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| Research Article

Behavioral assessment of soft skill development in a highly structured pre-health biology course for undergraduates

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ABSTRACT   In this study, we assessed a highly structured, yearlong, case-based course designed for undergraduate pre-health students. We incorporated both content learning assessments and developed a novel method called Multiple Mini Exams for assessing course impact on the development of skills that professional schools often seek in pre-health students, focusing on students' abilities to collaborate with others, display bedside manners, synthesize patient case details, appropriately use scientific and medical language, and effectively attain patients' medical histories. This novel method utilized a rubric based on desired medical student skills to score videotaped behaviors and interactions of students role playing as doctors in a hypothetical patient case study scenario. Overall, our findings demonstrate that a highly structured course, incorporating weekly student performance and presentation of patient cases encompassing history taking, diagnosis, and treatment, can result in content learning, as well as improve desired skills specific for success in medical fields.

KEYWORDS   pre-health undergraduate education, active learning, soft-skill assessment, biology education, patient simulations, collaborative learning, videotaped simulations, pre-health skill development, critical thinking analysis, behavioral analysis, scientific literacy, case-based education, group work, design-based research, Multiple Mini Exams (MME)

The goal of this study was to assess the N120 keystone course series for the Human Biology Major at the University of California, Irvine (UCI). This major is designed for undergraduate premedical students, and its course series aims to synthesize knowledge from lower-division biology courses by relating them to infectious, noninfectious, and diseases of the nervous system. It was also designed to foster behavioral attributes and patient care approaches that are associated with successful clinicians. Given the large variety of skills and academic competence that are expected of medical students, it is hypothesized that incorporating active learning into undergraduate curricula is an effective method for preparing pre-health students to meet these expectations.

A variety of techniques have been implemented in active learning. McCoy et al. conducted a study that examined 25 different techniques for active learning on first-year medical students, in which the three most common were discussion/debate, case-based instruction, and audience response (1). These methods simulate real-life applications of the material, analysis, and interpretation of clinical scenarios, which promote effective use of soft skills like problem solving, teamwork, and communication. In addition, active learning has gained traction among educators because it improves overall participation, interactivity, sense of community, engagement, learning, flexibility, and satisfaction (2). For example, in a college-level microbiology course, the incorporation of specific active learning activities—such as collaborative group presentations, group and class discussions, and worksheets on case studies, and more—generated higher rates of students passing this intensive course (3). Active learning has also consistently

demonstrated an enhancement in content learning and recall, which can be assessed using traditional measures, such as exams (4).

However, while content learning is objectively easy to measure with exam assessments, it is more difficult to assess the behavioral development of interpersonal and communication skills, scientific literacy, and synthesis of complex knowledge, all of which are vital qualities in medical education. In a systematic review by Steiner-Hofbauer et al., six main attributes of a good physician were identified to be general interpersonal qualities; communication and patient involvement; medical competence; ethics; medical management; and teaching, research, and continuous education (5). Indeed, beyond grades and Medical College Admission Test scores, one of the major selection factors detailed by the Association of American Medical Colleges (AAMC) is personal qualities, which notably include interpersonal skills and integrity (6).

Thus, evaluating the development of these attributes requires a unique approach: using "design-based research" (7) to tackle this lack of behavioral analysis methods in undergraduate pre-health education, this study bridges this gap with the creation, implementation, and evaluation of a novel technique dubbed "Multiple Mini Exams" or "MME." This technique is a scored behavioral analysis of videotaped patient simulations that provide a measure of the characteristics and skills that the AAMC has emphasized medical students should hone, such as collaboration and the "ability to reason deductively in solving clinical problems" (8). MME is a group activity that was inspired by the popular Multiple Mini-Interview (MMI) format (9) that is often used during the interview process by admission committees at professional schools. In this process, student candidates may be presented with various hypothetical cases involving patients to observe how each individual would respond to the given scenarios. Previous surveys regarding the MMI format demonstrated that both interviewers and interviewees may view it as a more comprehensive means to evaluate one's hard and soft skills compared to how interviews are traditionally conducted (10). Additionally, in the classroom, students have demonstrated greater memory of course material, critical thinking skills, and compassion toward patients when case studies are depicted "as a story about the patient [with] information regarding their family circumstances, personal characteristics, appropriate ethnic information and individual motivations" as opposed to purely clinical facts (11). Thus, our version of the MME evolved from the MMI and incorporates these aspects of a "personal narrative" (11) through the use of patient simulations. Consequently, our MME activity is designed to serve as a new tool that evaluates the development of students' soft skills as they are presented with hypothetical case studies over time. Given that assessing clinical skills through recordings has been shown to be reliable (12), the MMEs in this present study were also recorded, allowing us to measure the following attributes in our pre-health students: patient history taking, bedside manners, appropriate use of scientific and medical language, synthesis of case content, group communication, and collaboration. Overall, there were significant gains for the latter three categories. Additionally, this study demonstrated that active, case-based learning in the curriculum resulted in increased learning outcomes within all three academic quarters, illustrating student success in content mastery within a highly structured learning environment. Student sentiment surveys that were also administered during this study demonstrate that such outcomes were reached in a manner that students found subjectively enjoyable.

METHODS

Keystone series

The Human Biology Major at the University of California, Irvine, involves a yearlong upper-level course series designed to prepare pre-health undergraduate students for professional schools, such as medical, dental, and physician assistant programs. All Human Biology students are expected to complete N120A, N120B, and N120C sequentially in the Fall, Winter, and Spring Quarters, respectively, in the third or fourth year of their undergraduate education. Each yearly cohort consists of approximately 100–120

students, who are randomly divided into eight groups per course section that rotate each academic quarter. Traditional lectures provide the scientific background necessary for professional health education, while the hybrid classroom format, detailed below, helps students uniquely improve on other critical professional attributes.

