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Investigating the Impact of International Education on Cultural Understanding, Health Disparities and Collaboration through Project-Based Learning

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Abstract

Global health is an interdisciplinary field emphasizing international health issues, causes, and solutions based on cultural and global understanding. We have all witnessed how crucial global health is with the global COVID-19 crisis that has affected everyone. To effectively work to solve global health issues, people from different backgrounds must work together to complete a common goal. Before problem solving begins, gaining a basic understanding of cultural differences and collaborating with different people is an essential skill to have. Previous studies have demonstrated the usefulness of study abroad experiences and international service-learning opportunities in promoting collaborations, cultural competency and personal development.

The Biomedical Innovations for Global Impact (BMEG 4593/SEVI4103) course at the University of Arkansas focuses on specific problems triggered by healthcare challenges and gives students the opportunity to work creatively and with students from different countries and disciplines. The course is designed to include students from the United States, Panama, and India. Business and engineering professors instruct students on the importance of the design process during product development and how global health needs impact the process. All students are put on teams with a clinical advisor and consist of students from different majors. At the end of the semester, each interdisciplinary team will present their proposed solution to meet the targeted global health need.

This research project will test the effectiveness of the course through pre-course and post-course surveys focused on 4 different areas: cultural understanding, educational experience, personal growth, and professional development. Through use of qualitative and quantitative data, we tested the hypothesis that the course will widen students' understanding of healthcare disparities and help develop skills for working in interdisciplinary teams to problem solve. Overall, our results indicate that post-course survey responses aligned with high expectations expressed in the pre-course responses with regard to personal growth, educational experience, and professional development. However, there is room for improvement with cross-cultural team dynamics and cultural understanding to develop meaningful biomedical innovations with potential for broad impact.

Introduction

Internationalization and promotion of global understanding are important areas of focus for educators with interdisciplinary approaches emphasizing international health issues, causes, and technology-based solutions of global health issues. To effectively solve global health issues, people from different backgrounds must come together to develop innovative solutions. However, prior to addressing the problem, gaining a basic understanding of cultural differences and collaborating with different people is an essential skill to develop. This understanding can be gained in the classroom to prepare students to be global changemakers and leaders in the global health and technology field. Previous studies have indicated that international service-learning opportunities via study abroad programs contribute to development of intercultural competencies and promote increased awareness of global health issues [1-4]. In 2019, a study was conducted to investigate the impact of an international service-learning experience for nursing students from Michigan. The researchers hoped that the implementation of a service project in a different country would increase the student's awareness of global health issues and provide the opportunity to test the knowledge and skills developed in the classroom. After the students conducted their service-learning project in Kenya, it was observed that the experience "transformed the [students'] personal and professional lives" [3]. This international experience proved to be beneficial to the students' overall understanding, cultural competency, and personal growth.

Acknowledging the interdependence of our world, faculty at the University of Arkansas have designed a "Biomedical Innovations for Global Impact" course that connects participating students with a global and local network of students, faculty, community partners, and mentors, and invites them to develop viable solutions to pressing health care or sanitation related challenges in different locations around the world. It is our hope that creating a global collaborative classroom environment will encourage students to develop cultural understanding in conjunction with the tools for product development. We wanted to foster a 'global health' environment in the classroom without taking the students abroad.

The "Biomedical Innovations for Global Impact" (BMEG 4593/SEVI4103) course offered by the Departments of Biomedical Engineering in the College of Engineering and the Department of Strategy, Entrepreneurship, & Venture Innovation in the Walton College of Business at the University of Arkansas focuses on specific problems triggered by healthcare challenges and gives students the opportunity to work creatively with students from different countries and disciplines. The course is designed to include students from the United States, Panama, and India. Business and engineering professors instruct students on the importance of the design process during product development, and how global health needs impact the process. All students are placed in teams with a clinical advisor and consist of students from different majors. During the course, guest speakers give lectures on different subjects to help students understand product development, business planning, and global health needs. These speakers were healthcare workers, biotechnologist, and CEOs of start-up companies. At the end of the semester, each interdisciplinary team present their proposed solution to meet the targeted global health need. The purpose of the course is to develop critical thinking skills, learn about the product design process, and expose students to international collaborations and healthcare issues around

the world by creating engineering solutions. This study is focused on investigating the impact of the project-based learning course on cultural understanding, health disparities and collaboration.

