. The overall conclusion of this study was that this course, despite its modified structure and additional safety measures, taught students effectively and maintained the safety of all individuals involved.

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INTRODUCTION

COVID-19

Sars-CoV-2 is a strain of coronavirus that causes a disease known as COVID-19, which has infected approximately 92 million people worldwide (Think Global Health, 2020). Of those cases, over 22 million have been reported in the United States alone (Ritchie, 2020). Beginning in March 2020, several authorities in the U.S. on the local, state, and federal levels instituted various mitigation policies in attempts to reduce transmission of COVID-19. The majority of these policies focused on social distancing, wearing masks, and testing. Initially, this global pandemic, as declared by the World Health Organization on March 11, 2020, incited a shutdown, during which Americans were encouraged to stay home. To support these efforts in preventing the transmission of COVID-19, businesses and schools transitioned to working and learning online. As a result, universities across the U.S. ceased all in-person coursework, regardless of course subject. As the quarantine restrictions were gradually lifted and individuals returned to work and school, rates of COVID-19 rose, despite preventative efforts. By June 2020, rates increased in all age groups, but most rapidly and drastically among young adults aged 18-24 years (CDC, 2020). There was a spike in cases surrounding the beginning of the academic year, especially among those younger than 25 years of age.

Social Distancing

Social distancing was one of many measures that the Center for Disease Control and Prevention recommended to combat COVID-19. This measure required there to be at least six feet of distance between individuals who did not live in the same household. Social distancing

has been proven to reduce the risk of contracting COVID-19 (Doung-ngern, 2020). In the anatomy lab at QCOM, the number of students in the lab during each session has been reduced to 36, only half of the original number. Each station, consisting of a total of four team members, only two of which were allowed in each session, were spaced so that the maximum amount of space between students was achieved. Following normal procedure, each station was equipped with all necessary tools and cleaning equipment for each team, preventing students from congregating in common areas. Students were encouraged to socially distance when able both within and outside the anatomy lab.

Masks

As part of the effort to reduce transmission of COVID-19, the CDC encouraged the use of masks when not socially isolated. Masks should cover the nose and mouth to be effective. N95 respirators were the most highly recommended, but any face coverings, such as medical masks, bandanas, scarves, and gaiters, were recommended in the absence of an N95 mask. Masks have been proven to significantly impact the rate of COVID-19 transmission and have directly been linked to reducing risk for infection. At ETSU QCOM, masks were required to be worn on campus and in all university buildings unless in the confines of one's personal office. During Anatomy courses, all students, faculty, and laboratory staff were required to wear a mask at all times. In addition to wearing a mask, all persons in the anatomy lab were required to wear a face shield or protective eyewear of some kind. Persons in the lab were also required to dawn gowns and gloves as additional protective measures. While gloves are always required in the lab, the students at QCOM are usually charged with providing their own gloves. However, because of the shortage of gloves during the pandemic, QCOM provided gloves for students this academic year.

Covid-19 Testing and Self-Monitoring

Students underwent testing for COVID-19 at several intervals throughout the semester. Students and faculty were all required to stay home if feeling ill or experiencing symptoms of COVID-19. These symptoms included, but were not limited to fever, cough, shortness of breath, headache, muscle or body aches, and loss of taste or smell. Those who had recent exposure to a positive case or an individual who was expressing symptoms were required to undergo testing and abstain from attending class until a negative test result was achieved. The type of test used to identify positive cases among faculty and students was the TaqPath™ COVID-19 Combo Kit. These tests have a positive identification rate of 95% (Thermo Fisher Scientific, 2020).

Additional Cleaning Procedures

While the anatomy lab at QCOM employed rigorous cleaning measures to ensure the health of the students and staff on a regular basis, additional cleaning measures were followed to minimize the opportunity for COVID-19 transmission. All persons in the lab were encouraged to wash and sanitize their hands upon entering and exiting the lab. After each session, commonly touched surfaces such as door handles, tanks, sinks, and chairs were sanitized.

