Learning Lessons: Differences in Student Performance in Analytical Problems in Remote Learning Vs In-person Learning of a Biochemistry Course

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Abstract

Covid-19 affected people regardless of nationality, level of education, income, age, or gender, and its consequences have hit the most vulnerable the hardest.[1] Education *is one area that got tremendously affected by Covid-19's effects and the impact will dwell in the world for decades. It has been known that teaching, as well as learning Biochemistry, is challenging.*[2] *Changes in the learning platforms due to Covid-19 made teaching and learning Biochemistry even more challenging. Sudden switch of learning modalities due to the world's emergency forced significant changes in the manner teachers teach and learners learn with minimal time for gradual adaptation. The changes were rigorous due to related encounters such as accessibility issues, lack of technological literacy and skills, increased stress levels among others.*[3] *To learn how students' ability to successfully solve analytical problems got affected by switching to remote learning, a classroom study involving Biochemistry students was performed. This study involves a comparative analysis of student learning outcomes of pre-Covid in-person student performance data and remote learning student performance data during years 2019, 2020, and 2021 of Biochemistry class (CHEM 341) at Medgar Evers College. Six semesters worth of data was analyzed to identify trends associated with the change of student performance owing to the change of learning platforms. Specific analytical problems were selected as research problems and incorporated into regular tests to understand students' approaches to solving these problems. Students' overall performance in mixed problem tests was used to normalize the score of analytical problems to eliminate all the other variables in student performance. Overall grades and student participation were also closely monitored. However, this study indicates a significant decrease in students' ability to logically approach an analytical problem among online students compared to that of in-person students. Although various sources such as the Department of Education. State-wide and City-wide programs, Institution level support programs eased this transition by providing additional resources, and training, this study indicates a significant impact on the analytical problem solving of Biochemistry students.*

Keywords: *Student performance, remote learning, Analytical problem solving*

1. Introduction

The world experienced significant changes in the last two years due to the Covid-19 pandemic which has influenced humans in numerous ways. The uncertainty and complexity of the "new normal" forced us to find alternative ways of teaching and learning, pushing millions of college students around the world into virtual learning. The advent of online education has made it possible for students to continue education through a single Internet connection despite the pandemic while facing social and economic challenges. Although online education boasts several advantages over traditional education, such as flexibility and location independence, online instruction still has its drawbacks, including limited learning community synergies.[4] Furthermore, among others, students need time management skills, discipline and motivation, communication skills, computer/online familiarity and comfort, and access. Nevertheless, in future years, online education seems to be the path many students are taking to secure a degree. Therefore, it is important to monitor the quality of online education compared to in-person education with the focus on the development of deeper knowledge as well as inquiry, critical thinking, analytical thinking, problem-solving, and decision-making abilities of the students.[5]

This study compared the effectiveness of online vs. traditional instruction in terms of students' ability to successfully answer questions that require analytical thinking. Using student performance data, we attempted to see if students' scores for analytical questions had an effect due to switching from in-person to online modality. Although there were limitations to the study, this examination was

conducted to provide us with evidence of students' ability to reap deeper knowledge as well as inquiry, critical thinking, analytical thinking, and problem-solving skills in the online modality.
The methods used in this assessment can be expanded upon in future studies to further analyze this topic during major changes to learning modalities including the recent switch back from online to in-person learning.

2. Methodology

2.1 Participants

The study sample consisted of total of 205 participants; 97 in-person students (Fall 2018, Spring 2019 and Fall 2019) and 108 online students (Fall 2020, Spring 2021, and Fall 2021), who completed the Biochemistry (CHM341) class at Medgar Evers College, City University of New York, USA. Student performance in three mid-semester exams and the final exam that consisted of 22372 in-person responses and 13223 Online responses were analyzed. All sections of the course were taught by a full-time biochemistry professor at Medgar Evers College. The professor had over 10 years of teaching experience and the same course material was used in teaching the class in both in-person and online modalities. The same number of contact hours and office hours were offered to the students in both modalities. Online students were expected to attend office hours to clarify the material. The professor combined textbook learning, open educational resources (OER), PowerPoint notes, lectures, class discussions, and assessment tasks to engage students in the learning process in both modalities. The normalized score of the analytical problems and the non-analytical problems of the participants from in-person instruction and online instruction served as the primary comparative factor in assessing performance differences between online and in-person students. Of the total participants, the in-person population was composed of 17.5% freshmen, 11.3% juniors, 1% sophomores, and 70.1% seniors. The online population was composed of 15.7% freshmen, 11.1% juniors, 0.9% sophomores, 69.4 % seniors, and 2.8% second-degree students. No special preferences or weights were given to students based upon gender or rank. Each student's separate answer choices were considered a single, discrete entity or statistic. This study did not differentiate between male and female students, part-time and full-time students or non-transfer and transfer students.

