EVALUATION OF ONLINE MEDICAL TECHNOLOGIST TRAINING COURSES CONDUCTED DURING THE COVID-19 PANDEMIC IN 2020 COMPARED WITH FACE-TO-FACE LECTURES IN 2019

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ABSTRACT: This study compared students enrolled in face-to-face (F/F) lectures in 2019 to those who received online teaching (O/T) during the COVID-19 pandemic in 2020 in terms of class evaluation questionnaires, regular exams scores, and the national medical technologist qualifying examination. A statistical comparison of survey results and grades was conducted with 389 students (first- to fourth-year students) enrolled in the Department of Clinical Laboratory Medicine at Teikyo University's Faculty of Medical Technology in 2019 who received F/F lectures and 403 first- to fourth-year students enrolled in the same department in 2020 who received O/T entirely. Statistical significance was determined using a *t*-test with $p<0.05$ considered statistically significant. The class evaluation questionnaire results showed that students' self-study time, interest in the subject, and sense of achievement were significantly higher for first-, second-, and third-year students in F/F courses than those who received O/T lectures. However, this trend was reversed for fourth-year students. The fourth-year students scored much higher on the national medical technologist examination than the 2020 class. These results indicate that O/T education encourages students to learn independently, leading to improved performance. Therefore, this study suggests that education quality can be improved by combining O/T education with F/F education.

KEYWORDS: *COVID-19; Face-to-Face Lecture; Medical Technologist; Online Teaching; SDG4: Quality Education.*

1.0 INTRODUCTION

Various factors have been cited as problems in clinical laboratory technician education in four-year colleges and universities, including issues with academic performance during college entrance examinations [1] and maintaining motivation for continued learning after enrollment [2]. The COVID-19 pandemic changed social structures worldwide, and higher education was no exception, with face-to-face (F/F) lectures being replaced by online teaching (O/T). In Japan, O/T was practiced on satellite campuses and universities headquartered abroad before 2020. However, due to the pandemic, almost all F/F lectures were replaced with O/T lectures in April 2020. As of late 2020, 59.6% of universities held all lectures in the O/T format, and 19.9% of universities held 50–80% in the O/T format [3]. Although there have been several reports on the validation of O/T in higher education [4-6], few have specifically addressed the validation of O/T outcomes in medical technologist training. In the future, O/T lectures are expected to play an essential role in this area, as well as in venues such as flipped lectures.

Objectively examining the significance of online lectures is vital in unique situations such as the COVID-19 pandemic. In particular, the need for online medical education will increase as medical knowledge continues to expand. This study aims to investigate the usefulness of O/T and examine its associated problems in medical technologist education. This was done by comparing the results of a questionnaire survey and regular exam scores between first- to fourth-year students who were enrolled in F/F courses in 2019 and in O/T courses in 2020. Furthermore, we compared fourth-year F/F and O/T students' national medical technologist licensing exam scores.

2.0 MATERIALS AND METHODS

2.1 Participants

A total of 105 first-, 105 second-, 106 third-, and 73 fourth-year students were enrolled in the Department of Clinical Laboratory Medicine at Teikyo University School of Medical Technology, Japan, in the academic year 2019. A total of 91 first-year, 109 second-year, 105 third-year, and 98 fourth-year

students were enrolled in the same department in the academic year of 2020. Although the cohorts of first-, second-, and third-year students enrolled in 2019 and second-, third-, and fourth-year students enrolled in 2020 belong to the same group, the numbers do not necessarily match because of retention issues.

All department-affiliated students were surveyed, and their participation was voluntary. The questionnaire response rates were 90.8, 58.4, 89.2, 69.8, 56.7, 52.6, 41.0, and 43.9 %, respectively. Despite being assured that non-participation would not disadvantage them, some students did not participate. The reasons students chose not to participate in the survey were unknown. . Lecture Format

All lectures in FY2019 were given in F/F format, and all lectures in FY2020 were given on demand in O/T format using a learning management system (LMS). Regular examinations were conducted in both years in an F/F format and retained the same characteristics as in previous years in terms of timing and method. Each course was held 15 times over six months. In the F/F courses, each lecture lasted for 90 minutes. In the O/T courses, the lectures were conducted in an on-demand style, through which students viewed PowerPoint files with audio, which took approximately 30 minutes to complete.

2.2 Class Evaluation Questionnaire Survey

At the end of the academic year (March 2022 and March 2021), a survey was administered to students in first- to fourth-year students for class evaluation. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and the Ethical Guidelines for Life Sciences and Medical Research Involving Human Subjects. This study was approved by the Teikyo University Ethical Review Board for Medical and Health Research Involving Human Subjects (Approval No. Tei Rin 23-061). Consideration was given to ensure that the questionnaire responses could not be used to identify individual participants.

Informed consent was not obtained from participants because of the retrospective nature of the study. Although the researcher originally received the questionnaire survey results in a form that did not allow personal identification, the data of those who refused to participate were obtained from the office that conducted the survey. Similarly, the data of those who refused to participate in the study were deleted, and the results were recalculated and used as research data.

The survey items were shown in Table 1.