This study focuses on the Human Biology cohort of the 2021–2022 academic year, where courses in the Fall and Spring Quarters were conducted in person and the Winter Quarter was a mixture of in person and online. Classes took place within the Anteater Learning Pavilion at UCI, an instructional building that is designed specifically for modern active learning. In this course, students would sit at a table with their assigned group members, making it easy for them to participate in group activities and discussions. Additionally, there is a monitor attached to each table that is synchronized to a large central screen at the front of the classroom. Any student could have anonymously opted out of the study to a third party, as stated in an information sheet provided to students on the course's Canvas website, and this would not have been revealed to the instructor until the course was completed. However, all students chose to participate.

Previous research has demonstrated that biology courses, which implement a highly structured curriculum embedded with active learning activities, fare better in student success rates compared to those that use traditional, low-level styles of instruction (13). Therefore, the hybrid classroom format of the N120 series is based on a highly structured learning environment, where traditional lectures are supplemented by weekly group activities, student presentations, peer reviews of presentations, and writing assignments (Fig. 1). Lectures in the Fall and Spring Quarters were in person, while in the Winter Quarter, a subset of lectures were hybrid, synchronous, and recorded due to temporary coronavirus disease 2019 restrictions. Group activities were performed on a weekly basis and included readings and/or data interpretation. Additionally, many activities were gamified to encourage participation and elaborate on lecture topics (such as cholera and antibiotic resistance) in a fun, collaborative manner (14, 15). A day of student presentations followed the group activities and centered around the specific topic for the week (e.g., cardiovascular disease, pulmonary disease, vector-borne diseases, etc.). Subsequently, the students were assigned a collaborative writing assignment based on the presentation of the week (see "Part B" in File S1). Student presentations during temporary isolations in the Winter Quarter were all synchronous and proceeded as would a live presentation.

Each group presented twice per academic quarter, with differing roles each turn. Students were assigned roles to play [e.g., physicians, patients, Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), or scientific experts at a conference panel for a hypothetical outbreak, etc.] and were provided a detailed presentation rubric (see File S1) to adequately prepare for their roles. The overarching topics for the group presentations were chosen for the students, but the students' case study was based on the specific subtopic of their choice. Students who served as audience members filled out peer review surveys after each presentation, contributing constructive criticism and rating each group's performance (see "Part B" in File S1).

High-Structured Learning Environment

Lecture → Group Activity → Student Presentations & Peer Review Surveys → Writing Assignment
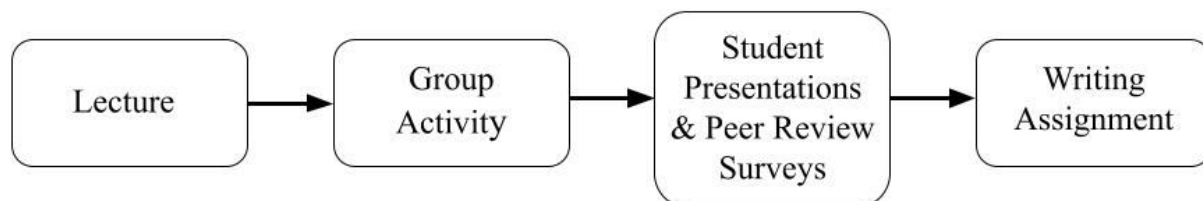
FIG 1 Graphical representation of N120 series course structure. The keystone series consisted of weekly lectures, where the main topics of each were reinforced with a group activity, student presentation, and comprehensive writing assignment.

Observers then completed rubric-based collaborative writing assignments that followed presentations, utilizing the content that was showcased by presenters within the context of specific epidemiology and demographic factors. Essays, midterms, and final exams were given in both group-based and individual formats. Individual exams were multiple-choice content questions focused on content knowledge, and group exams were long, case-based essay questions focused on critical thinking about hypothetical cases. All content from lectures and presentations were potential topics that could be found in either individual or group exams.

Assessment of soft skill development: Multiple Mini Exams (MMEs)

In this study, we evaluated multiple components within the Human Biology courses and their overall impact on the students. To evaluate the proficiency and progress of students, case studies, such as MME and content assessments, were implemented. The MME examined the development of the students' hard and soft skill sets, whereas the pre- and post-quizzes evaluated their learning gains within the highly structured course environment.

Due to the complex range of skills expected of medical students and the difficult nature of evaluating these skills, this study developed the case-based MME to gauge how well students build these qualities given the highly structured learning environment of the N120 series. The MME involves hypothetical patient interactions where students role-play as physicians to gather information and form a possible diagnosis for the presented patient. This activity was conducted in the Fall and Spring Quarters to assess whether there was an improvement overall in the following skills: patient history taking, bedside manners, appropriate use of scientific language, synthesis of case content, group communication, and collaboration (see File S2). On the first day of instruction, students were randomly assigned to one of eight medical case studies that were created based on the course material to be covered in that respective quarter. Each group was video recorded during their MME session, and each recording was subsequently scored by two reviewers, who used a behavioral scoring rubric. This scoring rubric was created in collaboration with the course instructor, ensuring that it aligned with learning objectives of the course, as well as the aforementioned skills. An "all-or-nothing" format was used with the rubric, where points were given only for criteria within an overarching category. For instance, "Bedside Manners" is considered an overarching category, and a specific criterion within this overarching category was "The group was polite and professional toward the patient throughout the entire session" (see File S2). A point was given if the scorer determined that the group overall displayed the desired behavior or action outlined in this specific criterion. If not, then no point was given—hence "all or nothing" since no partial credit was given. Next, overall points were calculated for each overarching category. MME scores were then compared between the Fall and Spring Quarters to assess the students' growth in the required skills.