Materials & Methods

Survey

This project collected qualitative and quantitative data through pre-course and post-course surveys administered using the Qualtrics system. Two 30-question surveys were used for data collection. The surveys collected qualitative data through short-answer questions focused on four themes: personal growth, professional development, educational experience, and cultural understanding. This data is collected at the beginning and end of the course to observe the growth the students experience throughout the semester. Quantitative data was collected with Likert scale questions focused on the four different categories to determine if the course outcomes met course expectations. Students representing three countries (Panama, India, and the US) participated in the study.

Data analysis

The data collected from the survey was exported and graphed using GraphPad. For Likert questions, percentages of each response were calculated and grouped together by country to be graphed. All questions were grouped according to their associated category to draw conclusions.

Results

The surveys provided information about student feedback on their experience and knowledge gained in the course. It was intended to measure the students' educational experience, professional development, personal growth, and cultural understanding.

Educational Experience

To measure educational experience, 14 Likert-scale questions were asked. These questions and the student response distributions are shown in **Fig 1** and **Table 1**. In evaluating question 28, we noted that 72% of students agreed and 27% strongly agreed that they understand the process behind the design process from idea to prototype. For question 13, 75% of students agreed that they learned how to better determine the way in which limited infrastructure and resources is capable of meeting (or not) a growing demand. Only 15% of students disagreed with the learning objective, indicating that the methods of instruction used in the course were effective. Overall, majority of the students agreed that the course contributed to positive educational experiences.
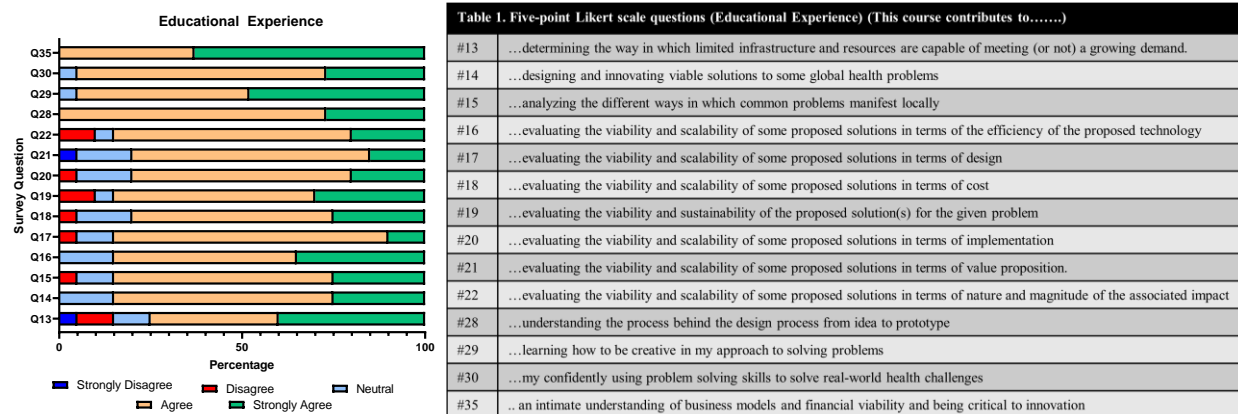
Figure 1. Student responses to the questions regarding educational experience, reported as a percentage.