Table 1. The survey items

Question 1	Time spent preparing for this class in advance (preparation, review of previous classes, etc.). Response options—4: 90 min or more; 3: 30 min or more to less than 90 min; 2: Less than 30 min; 1: Not at all.
Question 2.	Did you read the assigned materials for this class in advance? Response options—4: I read them carefully; 3: I read them; 2: I did not have time to read them; 1: There were no specified materials.
Question 3	Did you achieve the objectives of this class? Response options—5: I achieved all of them; 4: I achieved almost all of them; 3: I achieved about half of them; 2: Not so much; 1: I did not understand the objectives.
Question 4	Did you find the instructor's speaking style clear and easy to listen to? Response options—5: Very clear; 4: Relatively good; 3: Average; 2: Not very good; 1: Poor.
Question 5	Was the instructor's writing style and use of visual aids (e.g., projectors) appropriate? Response options—5: Appropriate; 4: Relatively good; 3: Average; 2: Not very good; 1: Poor.
Question 6	Did you feel that the instructor tried to help you understand the content? Response options—5: Very much; 4: Relatively; 3: Fairly; 2: Not very much; 1: Not at all.
Question 7	Did your knowledge and skills increase after taking this class? Response options—5: Increased; 4: Slightly increased; 3: Cannot say; 2: Did not increase much; 1: Did not increase at all.
Question 8	Was the course designed to allow students to think and discuss among themselves? Response options—5: Agree; 4: Somewhat agree; 3: Neither agree nor disagree; 2: Do not really agree; 1: Do not agree at all.
Question 9	Did the instructors respond appropriately to students' questions and opinions? Response options—5: Agree; 4:

	Somewhat agree; 3: Neither agree nor disagree; 2: Do not really agree; 1: Do not agree at all.
Question 10	Did you find the content of this class interesting? Response options—5: Very interesting; 4: Relatively interesting; 3: Average; 2: Not very interesting; 1: Not interesting.
Question 11	On a scale of 1–5, how would you rate the course? Response options—5: Very good; 4: Somewhat good; 3: Average; 2: Somewhat poor; 1: Poor.

The survey results were presented as averages, with the total score divided by the number of students. The survey results were compared by cross-tabulating the 2019 and 2020 results for the scores on each survey item. Both were tested for significance using the $\chi 2$ test, and the results with $p<0.05$ were considered statistically significant.

The regular exam grades of students enrolled in 2019 and those enrolled in 2020 were compared; the courses for which grades were compared are listed below.

Courses administered in the first year included Basic Medical Theory, Chemistry, Clinical Physiology I, Human Body Structure and Function, Human Communication, Introduction to Medicine, Introduction to Microbiology, and Life Sciences I. The results for the eight subjects were compared. The courses conducted in the second year included Biochemistry, Clinical Laboratory Testing, Clinical Pathology I, Clinical Physiology II, Hematology Informatics, Histocytology, Immunology I, Laboratory Instrumentology, and Microbiology I. The results for the nine subjects were compared. The courses conducted in the third year included Advanced Clinical Examination, Clinical Chemistry II, Clinical Cytology, Clinical Microbiology, Clinical Pathology II, Clinical Physiology III, Genetic Testing, Hematology, Laboratory Management, Medical Electronics, Parasitology, Radiation Science, Special Topics in Pathology, and Team Medicine Exercises. The results for the 14 subjects were compared. The results of the graduation test and nationalexamination by medical technologists were compared for

fourth-year students.

For the above subjects, the total scores in 2019 and 2020 were divided by the number of students to obtain the mean score for each subject, and a *t*-test was used to test for significant differences; $P<0.05$ was considered statistically significant. The SPSS software (IBM SPSS Statistics, ver. 28.0.0.0 IBM Japan, Tokyo, Japan) was used for statistical analysis.

3.0 RESULTS

Table 2 summarizes the results of the class evaluation questionnaires conducted in the 2019 and 2020 academic years which shows the class formats of F/F and O/T, with significantly higher scores. The details of the results can be found in the Appendix section where Figures 1–11 present bar charts that were created based on the cross-table of the results of the class evaluation questionnaires.

In the comparison between F/F and O/T for first-year students, of the 11 questions, only Question 9 (faculty answered students' questions sincerely) was significantly higher in the F/F lecture evaluation. All remaining questions had significantly higher O/T ratings. In the comparison between F/F and O/T for second-year students, five of the 11 questions were rated significantly higher for O/T (Qs 1, 2, 5, 6, and 9), and four were rated significantly higher for F/F (Qs 3, 4, 10, and 11). In a comparison between F/F and O/T for third-year students, no items had significantly higher F/F ratings, and all items had significantly higher O/T ratings, except for Q4 and Q9, where no difference in ratings was found. However, a comparison between F/F and O/T for fourth-year students showed no items with significantly higher O/T ratings or significantly higher F/F ratings for Qs 4, 6, 9, and 11, but no differences in ratings for the other items.

Table 2. Highly rated face-to-face lectures held in 2019 and online teaching held in 2020

A summary of Figures 1–11

	Fiscal Year with Significantly High Evaluations for Each Question Item			
	1st-year student	2nd-year student	3rd-year student	4th-year student
Q1	O/T*	O/T	O/T	=**
Q2	O/T	O/T	O/T	=
Q3	O/T	F/F***	O/T	=
Q4	O/T	F/F	=	F/F
Q5	O/T	O/T	O/T	=
Q6	O/T	O/T	O/T	F/F
Q7	O/T	=	O/T	=
Q8	O/T	=	O/T	=
Q9	F/F	O/T	=	F/F
Q10	O/T	F/F	O/T	=
Q11	O/T	F/F	O/T	F/F

O/T*: The evaluation of remote lectures held in 2020 was significantly higher compared with the evaluation of face-to-face lectures held in 2019 ($P<0.05$).