2.2 Test Instruments

In this study, student performance was quantified and compared in in-person and online modalities based on students normalized average score per analytical question and normalized average score per non-analytical question. Raw scores were used where appropriate. The scores were calculated based on 3 midterms and final exam scores per semester. Other assignments including lab scores, discussion board, and homework were not considered due to lack of comparable data from in-person semesters for a fair comparison. Where needed, data were normalized to their own score per question obtained by dividing the total score by the sum of attempts. Any answer choices with zero standard deviation were removed from the study (including questions with zero points, full points, or any other number of points scored by all the students in the entire class).

2.3 Data Collection

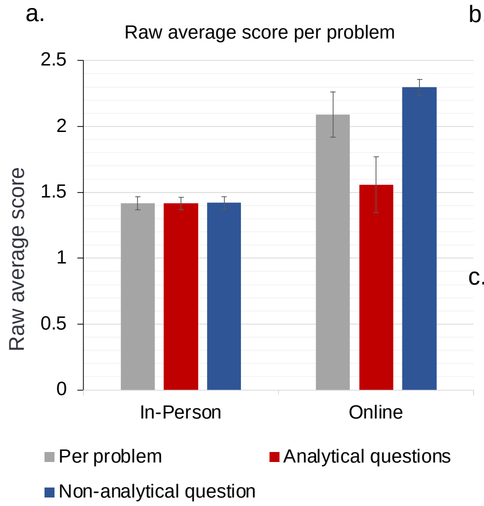
The in-person student grades were obtained from students' past exams. The questions and student responses were manually recorded. Online student performance data was downloaded from Blackboard Learning Management System. The instructor sorted the questions as analytical or non-analytical based on the nature of each question. Any question that can be answered directly by what is written or mentioned in the lecture or can be answered by a web search was categorized as a non-analytical question while questions that involved calculations or need to be deduced by using methods learned in the classroom were categorized as analytical questions. The scores earned for each question were manually entered into Excel sheets. Data obtained were analyzed and processed to calculate specific values. The numbers were normalized and were subsequently used to draw conclusions and validate the hypothesis.

3. Results and Discussion

Summary of the Results: The chi-square analysis of in-person and online question scores showed no significant difference in their distribution (raw scores: [χ^2 (1, N = 24) = 0.06, $p > 0.05$], normalized scores: [χ^2 (1, N = 24) = 0.04, $p > 0.05$]). Comparable distribution of scores confirms the validity of the samples. Unnormalized(raw) scores demonstrated a significantly higher score per problem in online education than that of in-person [$t(22) = 2.07$, $p < 0.05$], Fig.1. A 2-tailed t-test showed no significant difference in average student scores between analytical questions and non-analytical questions in in-person modality [$t(22) = 2.07$, $p = 0.7$], The 2-tailed t-test showed a significant difference in average student scores between analytical questions and non-analytical questions in online modality [t(20) =2.09, $p < 0.001$].In-person students showed an excellent performance correlation between their scores of analytical and non-analytical questions (Pearson Correlation factor = 0.94, R^2=0.87, Sig F = 5.5896E^{-06}). Online students showed a poor performance correlation between their scores of analytical and non-analytical questions (Pearson Correlation factor = 0.56, R^2=0.32, Sig F = 0.06, not significant).Students' final grade distribution of online learning and in-person learning were significantly different($\chi 2$= 29.56, df = 10, p=0.001).(Data not shown)

To assess if the differences are due to difference in students' academic level, the academic level composition of the two modalities were compared. Percent online lower and upper junior, senior and second-degree combined percentage was 83.33% and, that of in-person percentage was 81.44%. The two percentages were not significantly different (Fig. 2, Probability attached to the difference in percentages, z= 0.355, 2-sided P= 0.76). Another factor that may lead to better understand the material is participation in help sessions. Therefore, students' participation in office hours during the two methods of instruction was compared using TTEST and Chi square analysis (Fig. 3). The number of students who participated in-office hours was significantly different in the two modalities ((t(449),p= 1.17* 10^{-10}). However, both modalities encouraged the students to attend office hours in the same pattern resulting no difference in data distribution pattern (χ^2= 11.07, df = 14, p=0.68).