Assessment of learning gains: pre- and post-quizzes

Content learning was measured using pre- and post-quizzes that were created using the learning objectives of each course topic. Pre-quizzes consisted of a set of seven to eight multiple-choice questions, where each student was randomly assigned five questions out of the set. These quizzes focused on lower-level Bloom's taxonomy and assessed the students' preliminary knowledge about a disease before the course content was taught. Therefore, these quizzes were administered online via Canvas during the first 10 min of class each week and proctored. Post-quizzes were administered on paper, timed, and also proctored in the classroom. Students were not allowed to use the internet or notes for either pre- or post- quizzes.

Post-quizzes consisted of multiple-choice questions from each course topic taught in that particular quarter and were administered at the end of each quarter. These questions required the synthesis of information about multiple disorders. Students were not explicitly informed about the post-quiz topics and thus had to rely on their

course experience without intentional test preparation. A total of eight pre-quizzes were administered per academic quarter, followed by one cumulative post-quiz at the end of each quarter. Class averages from pre-quizzes were then compared to averages from post-quizzes to gauge content learning gains at the end of each quarter.

Statistical analysis

To assess skill development in students, MME scores attained from the Fall and Spring Quarters were analyzed using a mixed-effect linear regression analysis with interactions for student and group assignments. To gauge content learning, an overall average score for the pre-quizzes was calculated using the means from all eight content quizzes within a quarter. This overall average was then compared to the average post-quiz score of the respective quarter, which was cumulative in content. Unpaired t-tests were used to compare the pre- and post-quiz averages due to the fact that all students completed the post-quiz, but not all completed every pre-quiz as intended throughout the quarter. To further analyze the level of content learning, Cohen's D and Hake's G were calculated with pre- and post-quiz averages to measure effect sizes and normalized gains, respectively. Unpaired t-tests were also used to compare changes in student sentiments towards group work.

Student Likert survey

Students completed a 34-question Likert survey and were granted extra credit for the completion of the survey. They were gauged on a scale from 1 to 6, asking if they liked the Human Biology Major, how working in groups affected their growth as students, and if the structure of the course series better prepared them for their prospective healthcare field. Since the survey responses were listed as options of 1–6, if students chose 1–2, this was interpreted as "strongly disagree" and "disagree," respectively; 3–4 was interpreted as "neutral"; and 5–6 was interpreted as "agree" and "strongly agree," respectively. An initial survey was given at the beginning of the Fall Quarter to gauge their experiences before joining the Human Biology Major, and a post-survey was given at the end of each quarter to gauge students' experiences and sentiments of the N120 courses and major. Student responses were anonymous to the instructor and the teaching assistants in charge of giving student grades. The instructor was given a list of participants but was not provided with their individual responses. Students were made aware that their responses would be linked to their identity but only for the purpose of giving credit for participating.

RESULTS

MMEs

Overall, as seen in Table 1, MME scoring revealed significant improvement in the Use of Scientific and Medical Language, Case Synthesis and Diagnoses, and Group Interaction between the Fall and Spring quarters ($P < 0.001$), where all criteria under each category saw an increase in the average number of groups who effectively displayed the given behavior (see File S2). However, there was no statistical difference in the students' performance for Obtaining Background ($P = 0.377$) or Bedside Manners ($P = 0.757$).

TABLE 1 Results of mixed linear regression analysis of each MME rubric category[a]

	Coefficient	P-value	Standard error	Wald chi^2
Obtaining Background	−0.328	0.377	0.371	0.78
Bedside Manners	−0.0517	0.757	0.167	0.10
Use of Scientific and Medical Language	0.724	<0.001	0.191	14.34
Case Synthesis and Diagnosis	2.23	<0.001	0.263	71.99
Group Interaction	1.96	<0.001	0.291	45.21

[a]The students improved their performance in the categories of "Use of Scientific Medical Language," "Case Synthesis and Diagnosis," and "Group Interaction" (P-values < 0.001), whereas no improvement was demonstrated for "Bedside Manners" and "Obtaining Background."

Pre- and post-quiz assessments

When examining content learning gains from pre- and post-quizzes, the data indicated improvements in learning gains within each academic quarter (Table 2). The percentage differences in average scores between the initial and final learning assessments in the Fall, Winter, and Spring Quarters showed increases of 17.4%, 14.1%, and 27.1%, respectively. Unpaired *t*-tests revealed *P*-values less than 0.0001 for these percent differences in all three quarters, confirming the statistical significance of the observed differences. Effect size measures were also calculated to quantify the magnitude of the observed changes: Cohen's *D* values were determined to be 1.60 for Fall, 1.38 for Winter, and 2.32 for Spring. With Sullivan and Feinn's description, these values indicate large effect sizes in the comparison between pre- and post-quizzes since the Fall Quarter's average post-quiz score is above the 93rd percentile of the Fall pre-quiz scores, the Winter Quarter's average post-quiz score is above the 83rd percentile of the Winter pre-quiz scores, and the Spring Quarter's average post-quiz score is above the 97th percentile of the Spring pre-quiz scores (16). Similarly, Hake's *G* values were 0.302 for Fall, 0.254 for Winter, and 0.414 for Spring, which further support the substantial learning gains achieved in each quarter as each value is considered a "medium g," which is expected for an interactive course like the N120 series (17).