(=)**: There was no significant difference between the evaluations of remote lectures held in 2020 and the evaluation of face-to-face lectures held in 2019 ($P>0.05$).
F/F***: The evaluation of the face-to-face lectures held in 2019 was significantly higher than the evaluation of the remote lectures held in 2020 ($P<0.05$).

The results of the regular test scores for F/F and O/T students received are listed in Table 3. Students who received O/T had significantly higher scores than those who received F/F lectures in five of the eight first-year courses

(Chemistry, Clinical Physiology I, Human Communication, Introduction to Microbiology, and Life Science I). Furthermore, the scores of students who took the F/F course were significantly higher than those of students who took the O/T course alone. The remaining six courses (Basic Medical Theory, Clinical Physiology I, Human Communication, Introduction to Microbiology, Human Body Structure and Function, and Introduction to Medicine) showed no difference in scores between the two groups, and none of the courses were scored higher by the F/F students. Of the nine courses offered in the second year, six (Biochemistry, Clinical Laboratory Testing, Clinical Pathology I, Clinical Physiology II, Immunology I, and Laboratory Instrumentology) scored significantly higher for students who took O/T courses, and one (Histocytology) scored significantly higher for students who took F/F courses. The remaining two courses (Hematology Informatics and Microbiology I) showed no differences. Five of the 14 third-year courses (Clinical Microbiology, Clinical Pathology II, Genetic Testing, Medical Electronics, and Radiation Science) had significantly higher scores among O/T students, and one course (Special Topics in Pathology) had significantly higher scores among F/F students. In the remaining eight courses (Advanced Clinical Examination, Clinical Chemistry II, Clinical Cytology, Clinical Physiology III, Hematology, and Laboratory Management), although there was no difference between the two groups regarding their scores on the fourth-year graduation examinations, the O/T students performed significantly better on the national medical technologist examination taken after graduation, as shown in Figure 12.

Table 3. Comparison of test scores for each subject in face-to-face lectures (F/F) in 2019 and online teaching (O/T) in 2020

Subject	Course year	F/F (2019)				O/T (2020)				t-test	
		Score (/100 score) except "*"	SD	n		Score (/100 score) except "*"	SD	n		P*	
Basic Medical Theory	1	83.32	12.59	101		83.58	10.21	90		0.876	
Chemistry	1	76.58	17.34	105		92.68	8.41	90		0.010	**
Clinical Physiology I	1	60.15	13.51	105		69.08	12.49	89		0.010	**
Human Body Structure and Function	1	72.14	19.79	102		72.68	17.68	87		0.840	

Human Communication	1	86.68	9.39	103		90.17	5.29	90		0.002	**
Introduction to Medicine	1	71.93	15.63	105		74.66	8.81	90		0.129	
Introduction to Microbiology	1	75.62	18.75	101		91.11	74.76	90		0.046	**
Life Science Ⅰ	1	77.42	10.23	105		83.81	8.50	90		0.010	**
Biochemistry	2	64.00	8.7	101		67.19	10.90	68		0.010	**
Clinical Laboratory Testing	2	67.87	12.51	101		74.21	13.62	68		0.002	**
Clinical Pathology Ⅰ	2	70.34	12.53	102		79.29	10.52	68		0.010	**
Clinical Physiology Ⅱ	2	59.22	11.81	104		65.09	12.47	66		0.002	**
Hematology Informatics	2	69.36	18.44	102		64.53	18.62	68		0.097	
Histocytology	2	71.88	15.75	102		67.16	12.34	67		0.031	***
Immunology Ⅰ	2	64.47	16.61	103		74.84	14.6	67		0.003	**
Laboratory Instrumentology	2	63.34	14.9	103		73.91	8.97	68		0.010	**
Microbiology Ⅰ	2	67.33	21.19	102		60.78	21.76	68		0.052	
Advanced Clinical Examination (/200 score)	3	129.84*	27.72	100		126.08	25.84	100		0.320	
Clinical Chemistry Ⅱ	3	65.78	10.43	104		67.90	10.99	102		0.156	
Clinical Cytology	3	79.39	13.17	104		80.43	11.11	102		0.540	
Clinical Microbiology	3	62.19	19.09	104		77.38	18.76	102		0.010	**
Clinical Pathology Ⅱ	3	70.04	12.66	98		75.22	11.35	98		0.003	**
Clinical Physiology Ⅲ	3	71.70	10.99	98		70.82	11.11	97		0.580	
Genetic Testing	3	71.24	8.96	104		80.55	10.56	102		0.010	**
Hematology	3	65.95	17.28	104		69.51	17.89	102		0.148	
Laboratory Management	3	72.85	9.56	102		75.26	10.69	97		0.090	
Medical Electronics	3	63.88	13.55	104		75.15	13.74	103		0.010	**

Parasitology	3	69.79	16.45	104		67.41	14.66	102		0.275	
Radiation Science	3	76.88	12.22	104		82.65	12.10	103		0.010	**
Special Topics in Pathology	3	85.42	1.39	96		80.29	6.15	104		0.010	***
Team Medicine Exercise	3	61.83	12.97	97		56.62	11.92	99		0.210	
Graduation test (/200 score)	4	125.12*	18.86	73		130.08	19.03	96		0.094	
National examination (/200 score)	4	140.5*	11.69	60		146.02	14.76	90		0.016	**

*:Scores/200, **:Score of O/T (2020) is significantly higher than that in 2019, ***:Score of F/F (2019) is significantly higher than that in 2020.

*:Scores/200, **:Score of O/T (2020) is significantly higher than that in 2019, ***: Score on F/F (2019) was significantly higher than that in 2020.