a.



b.

	in-person analytical	in-person non-analytical
Mean	0.99	1.00
Variance	9.02E-04	2.18E-04
Observations	12	12
df	22	
P(T<=t) two-tail	0.73	non-significant
t Critical two-tail	2.07	

c.

	online analytical	online non-analytical
Mean	0.70	1.11
Variance	0.04	4.00E-03
Observations	11	11
df	20	
P(T<=t) two-tail	5.01E-06	significant
t Critical two-tail	2.09	

Fig. 1: Comparisn of in-person and online raw average score per question; a. Online students demonstrated a significantly higher score per problem in online education than that of in-person [t(22) =2.07, $p < 0.05$], b. No significant difference in average student scores between analytical questions and non-analytical questions in in-person modality [t(22) =2.07, p = 0.7], c. 2-tailed t-test showed a significant difference in average student scores between analytical questions and non-analytical questions in online modality [t(20) =2.09, $p < 0.001$].

3.1 Raw scores demonstrate a higher score per problem in online education

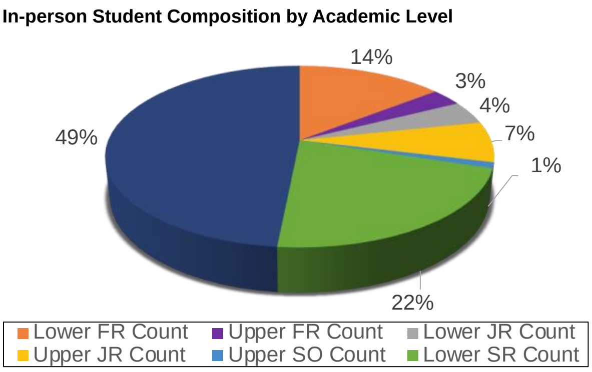
The unnormalized score was calculated by dividing the sum of the scores by the number of questions offered in each class. Students' scores with zero standard deviation within the same class were periodically found in every online semester while no such pattern was observed in in-person student grades signifying the possibility of students' access to the answer choices of such questions either online or via a student group chat. Any questions that resulted in zero points to all the students in the class were considered as "unfair" questions and eliminated from the study. Zero grade per every student for a given problem is statistically unlikely unless, either all the students had access to the wrong answer choice, the instructor's clarification of the material needed to answer such question was not clear enough, or the instructor's expectation was too high for the student's general performance level and therefore the question standard was too high. Correspondently, problems that resulted in full points to the entire class were also eliminated because, such a result is unrealistic unless, either students had access to the correct answer or the instructor's expectation was too low for the performance level of the class. After eliminating questions with zero standard deviation, points earned for every attempt were summarized and summed under the analytical question category and non-analytical question category. The scores were divided by the number of attempts in each category for both in-person and online modalities. The data indicated higher scores in the online modality. Online exams allow students to refer to textbooks, online resources, and any other help while in-person exams were performed in the presence of a proctor with no access to such help. Therefore, higher grades were expected for online classes

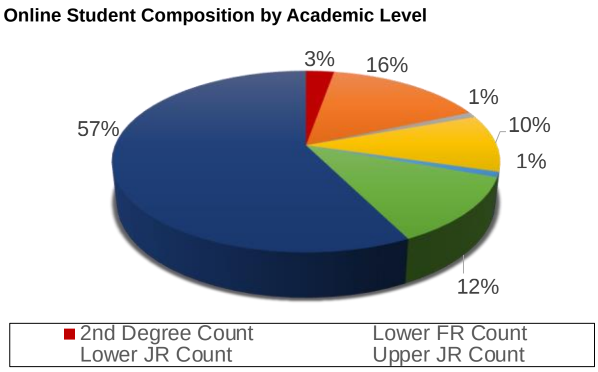
3.2 No significant difference in raw average scores of analytical questions and non-analytical questions in in-person modality, but in the online modality

The independent sample t-test showed no significant difference in raw average scores of analytical questions and non-analytical questions in in-person modality (TTEST, Null hypostasis: There is no significant difference between an average analytical score and the non-analytical score of students in in-person modality ($p = 0.7 > 0.05$), whereas the independent sample t-test showed a significant difference in raw average scores of analytical questions and non-analytical questions in online modality (TTEST, Null hypostasis: There is no significant difference between an average analytical score and the non-analytical score of students in online modality($p = 5.01$ E-6 < 0.05). The Chi square test of the data demonstrated an equal distribution of the two data set. However, the difference of population averages indicates that there is a significantly lower score for analytical questions compared to non-analytical questions within the online group despite the overall higher scores they have. This could be due to numerous reasons such as, they might be less engaged in the course due to Covid-19 related current social and economic condition, less participation in one-to-one interaction with the professor to clarify material, hence insufficient deeper understanding of the material, lack of interest due to absence of communal synergy.