Student Likert surveys

At the end of the Spring Quarter, 74% of the cohort responded to an end-of-the-year survey. From this survey, 94.3% of the respondents agreed that Human Biology was interesting to learn, where 21.3% "agreed" to this sentiment and 73% "strongly agreed" (Fig. 2); 95.5% agreed that they enjoyed learning Human Biology because it was applicable to their lives, where 23.6% "agreed" and 71.9% "strongly agreed" (Fig. 3); 79.7% agreed that performing well in the course would help them attain a good career or job, where 39.3% "agreed" and 40.4% "strongly agreed" (Fig. 4); and 88.7% agreed that they can apply the problem-solving skills they have learned in this course to their life, where 39.3% "agreed" and 49.4% "strongly agreed" (Fig. 5).

Additionally, the cohort expressed a positive shift in sentiments regarding participating in group work after having gone through the N120 series. Specifically, compared to the pre-survey taken at the start of the Fall Quarter, the average proportion of students who "agreed" or "strongly agreed" grew on average from all post-quarter surveys for each of the following statements: (i) "Working in groups enhanced my learning experiences in the course" (*P* < 0.0001, Fig. 6) and (ii) "When I work in a group, I believe I do better in a course compared to if I were to work alone (i.e., I perform better on exams, assignments, etc.)" (*P* < 0.0001, Fig. 7). A shift was also seen for sentiments regarding students' self-perceived roles within their groups, where more students on average disagreed that they assume the role of a follower (*P* < 0.0001, Fig. 8) and agreed that they tend to assume the role of a leader over the course of the academic year (*P* < 0.0001, Fig. 9).

DISCUSSION

MME analysis results in the context of the course

As aforementioned, the Human Biology N120 course series is organized in a highly structured learning format, where there is a new course topic introduced each week,

TABLE 2 Results from pre- and post-quizzes for Fall, Winter, and Spring Quarters

		Fall	Winter	Spring
Average score (%) + SD	Pre-quiz	42.6 (13.5)	44.1 (6.62)	34.5 (6.86)
	Post-quiz	60.0 (10.8)	58.2 (12.9)	61.6 (15)
Hake's *G*		0.302	0.254	0.414
Cohen's *D*		1.60	1.38	2.32

I think learning human biology is interesting.
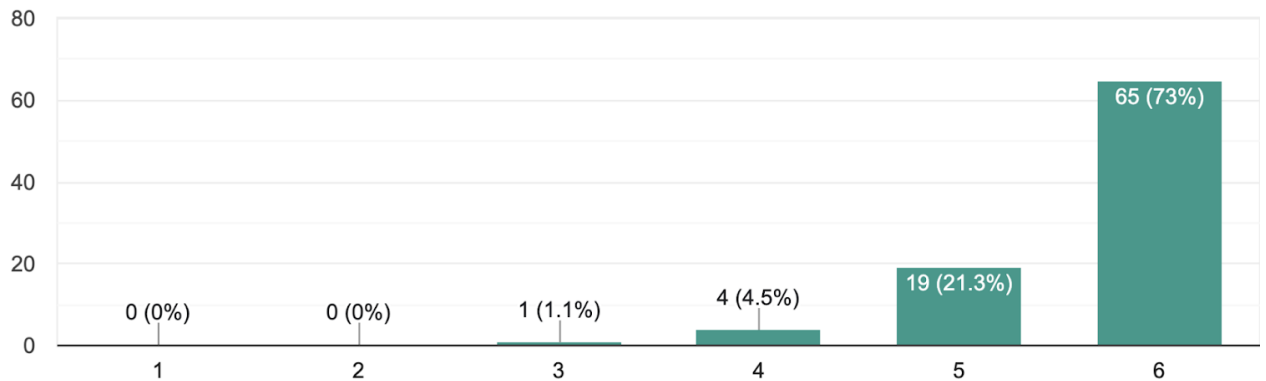
89 responses

FIG 2 Student sentiments regarding the Human Biology content. For this question on the Likert survey, students were asked to rate on a scale of 1–6 how much they agreed with the following statement: I think learning Human Biology is interesting. Of the respondents, 21.3% "agreed" to this sentiment, and 73% "strongly agreed," while 5.6% felt neutral.

followed by a corresponding group activity, a group case-study presentation, and a writing assignment. Evaluation of student growth with the MME activity demonstrated that overall students improved in the following three major skill categories:

First, students had significant growth in "Use of Scientific and Medical Language," which is likely due to the extensive nature in which students encounter such language throughout the course. Lectures serve as a primary avenue for introducing scientific terminology, ensuring that students are familiarized with the language essential to understanding complex medical concepts. Students then have opportunities to apply

I enjoy learning human biology because it is applicable to my life.
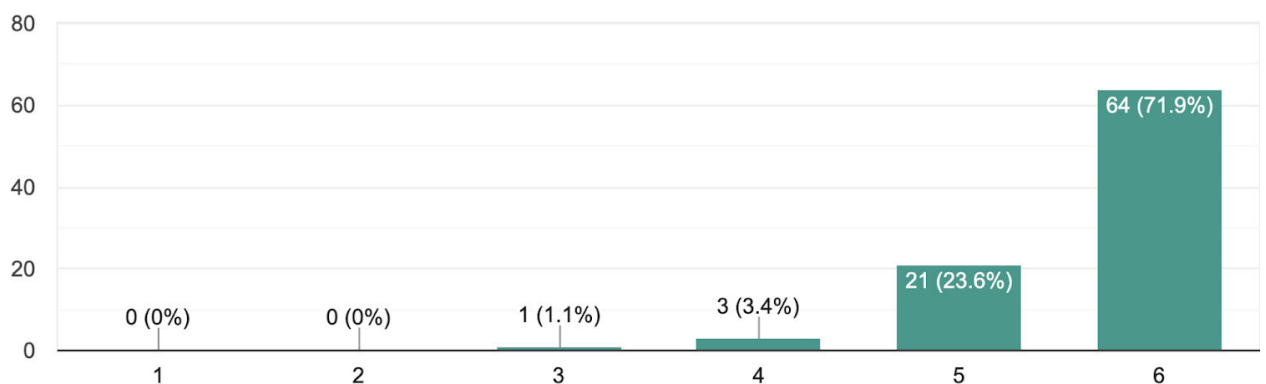
89 responses