Table 1. Five-Point Likert scale questions specifically asked in the pre- and post-course surveys to measure Educational Experience

Table 1. Five-point Likert scale questions (Educational Experience) (This course contributes to…….)	
#13	…determining the way in which limited infrastructure and resources are capable of meeting (or not) a growing demand.
#14	…designing and innovating viable solutions to some global health problems
#15	…analyzing the different ways in which common problems manifest locally
#16	…evaluating the viability and scalability of some proposed solutions in terms of the efficiency of the proposed technology
#17	…evaluating the viability and scalability of some proposed solutions in terms of design
#18	…evaluating the viability and scalability of some proposed solutions in terms of cost
#19	…evaluating the viability and sustainability of the proposed solution(s) for the given problem
#20	…evaluating the viability and scalability of some proposed solutions in terms of implementation
#21	…evaluating the viability and scalability of some proposed solutions in terms of value proposition.
#22	…evaluating the viability and scalability of some proposed solutions in terms of nature and magnitude of the associated impact
#28	…understanding the process behind the design process from idea to prototype
#29	…learning how to be creative in my approach to solving problems
#30	…my confidently using problem solving skills to solve real-world health challenges
#35	.. an intimate understanding of business models and financial viability and being critical to innovation

We then decided to evaluate the student responses for each of the questions from both the pre-course and post-course surveys to determine if the educational experiences matched student expectations. After evaluating all the combined data, three individual comparisons were created for the different student groups: India, Panama, and the US. A one-way ANOVA comparison across the different groups, indicated that there was no significant difference in pre-course and post-course responses for all questions (**Fig 2**) and even between student groups across different countries (data included in the Appendix), indicating that that the course outcomes met student expectations. Results also indicate that an inclusive educational environment for a diverse group of students was created and upheld. Majority of the questions had a median score of 4 out of 5, indicating that most students agreed with the statements listed in Table 1.

In the post-course survey, students were asked "How did this course contribute to your educational experience?" and this can be used to get more qualitative data from the students. In this question, we wanted students to expand on their educational experience in the course. Students used words like "develop more as a researcher", "business emphasis", "expanding general knowledge outside of textbook/classroom knowledge", as testimonials to the education experience. Students also commented on the product development process and how this course contributed to their overall understanding as engineers. Business students commented on how they learned how to "communicate with engineers better" and apply their unique skills to the project to help understand product viability and feasibility.
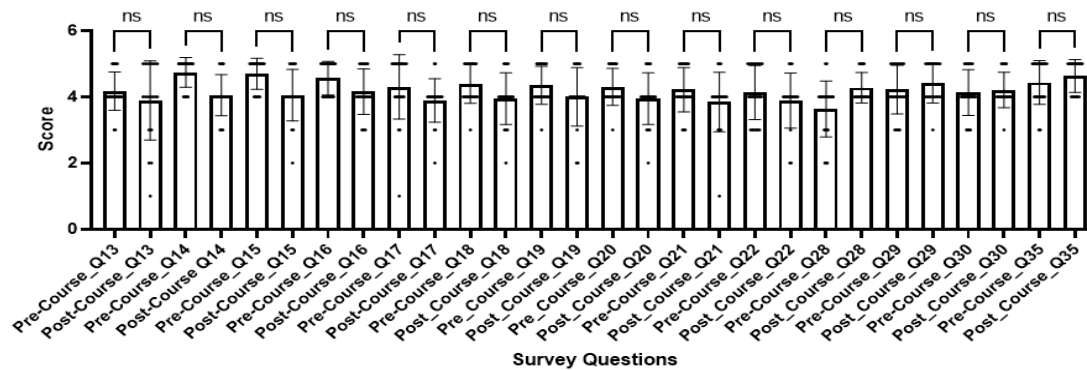
Figure 2. Summary of student response scores to all the survey questions (Table 1) related to educational experiences. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).