Teaching Methods

Ideology Behind the Method

QCOM often uses the “flipped classroom” method of teaching to educate their medical students; the Gross Human Anatomy course was the first course to utilize this method. The “flipped” style reverses the conventional relay of information. Students, instead of absorbing information passively, are charged with learning the subject material outside of class through pre-recorded lectures, readings, videos, etc. When students arrive in the classroom, it is common

for there to be a brief review of the material, or an emphasis on key points; in this course, this was achieved through group quizzes that were taken before each dissection regarding the daily material. The goal of this style is to then engage students in answering questions, groupwork, hands-on tasks, or anything else that involves them in applying the content material. It has been stated that this method places students as the focus of a course rather than the instructor.

Course Structure

Traditionally, medical students at QCOM experience a flipped classroom style when taking the Gross Human Anatomy course. They are responsible for engaging with course materials before class and being prepared for lectures, quizzes, and dissections each day. All students are required to attend a lecture, which is led by the Biomedical Sciences faculty. These lectures are normally held in a hall adjacent to the Anatomy Lab and briefly review the assigned material and prepare students for the day's dissection. Following the lecture, students may ask questions before taking a quiz on the material that was covered. Upon finishing the quiz, students and faculty migrate to the Lab, where they perform their dissections. During the dissections, students work in teams of four, following a guide with detailed instruction. The faculty are present to answer questions and aid in dissection. Once the lab period has ended, students are allowed to return during open lab hours to study their cadavers.

Grading and Examinations

The students' grades are based on their quizzes, in-class presentations, and exams. There are two components to each exam: practical and written. Students take the written exam in the lecture hall under supervision of a proctor prior to entering the Anatomy Lab for the practical. The practical exam consists of identifying anatomical structures found in the students' cadavers and additional cross-sections. During this exam, students move from station to station, recording

their responses on their answer sheets as they proceed. The examinations are separated into sections corresponding with learning units in the course. There are six written exams, five practical exams, and a final examination proctored through the National Board of Medical Examiners. For the purposes of this study, data from the practical exams and the final exam will be reviewed.

Adaptations to the Course During COVID-19

This course maintained the "flipped" classroom style. However, the number of students in the lab at one time was reduced and only two students from each team were allowed to dissect each day. The students who did not actively participate in the dissections were present for the lecture via Zoom. These students were also allowed to review recordings that their teammates made and their team's dissection during open lab hours. Minimizing the number of people in the lab reduced each student's lab exposure by half. Quizzes were administered online before class instead of during the lecture. Written exams were also administered online instead of in-person. Students were provided with materials that they potentially could not obtain due to the demands of the pandemic, such as gloves and personal protective equipment including eye wear and gowns. Students were allowed to view the Prosection. The number of faculty present during the dissections was unaffected. The manner in which the practical examinations were administered was unaffected, as well.

LITERATURE REVIEW

The current literature surrounding higher level education, especially that of medical students, focuses on experiential learning. Active, hands-on learning promotes students' retention of information and integrates curricula during the process; both of these are integral in building a strong foundation for clinicians (Papa & Vaccarezza, 2013). Additionally, experiential learning enhances the development of clinical skills. Janssen, VanderMeulen, Shostrom, and Lomneth, published a study in 2013 evaluating students' performance on a Lachman test. A Lachman test assesses the integrity of the anterior cruciate ligament of the knee by manipulating the joint through movement of the lower leg. All students received the same lecture detailing the procedure, but only half of the students had the opportunity to attempt the Lachman test on a "lightly embalmed cadaver". "Students with hands-on training performed significantly better than students with lecture-only training in completing the checklist, a post-test, and correctly diagnosing an ACL tear" (Janssen et al., 2013). The hands-on group also reported higher levels of confidence when performing the test. Similar results were obtained in studies observing pelvic examinations and central venous catheterizations (Siwe, Wijma, Silén, & Berterö, 2007; Ma et al., 2013).