FIG 3 Student sentiments regarding applicability of N120's Human Biology content. For this question in the Likert survey, students were asked to rate on a scale of 1–6 how much they agree with the following statement: I enjoy learning Human Biology because it is applicable to my life. Of the respondents, 4.5% were neutral toward the statement, while 23.6% of the respondents "agreed," and 71.9% "strongly agreed."

Doing well in this class will help me get a good job or career.
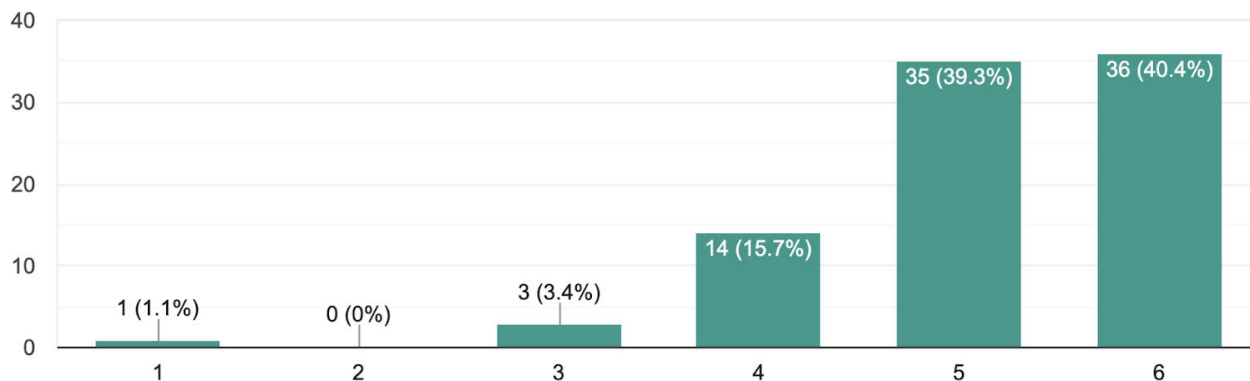89 responses

FIG 4 Student sentiments regarding correlation between individual performance and attaining a career. For this question on the Likert survey, students were asked to rate on a scale of 1–6 how much they agree with the following statement: Doing well in this class will help me get a good job or career. Of the respondents, 1.1% "strongly disagreed" with the statement, while 19.1% were neutral, 39.3% "agreed," and 40.4% "strongly agreed."

this newfound knowledge in various group activities, such as presentations. While only two student groups are assigned to present on each given topic, all groups that acted as the audience were encouraged to remain attentive. The audience is responsible for both peer reviews, providing constructive feedback on the case-study presentations and for subsequent writing assignments that demonstrate their comprehension of the epidemiology and demographic factors portrayed in a given presentation—which requires an understanding of how to correctly use the scientific terminology they previously learned. Moreover, students may be tested on material covered within

I can apply problem-solving skills that I've learned in this course to my life.
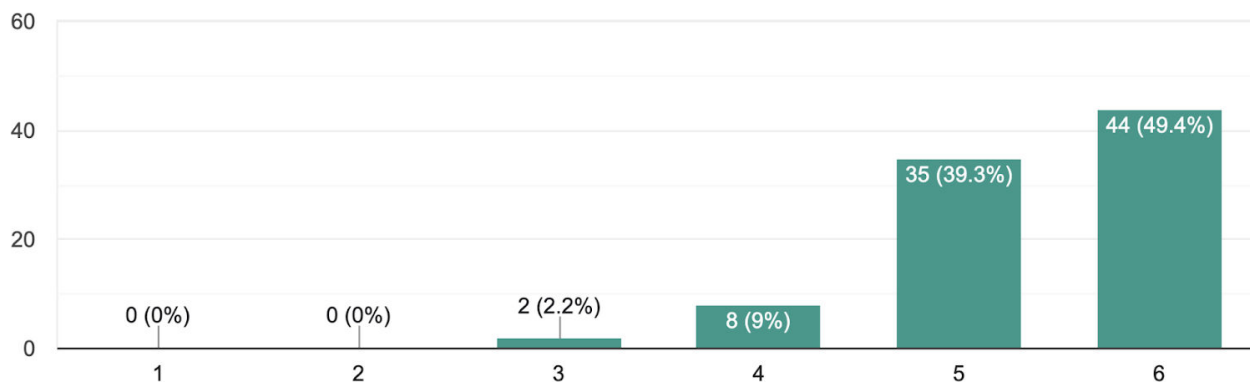89 responses

FIG 5 Student sentiments regarding applicability of problem-solving skills developed during the N120 series. For this question on the Likert survey, students were asked to rate on a scale of 1–6 how much they agreed with the following statement: I can apply problem-solving skills that I've learned in this course to my life. Of the respondents, 11.2% were neutral toward the statement, while 39.3% of the respondents "agreed" with the statement, and 49.4% "strongly agreed."