4.0 DISCUSSION

The COVID-19 pandemic had a significant impact on Japan. It impacted not only economic activities but also the education system, as most F/F classes have been replaced by O/T formats [7,8]. One major difference created by the pandemic, as revealed by the survey results, was that the average amount of time students spent on prior learning during O/T courses was significantly higher than that in F/F courses for students in all years except the fourth. Specifically, in the first year, 2.4% and 1.4% of students spent more than 90 minutes per day, 13.6% and 21.7% spent between 30 and 90 minutes per day, 38.9% and 51.0% spent less than 30 minutes per day, and 44.1% and 26.0% did not study on their own at all in 2019 and 2020, respectively.

Japanese university students tend to have less time to study at home; however, the implementation of O/T forces them to do so. The fourth-year students tended to voluntarily study at home for national examinations, even when enrolled in F/F courses. Prior research has shown that, regardless of the COVID-19 pandemic, 58.4% of students in the United States spend more than 11 hours per week on practical training [9], far more than Japanese students.

Students' final evaluations of lectures at the end of the school year (Q11) tended to be higher in 2020 for first- and third-year students, but in 2019 for second- and fourth-year students (first-year score average 2019 vs. 2020 = 3.73 vs. 4.25, second-year 3.69 vs. 3.90, third-year 3.78 vs. 3.77, fourth-year 3.94 vs. 3.52) (Figure 11). The results also indicated that second-year students, who are about to start their specialized education, need more detailed guidance through F/F education and that fourth-year students, who are about to take the national examination, need more guidance than second-year students receive through O/T, as do second-year students. This is a general tendency among the survey items. Second-year students tended to rate approximately half of the items higher in 2019.

Grades generally tended to be higher for students in 2020; that is, those who had experienced O/T. This phenomenon appears to be influenced by the longer time allocated to independent studies. Although there was no difference in graduation exam scores between the students enrolled in the F/F and O/T courses, the performance of 2020 students

on the national exam was higher than that of 2019 students, suggesting that O/T education is effective when simply focusing on passing the national exam. Incidentally, the national exam pass rates for new graduates were 86.5% in 2019 and 83.1% in 2020 [10], indicating no significant difference in the difficulty of the national exam.

Hospital training is required at medical universities, including medical technologist training universities. In FY2020, hospital training was either conducted in an observation-only format or consisted of O/T-based visual training. Although this study did not examine the impact of O/T on practical training, it was inferred that O/T lectures encouraged students to study independently and contributed to higher grades when focusing only on the national examination scores in 2020. Allowance for hospital training in O/T should be considered in the future [11]. Continuing online medical education, including practice, has the potential to improve the satisfaction, knowledge, and practice of general practitioners [12]. In the future, the quality of clinical technologist training could be improved by combining O/T education, which promotes students' independent study, with F/F [13].

5.0 CONCLUSION

O/T education is useful because it emphasizes student autonomy. Our results indicated that students who engaged in O/T learning scored higher than F/F-educated students in most courses offered on campus and the national exam for clinical laboratory technician certification. However, it is difficult to provide experience-based education through O/T learning. Based on these points, we believe that the quality of student education can be improved by combining O/T education, which encourages independent learning, with F/F education, which is advantageous for practical purposes. While O/T was found to be beneficial for improving student performance, this study did not consider its effects on creativity, independence, or discussion skills. Because one of the goals of undergraduate medical students is to obtain certification, future research should examine whether O/T plays a beneficial role in achieving these goals in higher education.

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Compliance With Ethical Standards

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Research Involving Human Participants and/or Animals: This study was conducted according to the ethical principles of the Declaration of Helsinki and the Ethical Guidelines for Life Sciences and Medical Research Involving Human Subjects. This study was approved by the Teikyo University Ethical Review Board for Medical and Health Research Involving Human Subjects (Approval No. Tei Rin 23-061).

Informed Consent: Informed consent was not obtained from any participants because of the retrospective nature of this study.

Consent to Publish: Not applicable.

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FIGURE LEGEND

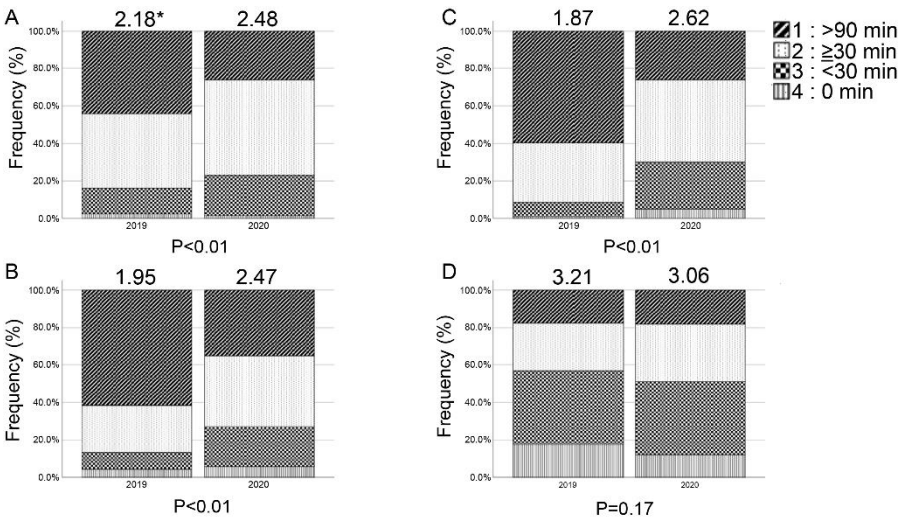

Figure 1: Custer bar graph of self-study time at home for first- through fourth-year students enrolled in 2019 and 2020. The length of self-study time was categorized as 4: *>90 minutes*, 3: *>30 minutes*, *<90 minutes*, 2: *<30 minutes*, and 1: *0 minutes*. Significant differences (p-values) in both years were determined by the $\chi 2$ test of cross-tabulation: A represents first-year, B represents second-year, C represents third-year, and D represents fourth-year students.