Presently, students have more access to technology than ever before. In the scope of Human Anatomy, dissection is not the only means of teaching. Many medical colleges are transitioning partially—and in some cases, totally—away from dissection (Memon, 2018). Instead of dissecting cadavers, these institutions are relying on 3D rendering software to teach students. This concept is fairly new, and there are limitations to the software. Such technology takes time to develop, and even when it is developed, there are many improvements that can be made. In conjunction, these programs may not be accessible to all students. Such programming

requires computers that have strong processing capabilities. These can be very expensive, as can the subscriptions to the software programs themselves. In addition to these, the primary concern is that this transition will cause a lapse in medical education for those students who do not have the option to perform dissection. This lapse, as seen in programs that have excised cadaveric dissection, has led to deficiencies in skills pertaining to physical examination, interpretation of radiological images, performance of basic medical procedures, as well as an overall lack of anatomical knowledge in upcoming physicians (Memon, 2018). Aside from software programs, students may also incorporate other technological resources such as YouTube for their anatomical education (Jaffar, 2012).

While dissection is not the only way to learn anatomy, Patel et al. argues that there is no single best method to teach anatomy, but rather to incorporate all methods that are beneficial to the students' education (2015). This article argues while educators are capable of teaching through the use of technology solely, there is an overwhelming amount of research that supports hands-on learning from both a practical and attitudinal perspective. Not only does dissection augment the physical performance of medical students, but their intangible skills, as well. Experiential learning, especially in the context of anatomy, increases confidence, retention, and the ability to interact with patients (Siwe et al., 2007). Therefore, while it is possible to teach medical students anatomy without dissection, it is wholly more beneficial to the individual to learn experientially while supplementing with additional resources, including the available technology.

Because of the recent nature of the global pandemic, there currently exists no literature surrounding the impact of COVID-19 on such teaching methods.

HYPOTHESES

This study aims to address three pertinent aspects of the current global pandemic's impact on medical education: academic performance among classmates, academic performance in comparison to medical school classes that matriculated before the pandemic, and student preferences concerning the structure of the course that was offered in the Fall 2020 semester. The following hypotheses will be examined:

Hypothesis 1: It is hypothesized that the students who were quarantined during the Fall 2020 semester, for any amount of time, exhibit a poorer academic performance on the exams pertaining to the instruction for which these students were absent.

Hypothesis 2: It is also hypothesized that the class of medical students under observation will, on average, score lower in this course than the previous four classes of medical students.

Hypothesis 3: Lastly, it is hypothesized that this class of medical students will prefer an instructional setting that resembles the traditional style of in-person lectures in which each student is present every day for dissection.

METHODS

The primary method of this study was observation by the principal investigator. During this time, the PI was an intern through the QCOM Anatomy Lab Intern/Extern Program. During this internship, the PI observed several lectures throughout the course. The PI also participated in dissections, prepared material for practical exams, and observed student dissections and faculty interactions. Because of this experience, there is a significant amount of background information that was reported through observation.

Secondly, a survey approved by the ETSU Institutional Review Board was administered to the class that took Gross Anatomy during the Fall 2020 semester. This survey consisted of sixteen multiple choice questions and one open-ended question. The purpose of this survey was to gauge the attitudes of the students surrounding the structure of the course and their individual performance. This survey was delivered via a LISTSERVE email by the course director. The survey was conducted through Google Forms. The study was completely voluntary, and participation was not mandatory. There was no incentive provided for participation in the survey.

Finally, exam averages were obtained for each class of QCOM students who took Gross Human Anatomy from 2016 through 2020. The individual grades of those who took this course during the Fall 2020 semester were also obtained. This data was provided by the course director. The confidentiality of the students was maintained, and the principal investigator was unaware of the identities of the students. A statistical analysis was performed on the course grades (see below).

Statistical Analysis

For Experiment 1, an independent t-test was performed to compare the academic performances of the quarantined students to that of the non-quarantined students. This analysis used test scores from the students' first practical exam only for comparison. The quarantined students were the sample group while the non-quarantined students functioned as the control group. For Experiment 2, an independent t-test was also performed to compare the class exam averages of the medical school class that took the course during the pandemic ("current class") to the four classes of medical students preceding this class who received the traditional course experience ("previous classes"). The exam averages of the previous classes were the control group for this experiment. The exam averages of the current class were the sample. The exam averages were obtained from the course records. Each class of medical students took five exams, each on a different anatomical region. The class averages of each of these exams were used for the second experiment.