Personal Growth

To measure personal growth, 3 Likert-scale questions and 1 open-response question were used from the student surveys. **Figure 3** and **Table 2** display the specific questions asked in the pre-course and post-course surveys. For all 3 questions, at least 50% of all students strongly agree that the course had a positive impact on their personal growth. 63% of all students agreed that they can confidently communicate with interdisciplinary teams after working with students in different countries; which was a main objective for the course. For question 23, only 10% of students disagreed that course contributed to an increase understanding of global health; while 80% of the students agreed or strongly agreed with the course contribution.
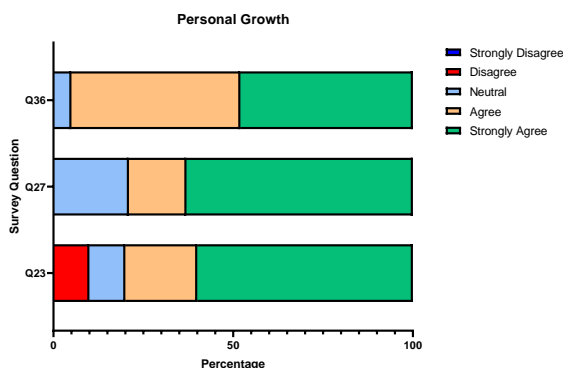
Figure 3. Student responses to the questions regarding personal growth, reported as a percentage.

Table 2 - Category 2: Personal Growth

Pre-Course Survey question in black. Post-Course questions in blue	
Questions	**What is Being Measured**
23. Do you believe that the course will contribute to an increased understanding of common global health issues? 23. This course has contributed to an increased understanding of common global health issues.	Personal Growth
27. I can confidently communicate with a group of people from different disciplines & nationalities to complete a project 27. I can confidently communicate with a group of people from different disciplines & nationalities to complete a project	Personal Growth
36. I anticipate seeing healthcare challenges in a different perspective 36. I now see healthcare challenges in a different perspective	Personal Growth

Table 2. Five-Point Likert scale questions specifically asked in the pre- and post-course surveys to measure Educational Experience

We then decided to evaluate the student responses for each of the questions from both the pre-course and post-course surveys to determine if the course experiences matched student expectations for contributing to their personal growth. After evaluating all the combined data,

three individual comparisons were created for the different student groups: India, Panama, and the US. A one-way ANOVA comparison across the different groups, indicated that there was no significant difference in pre-course and post-course responses for all questions in the personal growth category (**Figure 4**).
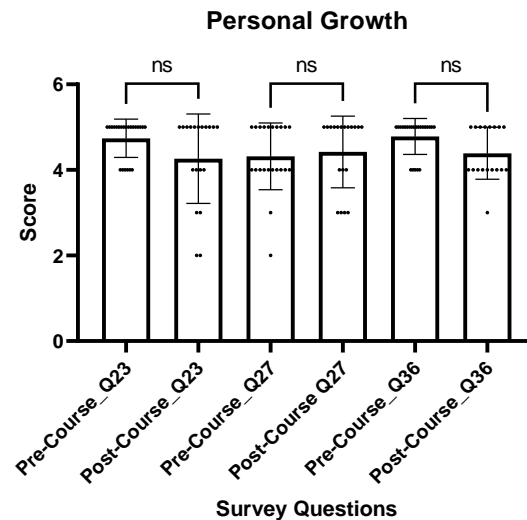

Figure 4. Summary of student response scores to all the survey questions (Table 2) related personal growth. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).