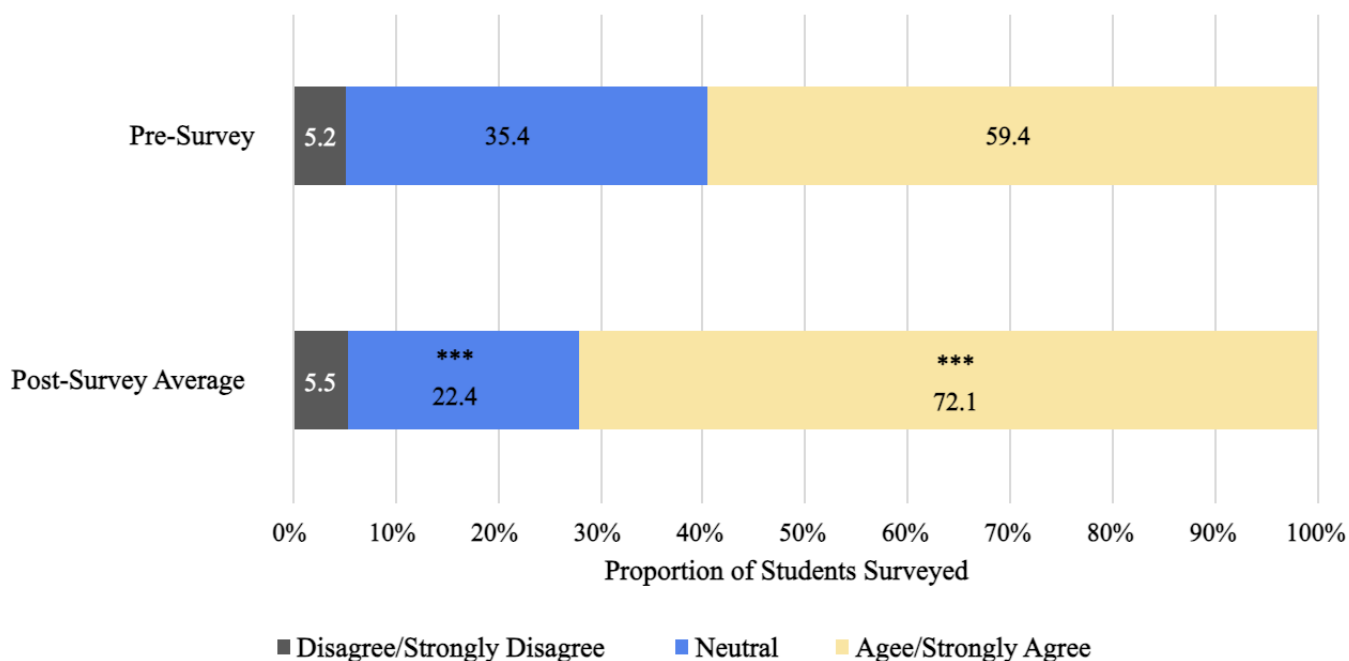## Working in groups enhanced my learning experiences in this course

FIG 6 More students felt that their learning experiences were enhanced by group work following completion of the course series. The "Pre-Survey" bar displays the proportion of respondents from the Fall pre-survey who selected each given category, and the "Post-Survey Average" bar represents the average proportion of respondents from all post-surveys who selected each category. Significantly less students on average were "neutral" toward this statement after participating in the N120 series ($P < 0.0001$), while significantly more students on average "agreed" or "strongly agreed" ($P < 0.0001$). No significant changes were observed in the proportion of students who "disagreed" or "strongly disagreed" ($P = 0.207$). ***$P < 0.001$

case-study presentations. Thus, the continual practice of utilizing lecture content and its consistent exposure through different mediums (i.e., written assignments, role-playing activities, traditional lectures, etc.) help students become accustomed to the appropriate use of scientific and medical language.

Second, students showed significant gains in "Case Synthesis and Diagnosis," possibly due to students' weekly exposure to new case studies. During the Fall Quarter of the academic year, students engaged in interactive sessions where they were fielded questions from the instructor that aimed at promoting their critical thinking on disease mechanisms, medical testing procedures, and treatment modalities. Building upon this skill, in the second quarter, the students assumed the roles of journalists investigating a disease outbreak, tasked with formulating and presenting their own inquiries to another group of students who assumed various roles as a panel (e.g., physicians, CDC representatives, patients, or other scientific experts). During this simulated conference panel, the panelists answer the journalists' questions while also being fielded additional questions from the instructor. This unique presentation style allowed students to answer existing queries and formulate relevant questions essential for diagnosis and treatment strategies. Thus, as students practice approaching various patient cases during these presentations—and as they witness their peers tackle cases as audience members—they become regularly exposed to the essential critical thinking skills required to hypothesize, understand, and treat certain diagnoses. Consequently, they employ these same critical thinking skills and diagnostic algorithms when presented with a new hypothetical case, such as those on their course exams and within the MME.