RESULTS

Survey

The survey received 24 responses. All 24 students were first year medical students at QCOM, took Gross Human Anatomy during the Fall 2020 semester, and had reliable internet access throughout the course. None of the students reported failing to submit assignments due to unstable internet connection; however, 20.8% of students reported being late to or absent from a class due to unreliable internet. 20.8% of students were unable to ask questions on days they were in class via Zoom, compared to only 4.2% of students who were unable to ask questions on days they were physically present in the lab. Only 37.5% of students felt as though they had sufficient time to complete their dissections. The majority of students (79.2%) did not feel as though their learning experience was impeded by the personal protective equipment they were required to wear while in the lab. However, 45.8% of students felt as though the structure of the course impacted their performance; and 54.2% of students felt as though they would have performed better had they experienced the course in the traditional style. Of those who responded, 6 students had to quarantine during the course. One-third of those students believed that their performance was impacted by the structure of the course. Of all 24 responses, only 25% preferred the in-person lectures. 20.8% of students preferred online synchronous lectures. 37.5% of respondents preferred online synchronous and in-person lectures equally (see Figure 1). This contradicts the hypothesis that these students would prefer a traditional classroom setting, and the null hypothesis must be accepted.

Experiment 1

This was a two-tailed, independent t-test was performed to test the hypothesis that quarantined students exhibited a poorer academic performance than students who were not quarantined. This test included a population size of 71. A group of 9 students were reported as having quarantined for the first practical exam, which constituted the sample set. The 9 students who were quarantined for the first exam (M = 89.63, SD = 16.04) compared to the 62 students in the control group (M = 86.59, SD = 8.46) demonstrated no significant difference in scores, t (69) = 0.883, p-value = .38, with p > .05. This contradicts the proposed hypothesis, and the null hypothesis must be accepted.

Table 1.1

	N	Mean (M)	Standard Deviation (SD)	Standard Error of the Mean (SEM)
Quarantined Students	9	89.63	16.04	5.34
Non-quarantined Students	62	86.59	8.46	1.13

Experiment 2

This analysis was performed to test the hypothesis that the class of medical students under observation will, on average, score lower in this course than the previous four classes of medical students. This was also a two-tailed independent t-test, with a population size of 25. The sample size was 5. The current class (M=81, SD=1.58) compared to the previous classes (M=83, SD=1.90) demonstrated significantly lower exam scores, t (23) = 2.12, p-value = .054, with p > .05. This supports the hypothesis, and the null hypothesis must be rejected.

Table 1.2

	N	Mean (M)	Standard Deviation (SD)	Standard Error of the Mean (SEM)
Exam Scores of Current Class	5	81	1.58	.707
Exam Scores of Previous Classes	20	83	1.90	.425

DISCUSSION

Hypothesis 2, which asserted that the current class of medical students would not perform as well academically as the previous classes, was supported by the data. While the difference in the average exam scores was statistically significant, it is important to note that there is variation between each class of medical students. The difference of 2 points, with a standard deviation of 1.58 and 1.90 for the current class and previous classes, respectively, can be explained by this variation. While the records for multiple classes were used to eliminate this variable, it is possible that the current class performed and will perform within this margin, albeit slightly lower than the previous classes, in every course. Another potential cause of this performance change could be attitudinal, a result of the order in which the courses were offered. In the traditional curriculum, medical students begin Gross Human Anatomy immediately. In the adapted curriculum, students completed a course in biochemistry before beginning anatomy. The demands of the biochemistry course, when compared to the intensity of the anatomy course, are more lenient. Subsequently, the slight in academic performance can be attributed to a lack of conditioning. The medical students could have acclimated to the pace of the biochemistry course and, when thrown into a more rigorous course, failed to perform as well. However, this could be caused by an entire class failing to perform to the standard, or it could be caused by outliers that weakened the current class average. Without conducting further research, it is inappropriate to form conclusions as to the cause. The statistically significant difference, however could have been caused by the adaptation to the course structure. In changing the course from strictly in-person and full participation to a hybrid model that incorporates online synchronous and pre-recorded lectures and reduced participation, it is possible that the students' academic performance suffered consequently. The survey, which was designed to elucidate the relationship between the course structure and the students' learning experience, indicated that students had

varied opinions about the course structure. Even so, over half of the respondents believed that if they had experienced the traditional course structure, they would have performed better academically. While the data supports the hypothesis, more research would need to be conducted to determine a specific cause in this performance change.