* Mean scores are shown.

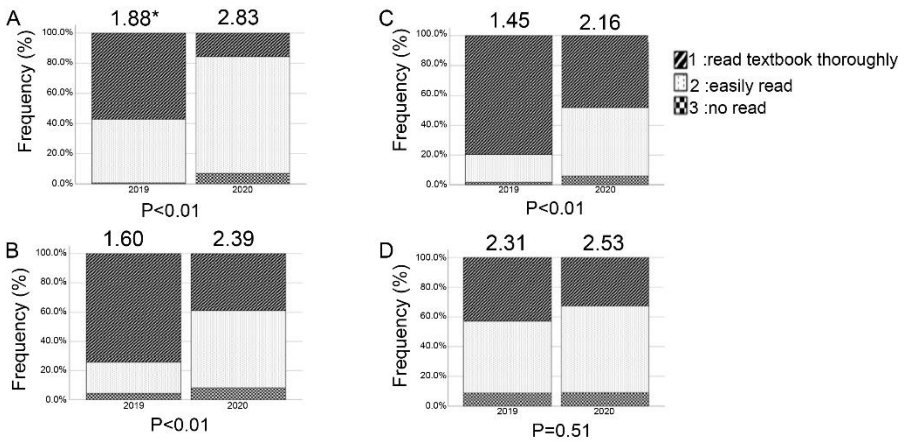

Figure 2: Cluster bar graph of whether students in years one to four enrolled in 2019 and 2020 read the textbook in advance, categorized as 3: *Read carefully*, 2: *Skimmed through*, and 1: *Did not read*. Significant differences (p-values) in both years were determined by the $\chi 2$ test of cross-tabulation: A represents first-year, B represents second-year, C represents third-year, and D represents fourth-year students.

* Mean scores are shown.

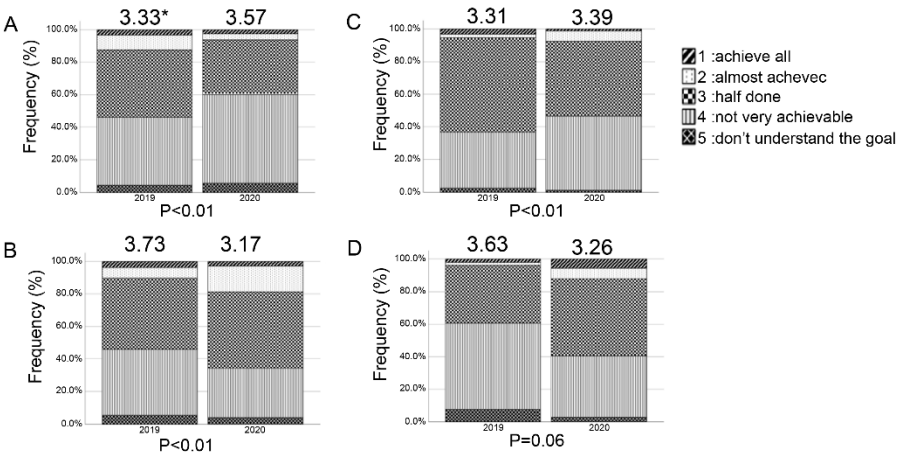

Figure 3: Cluster bar graph of first through fourth-year students enrolled in the 2019 and 2020 academic years asking if they were able to meet the achievement goals of the course, categorized as 5: *I met all goals*, 4: *I met most goals*, 3: *I met about half goals*, 2: *I did not meet many goals*, and 1: *I did not understand the achievement goals*. Significant differences (p-values) between the two years were determined by the $\chi 2$ test of cross-tabulation: A represents first-year, B represents second-year, C represents third-year, and D represents fourth-year students.

* indicates mean score.

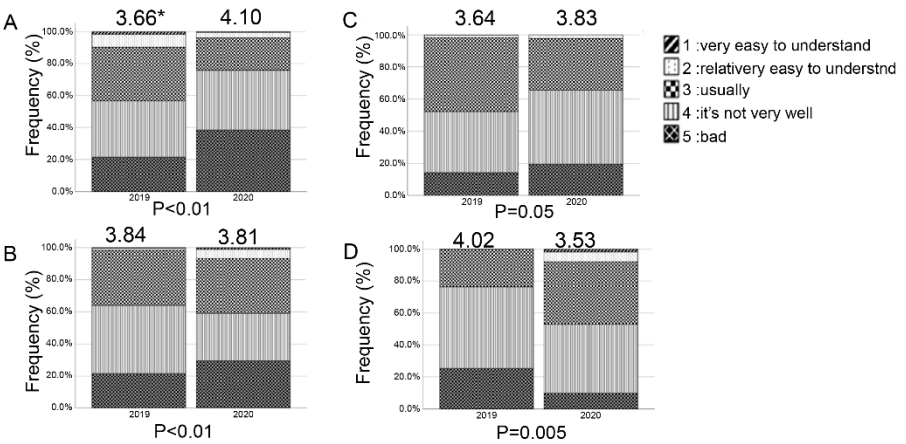

Figure 4: Cluster bar graph of responses to the question of whether the teacher's speech was clear and easy to listen to for first- through fourth-year students enrolled in 2019 and 2020, categorized as 5: *Very clear*, 4: *Relatively good*, 3: *Average*, 2: *Not very good*, 1: *Poor*. Significant differences (p-values) between years were determined by the $\chi 2$ test of cross-tabulation: A represents first-year, B represents second-year, C represents third-year, and D represents fourth-year students.