Finally, students improved their collaboration skills, which is expected given the nature of the N120 series. Assignments, presentations, activities, and specific exams in this course are intended to be completed as groups. Because students have the flexibility
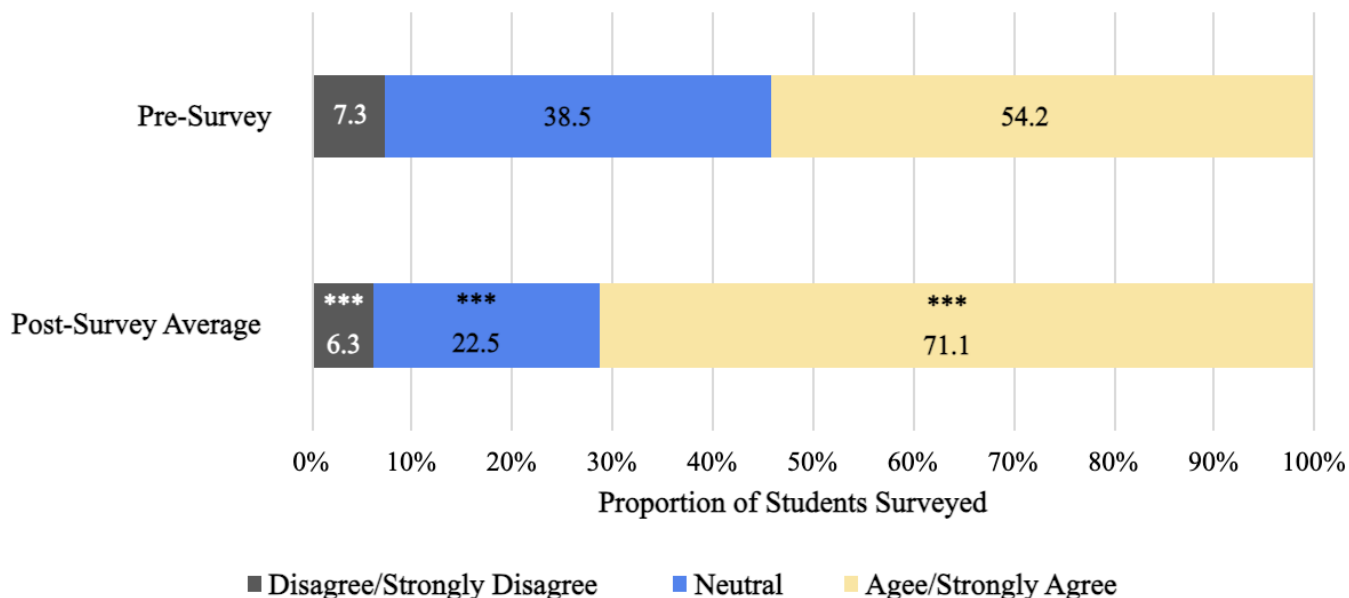
FIG 7 Student sentiment about the impact of group work on individual performance was more positive following completion of the course series. The "Pre-Survey" bar displays the proportion of respondents from the Fall pre-survey who selected each given category, and the "Post-Survey Average" bar represents the average proportion of respondents from all post-surveys who selected each category. Significantly less students on average disagreed, strongly disagreed, or were "neutral" toward this statement after participating in the N120 series ($P < 0.0001$), while significantly more students on average "agreed" or "strongly agreed" ($P < 0.0001$). ***$P < 0.001$

to decide how each task is handled within their assigned group, they are continually learning how to handle different group dynamics, as members of the group change each quarter. Therefore, throughout the entire year, students hone their cooperation and communication skills to adapt to each new group dynamic and ensure their group completes their assignments to the standards expected of them, all of which entails learning how to effectively navigate their roles as leaders and/or followers in their group as a means to work together productively.

Contrastingly, students did not show significant improvement overall within the categories of "Obtaining Background" and "Bedside Manners." This may be related to the fact that baseline scores in the Fall Quarter were already relatively high, leaving a smaller margin for improvement. Specifically, for six out of nine rubric items under "Obtaining Background," 50% or more groups met the expected criteria, while under "Bedside Manners," 50% or more groups met the expected criteria for three out of three rubric items. Moreover, since students have a pre-health background, it may be hypothesized that many already have some preliminary understanding of obtaining patients' medical histories, allowing them to deduce appropriate questions to ask. They also may very likely be aware of the level of professionalism and respect that is expected of physicians and demonstrate this high standard with their initial bedside manners. Additionally, the bedside manners that were displayed may reflect the attitudes and behaviors of the student actors who role-played as patients, as opposed to real patients.

All elements considered, this present study demonstrates that highly structured courses, like the N120 series, can help students hone necessary soft skills for professional schools. Soft skills are relatively more difficult to evaluate than content learning, which is why this study created the MME. While discussions regarding the use of

When I work in a group, I am more of a follower and tend to listen to what others tell me to do.
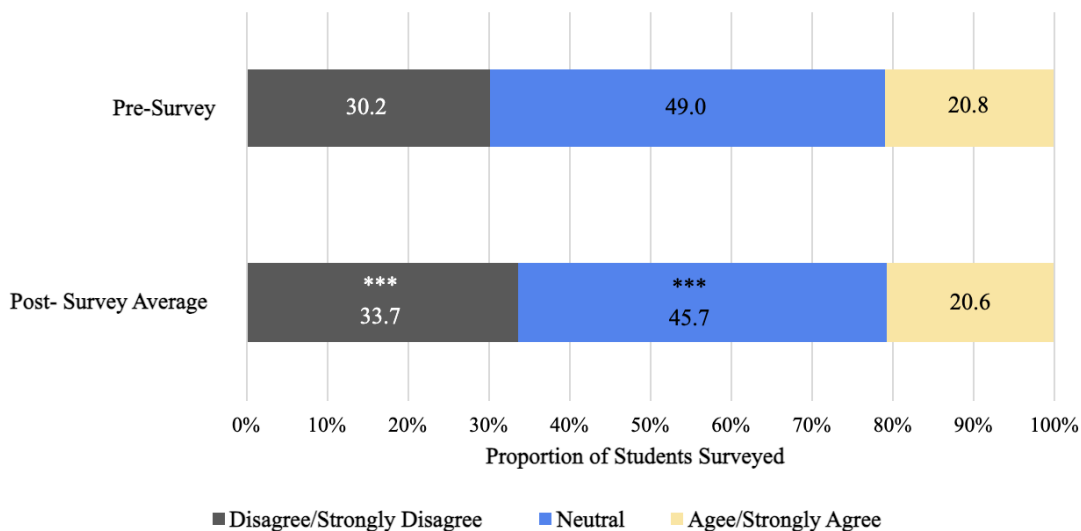