In regards to the first hypothesis, which was proven to be inaccurate in this circumstance, there are numerous factors that can explain the relationship, or lack thereof, between lab exposure and academic performance. The quarantined students exhibited similar academic performances to those who did not have to quarantine. The students who were quarantined also exhibited variability in their academic performances similar to the non-quarantined students. These similarities imply that the lack of dissection time did not affect their ability to identify structures in the lab practical. While this could indicate that there is no correlation between hands-on learning and improved academic performance, there exist a multitude of studies that support the opposite. This brings other factors into consideration; first, it is possible that quarantining could have offered students more time to study the exam material. While the quarantined students may not have had the opportunity to perform the dissections themselves, they did have access to the recorded lectures, as well as photos and videos taken by their group members. This could have supplemented the missed dissection time. Second, students who received a negative test result for COVID-19 were allowed to return to lecture, only missing two or three lectures, as opposed to the few that tested positive and missed anywhere from five to ten lectures. An overestimation of the number of lectures missed could attribute to the reasoning behind this hypothesis. Third, at this level of education, each student is highly motivated to not only pass their courses, but to excel. This attitude could motivate those students who were under quarantine to study more than they would have for the exam had they been in the lab. This

overcompensation could have caused the students to perform better than they would have originally. However, this could not accurately be concluded and is only speculation offered retrospectively. Regardless, the data illustrates that all students performed similarly in the course despite obstacles such as quarantining. This aids in answering the greater inquiry at hand, which concerns the effectiveness of this course in the proposed teaching style. The data demonstrates that this course was efficacious while instituting safety measures to reduce the transmission of COVID-19.

Finally, there was great concern surrounding the safety of students and faculty. Many of the first-year medical students were age 25 or younger. This placed these students in the age demographic which displayed the greatest risk of transmission of COVID-19. Furthermore, there was an increase in the number of positive cases reported as students returned to class, which amplified safety concerns for those who were returning to in-person courses such as Gross Human Anatomy. However, only 14% of the class had to quarantine, and even less tested positive for COVID-19. Through contact tracing, it was discovered that the positive cases did not contract COVID-19 from interactions in the Anatomy Lab. Moreover, none of the faculty had to quarantine during the course. This demonstrates that the safety measures instituted during the course were effectual in preventing the transmission of COVID-19. From the student survey it can be concluded that wearing personal protective equipment, social distancing, encouraging personal hygiene, and frequently testing students and faculty did not impose on the students' learning experience. Correspondingly, the methods QCOM adopted were successful in preserving safety and can be applied in other contexts where appropriate.

Limitations

In attempting to substantiate a single cause for the changes observed in this study, it is important to acknowledge that the students who took this course were adapting to the circumstances created by the COVID-19 global pandemic that affected them beyond the Gross Human Anatomy course. While it was necessary to modify the delivery of the curriculum, there are many provisions that these students had to make in their personal lives that relate to neither the course, nor the study being conducted. Correspondingly, the academic performance of the individuals in this course could have been *either diminished or augmented* by a number of variables that cannot be identified by this study. Without evaluating a considerable amount of variables that reach beyond the scope of this research, it is necessary to state that there are limitations of this study that have a significant impact on its applicability. However, this study may be applied to other subjects in which experiential learning promotes knowledge retention and practical skills. It may also be applied to situations in which there are limitations placed on education due to safety concerns imposed by physical presence.

CONCLUSION

While there are several factors that could have caused the changes exhibited in student performance, this study confirms that the students who took the Gross Human Anatomy course did not perform as well as previous classes who took the course in its traditional form. However, these students still met and exceeded the expectations for the course. It was demonstrated that quarantining students had no significant impact on their academic performance. Because the students who took this course during the COVID-19 pandemic contracted fewer cases than what was expected based on transmission rates for their demographic, it can be concluded that the safety measures instituted during this course were effective in maintaining the safety of those taking the course. Overall, it can be concluded that this course, despite its adapted structure, effectively taught students the pertinent information for which its purpose intended while preserving the safety of everyone involved.