* Mean scores are shown.

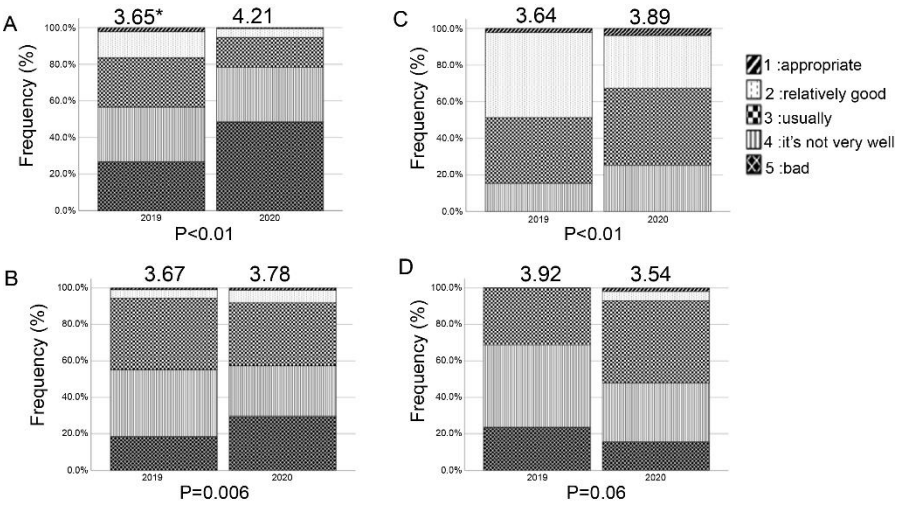

Figure 5: Cluster bar graph of responses to the question of whether the teacher's writing style and use of visual aids (e.g., projector) were appropriate for first- through fourth-year students enrolled in 2019 and 2020, categorized as 5: *Appropriate*, 4: *Relatively good*, 3: *Average*, 2: *Not very good*, 1: *Poor*. Significant differences (p-values) between the two years were determined by the $\chi 2$ test of cross-tabulation.

* indicates mean score.

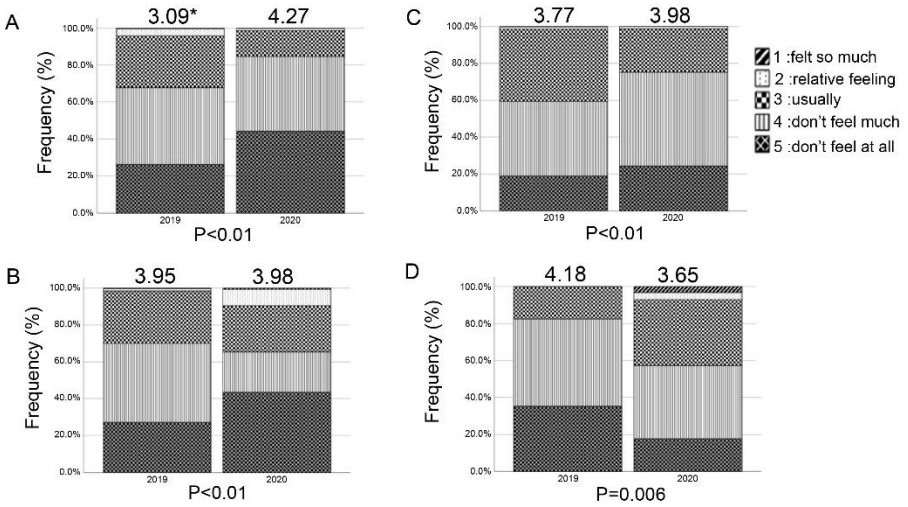

Figure 6: Cluster bar graph of responses to the question of whether teachers made an effort to make students understand the content in first- through fourth-year students enrolled in 2019 and 2020, categorized as 5: *Very much*, 4: *Relatively much*, 3: *Fairly much*, 2: *Not much*, 1: *Not at all*. The cross-tabulation was classified as follows. Significant differences (p-values) between the two years were determined by the $\chi 2$ test of cross-tabulation.

* Mean scores are shown.