FIG 8   Changes in student sentiments toward assuming the role of a follower in groups. The "Pre-Survey" bar displays the proportion of respondents from the Fall pre-survey who selected each given category, and the "Post-Survey Average" bar represents the average proportion of respondents from all post-surveys who selected each category. Significantly less students on average were "neutral" toward this statement after participating in the N120 series ($P < 0.0001$), while significantly more students on average "disagreed" or "strongly disagreed" ($P < 0.0001$). No significant changes were observed in the proportion of students who "agreed" or "strongly agreed" ($P = 0.313$). ***$P < 0.001$

videotaped clinical interactions in medical education have already begun, these have been with respect to how the Objective Structured Clinical Examination can be modified to enhance faculty assessment of such skills and how such recordings can be a useful

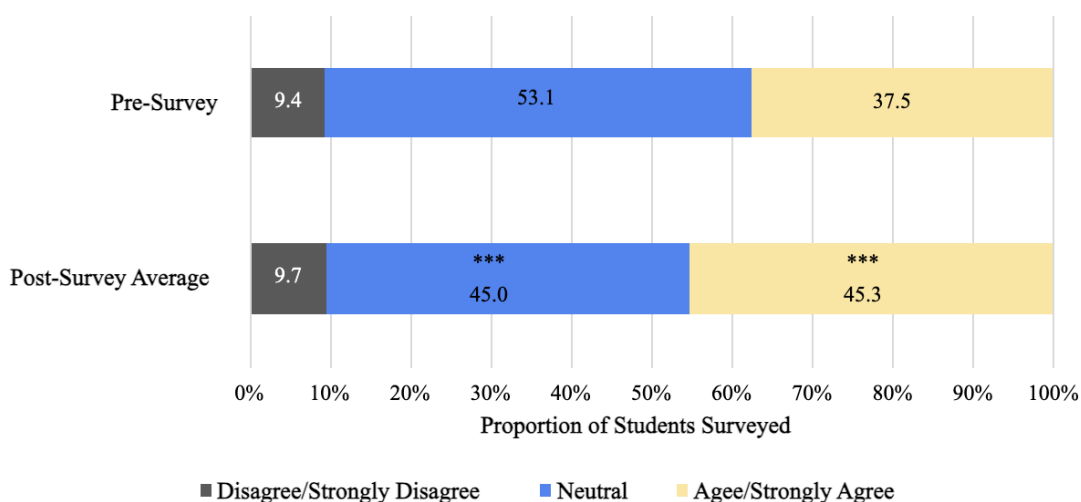## When I work in a group, I am more of a leader and tend to facilitate the tasks at hand.

FIG 9   Changes in student sentiments toward assuming the role of a leader in groups. The "Pre-Survey" bar displays the proportion of respondents from the Fall pre-survey who selected each given category, and the "Post-Survey Average" bar represents the average proportion of respondents from all post-surveys who selected each category. Significantly less students on average were "neutral" toward this statement after participating in the N120 series ($P < 0.0001$), while significantly more students on average "agreed" or "strongly agreed" ($P < 0.0001$). No significant changes were observed in the proportion of students who "disagreed" or "strongly disagreed" ($P = 0.359$). ***$P < .001$

tool for students to witness their areas of improvement (18, 19). Therefore, to our knowledge, the N120 series is the first to use an approach like the MME to successfully gauge the development of these soft skills within undergraduate students in a yearlong, active learning course. This introduces the potential for future pre-health undergraduate education to adopt this same model of instruction and student evaluation on a broader scale.

Pre- and post-quiz analysis results in the context of the course

Given that active learning environments have shown to be an effective and popular mode of instruction (2), the large learning gains and effect sizes within each quarter were expected. However, the present study illustrates that these results were achieved even without knowing the date of the post-quiz assessments, which further supports how courses that employ active learning reinforce content learning (4).

Herein, we present the unique course design of a yearlong keystone course series, Human Bio N120, tailored for undergraduate pre-health students. In our study, we developed a novel approach using MMEs to evaluate students' development of soft skills in undergraduate pre-health education, while also tracking learning gains through content quizzes. Our results show that this course design led to significant learning gains and improvements in students' ability to utilize scientific and medical terminology, conduct assessments and diagnoses in hypothetical patient simulation cases, and work in a team. Moreover, students expressed that they enjoyed the course, finding it both interesting and useful, and they expressed how they subjectively felt that the collaborative elements of the course benefited them individually. Therefore, the highly structured learning environment of the N120 series not only produced positive learning gains and skill development in students but also accomplished this in a manner that was enjoyable and subjectively effective for students. This present model may be emulated, modified, and expanded in other institutions, especially within other highly structured courses with case-based presentations, to improve necessary competencies for pre-health students.

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ADDITIONAL FILES

The following material is available online.

Supplemental Material

Rubrics for Presentations & MME Evaluation (jmbe00192-23-s0001.pdf). This file contains the instructor rubric and student rubric for in-class presentations (the latter is given to students in order to help develop their graded presentations and written

assignments that take place during the quarter) and an example of the rubric used to evaluate the MMEs.

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