APPENDIX A

Post-Completion Survey of Gross Anatomy Course at QCOM
1. Are you a student at Quillen College of Medicine?
Yes No
2. What year of your medical education are you in?
M1 M2 M3 M4
3. Did you complete Gross Anatomy during the Fall 2020 semester?
Yes No
Please answer the following questions in consideration of your experience only in Gross Anatomy.
4. Did you have access to a reliable internet connection while taking this course?
Yes No
5. Were you ever late to class because of your internet connection?
Yes No
6. Did you ever disconnect from class because of your internet connection?
Yes No
7. Were you ever unable to complete your assignments because of your internet connection?
Yes No
8. On days that you were not in the Anatomy Lab for lecture, were you able to ask questions as needed?
Yes No
9. On days that you were in the Anatomy Lab for lecture, were you able to ask questions as needed?
Yes No
10. Which of the following represents your preference on receiving lectures? I preferred…
online synchronous lectures. in-person lectures. online synchronous and in-person lectures equally. neither online synchronous nor in-person lectures, but another medium. I did not have a preference.
11. Do you feel as though you had sufficient time during class to complete your dissections?
Yes No
12. Did wearing masks, face shields, and/or other personal protective equipment impede your learning experience during this course?
Yes No
13. Do you feel that the structure of this course, meaning your lab rotation and online synchronous lectures, impacted your performance in Gross Anatomy?
Yes No

14. Do *you* believe that you would have performed better in Gross Anatomy if it would have been taught traditionally? (Meaning that you would have had in-person lectures and dissections every day with each of your team members present every day)
Yes No
15. Did you, at any time during the Gross Anatomy course, have to quarantine, for any amount of time, because of COVID-19?
Yes No
16. If you answered yes to the previous question, do you feel as though being under quarantine impacted your performance in this Gross Anatomy course?
Yes No I was not under quarantine during the Gross Anatomy course.
17. Please provide any feedback concerning the way that Gross Anatomy was taught this semester. What do you believe helped you succeed in this course? What did not help you succeed? Are there things you would suggest doing differently?

APPENDIX B

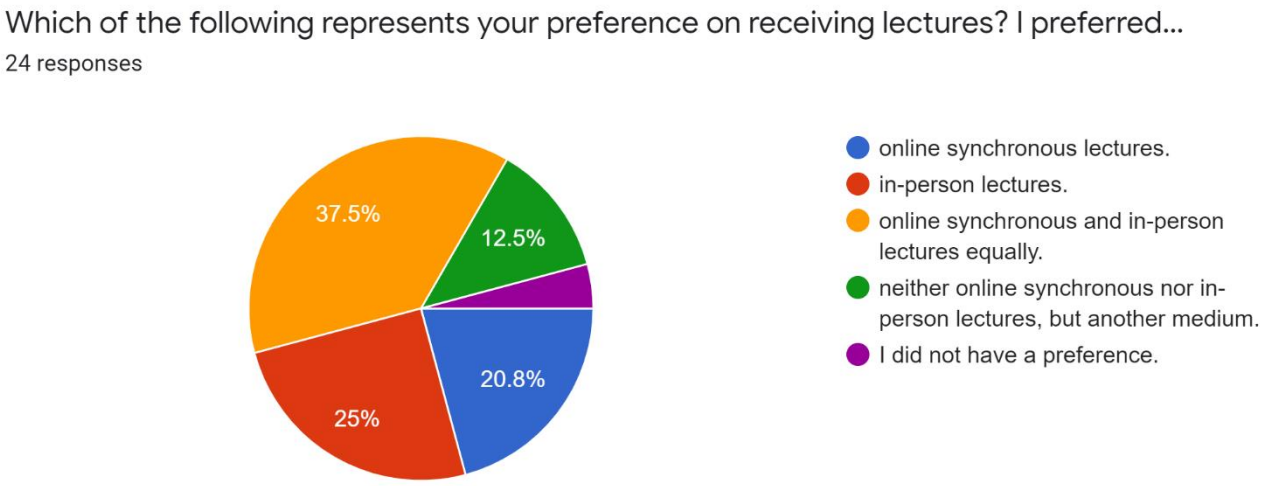

Figure 1

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