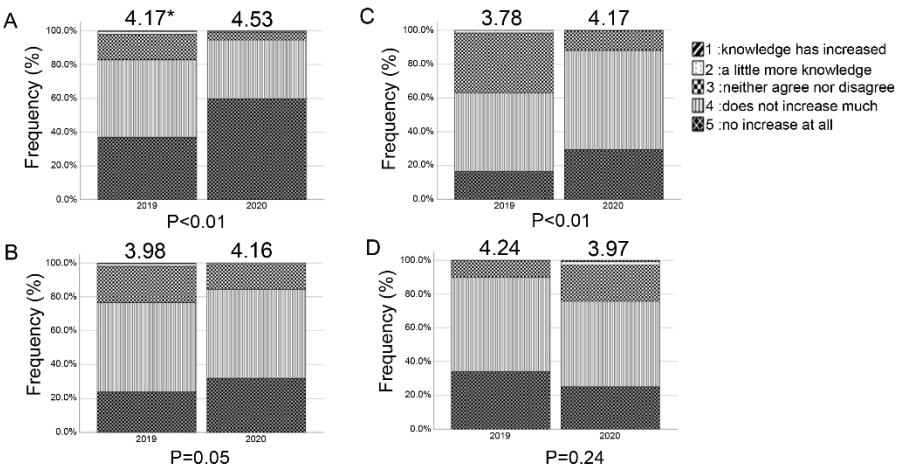

Figure 7: Cluster bar graph of responses to the question of whether knowledge and skills increased before and after taking this class for first- through fourth-year students enrolled in 2019 and 2020, categorized as 5: *Increased*, 4: *Increased somewhat*, 3: *Undecided*, 2: *Did not increase much*, 1: *Did not increase at all*. Significant differences (p-values) between the two years were determined by the $\chi 2$ test of cross-tabulation.

* indicates mean score.

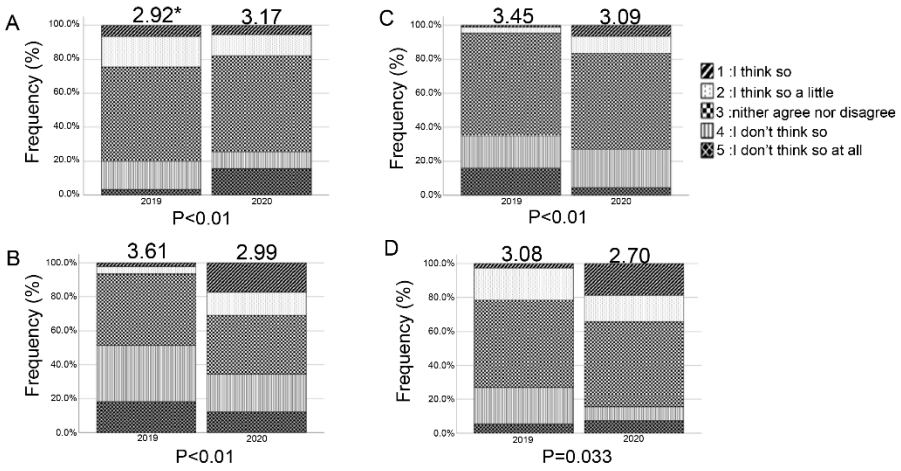

Figure 8: Cluster bar graph of responses to the question of whether students were encouraged to think and discuss issues on their own for first- through fourth-year students enrolled in 2019 and 2020, categorized as 5: *Agree*, 4: *Somewhat agree*, 3: *Undecided*, 2: *Do not really agree*, 1: *Do not at all agree*. Significant differences (p-values) between the two years were determined by the $\chi 2$ test of cross-tabulation.

* Mean scores are shown.

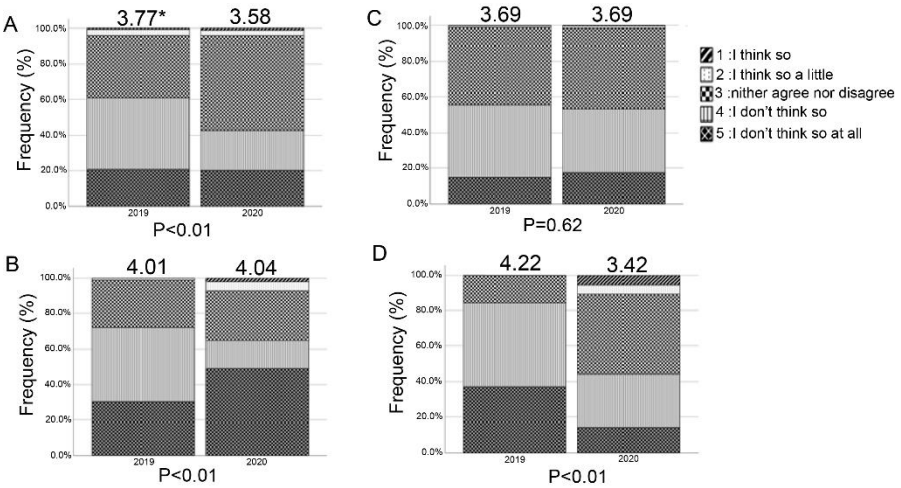

Figure 9: Cluster bar graph of responses to the question of whether faculty members responded appropriately to students' questions and opinions for first- through fourth-year students enrolled in 2019 and 2020, categorized as 5: *Agree*, 4: *Somewhat agree*, 3: *Neither agree nor disagree*, 2: *Do not agree*, 1: *Do not agree at all*. Significant differences (p-values) between the two years were determined by the $\chi 2$ test of cross-tabulation.

* indicates mean score.