3.3 Student populations participated were at an academically comparable level

Differences in student population in their academic level could lead to significant impact on their performance. Therefore, student populations were carefully analyzed to justify that there is no impartiality due to differences in participants' academic level. (Fig.2) The percentage of advanced students (lower and upper junior, senior and second-degree students) in the study were comparable in online (83.33%) and in-person (81.44%) modalities. The two percentages were not significantly different. (Probability attached to the difference in percentages, $z= 0.355$, 2-sided $P= 0.76$)





% In-person lower and upper junior, senior and second degree combined = 81.44%
% online lower and upper junior, senior and second degree combined = 83.33%

Fig. 2: In-person and online student composition by academic level; both modalities have a comparable percentage of students with the same academic level

3.4 Students participation in office hours was significantly different in the two modalities

Office hours were unquestionably implemented in response to major breakthroughs in higher education. In-class and out-of-class student-faculty interaction is the most important factor in understudy motivation and inclusion. The percentage of students who attend office hours declined drastically due to switching to online platform (Fig. 3). However, virtual office hours at flexible hours were offered through video conferencing platform such as Zoom or Google Hangouts. Low attendance to the office hours reduces the student's opportunity to clarify and ask questions about course content, exchange leaning experiences, prepare for an upcoming assignment, work through additional practice problems, and clarify individual concerns. These factors could contribute to deficit of inquiry, critical thinking, and analytical thinking of students. At the beginning of the semester and near the end of the semester students attended the office hours more frequently in both in-person and online. At the beginning of the semester, many students attend office hours to introduce them to the professor or to discuss about career path questions or other life issues. Students tend to come near the end of the semester when they are getting ready for the exam.

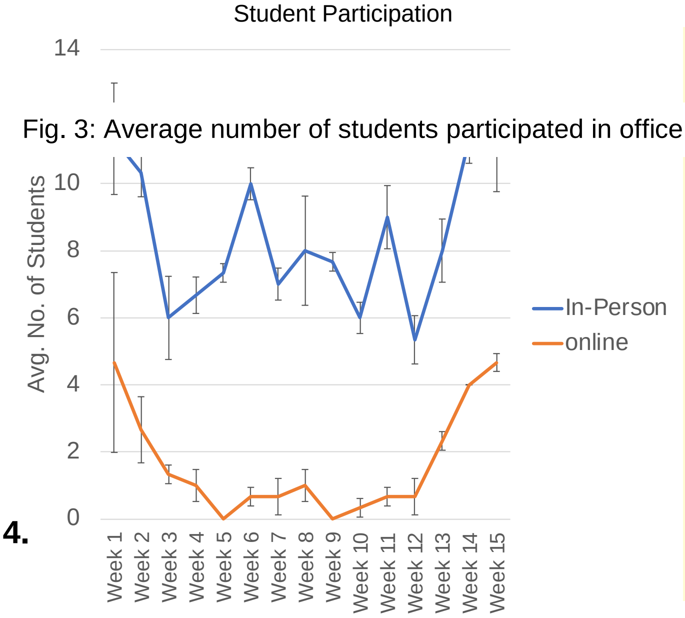


Fig. 3: Average number of students participated in office hours by week

- The pattern of student participation by week was not significantly different (
  tend to attend the office hours more often at the beginning of the semester and near the end of the semester in both modalities

- The number of students participated in office hours is significantly different in the two modalities (t (449) , p= 1.17* 10^{-10}). In-person students attended office hours significantly higher more frequently than the online students

4.

Conclusion and Future Research

The purpose of this research was to understand if student scores to analytical questions are significantly different from that of non-analytical questions and if the difference is due to the change of teaching modality from in-person to online. This study concludes a significant difference between normalized average scores of analytical questions and non-analytical questions in online students, but not within the in-person group. However, there was a significant decline in student participation in office hours that may lead to inability to apply concepts in higher order thinking. The study was done using Biochemistry CHM341 data only and this could preclude the generalization of our results. Subsequent studies should include students enrolled in multiple courses and universities to achieve an accurate representation.

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