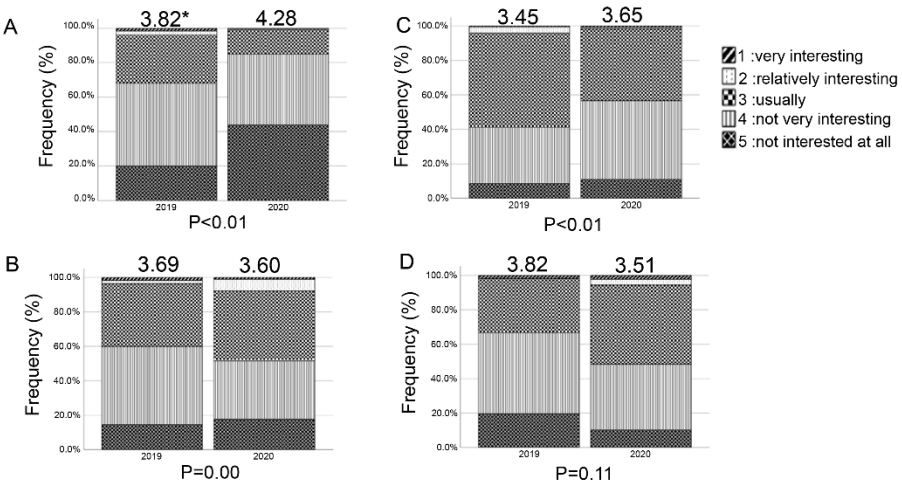

Figure 10: Cluster bar graph of responses to the question of whether first- through fourth-year students enrolled in 2019 and 2020 found the content of this course interesting, categorized as 5: *Very interesting*, 4: *Relatively interesting*, 3: *Normal*, 2: *Not very interesting*, or 1: *Not interesting*. The cross-tabulation $\chi 2$ test was performed. Significant differences (p-values) between years were determined by the $\chi 2$ test of cross-tabulation.

* Mean scores are shown.

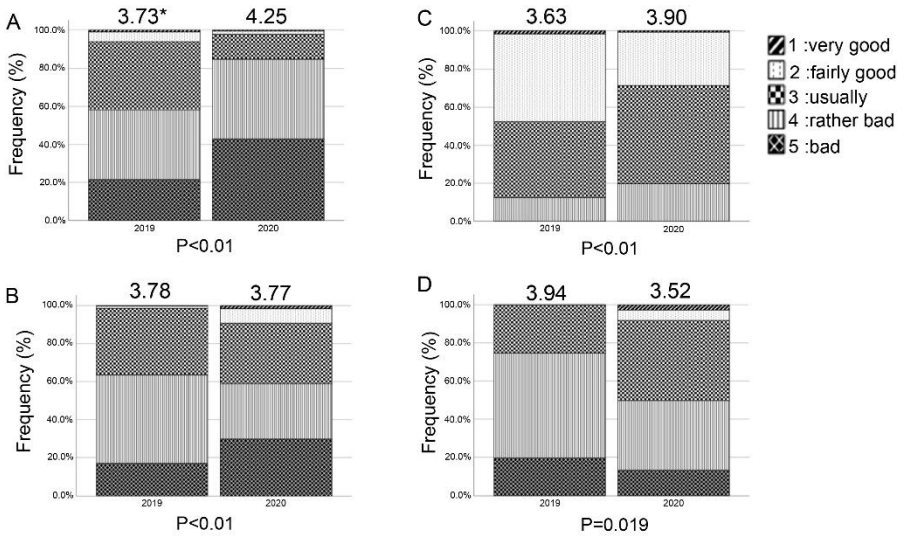

Figure 11: Cluster bar graph of responses to overall lecture evaluations for first- through fourth-year students enrolled in 2019 and 2020, categorized as 5: *Very good*, 4: *Somewhat good*, 3: *Average*, 2: *Somewhat poor*, 1: *Poor*. Significant differences (p-values) between the two years were determined by $\chi 2$ test of cross-tabulation: A represents first-year, B represents second-year, C represents third-year, and D represents fourth-year students.

* Mean scores are shown.

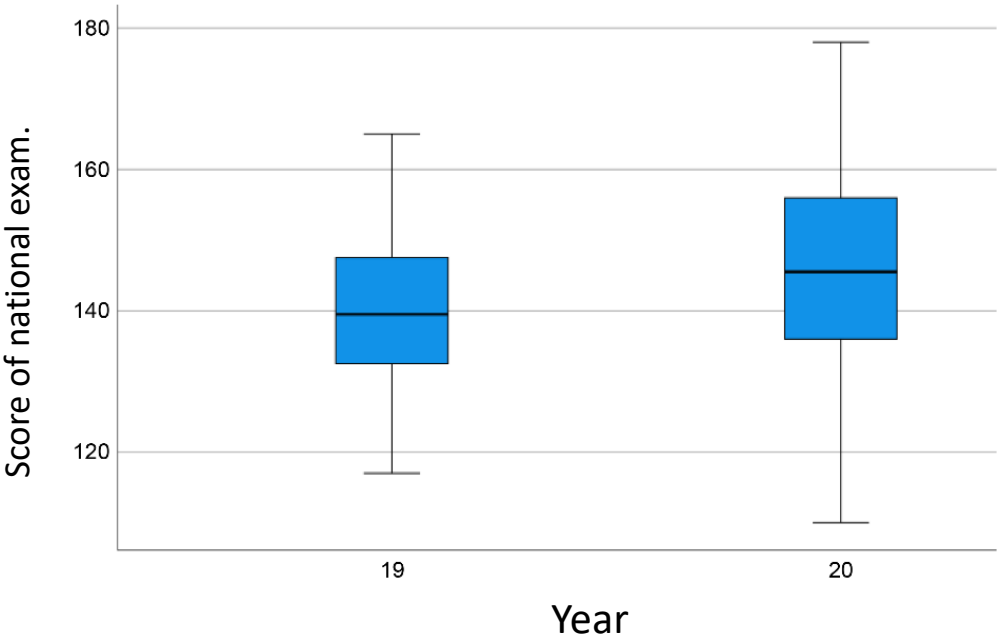

Figure 12: National Clinical Laboratory Technician National Examination scores in 2019 and 2020; the score for 2019 was 140.50 and for 2020 was 146.02 (out of 200), with the score for 2020 being significantly higher (P = 0.01).