Professional Development

To measure professional development, 2 Likert-scale questions were asked. These questions and the student response distributions are shown in **Figure 5** and **Table 3.** For question 31, all students agreed or strongly agreed that they understood the importance of the engineering and entrepreneurship partnership. For question 26, only 5% of the students disagreed that they were considering working in an international setting, and 85% of the students are considering working in international setting. This displays a positive experience while working with students and mentors in different countries. After evaluating all the combined data, three individual comparisons were created for the different student groups: India, Panama, and the US. A one-way ANOVA comparison across the different groups indicated that there was no significant difference in pre-course and post-course responses for all questions in the professional development category (**Figure 6**). This indicates that the course objectives for the course in the professional development category were met.
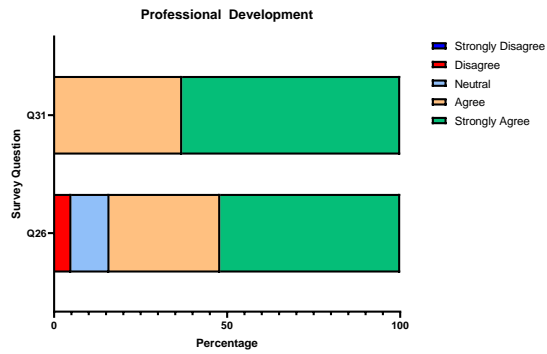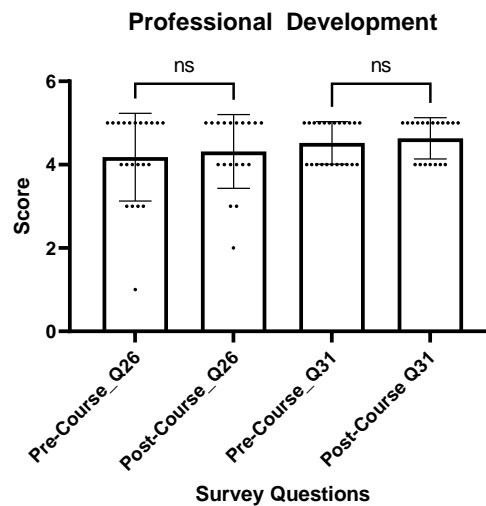
Figure 5. Student responses to the questions regarding professional development, reported as a percentage.

Table 3 - Category 3: Professional Development

Pre-Course Survey question in black. Post-Course questions in blue	
Questions	What is Being Measured?
26. I am considering working in an international setting 26. I am considering working in an international setting	Professional Development
31. I understand the importance of the partnership between engineering and entrepreneurship 31. I understand the importance of the partnership between engineering and entrepreneurship	Professional Development

Table 3. Five-Point Likert scale questions specifically asked in the pre- and post-course surveys to measure Professional Development

Figure 6. Summary of student response scores to all the survey questions (Table 2) related professional development. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).

In addition to the Likert-scale questions, students were asked to rank career options on a scale from 1 to 5. The career options were different industries involving engineering, product development, and global health; government/public policy, professional school (law, medicine, dental), entrepreneurship, academia, and industry. Overall, industry was the leading choice for most students while government/policy was rated as the last choice in the ranking (**Figure 7**).
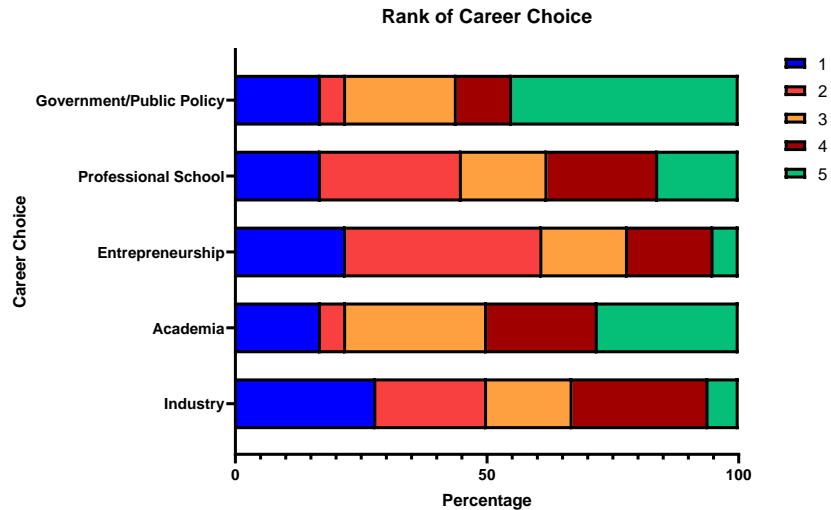
Figure 7. This figure displays how each student ranked their career choices, from 1 to 5, after completing the course.

Cultural Understanding

To measure cultural understanding category, 5 Likert-scale questions were asked. **Figure 8** and **Table 4** display the answer distribution and the corresponding questions for this category. This category had the most data variation between different student populations compared to the other categories. Question 24, 100% of students agreed that cultural awareness has an important role in global health, which was one of the main objectives of the course. Questions 32 and 33 had low percentages, 11% and 5% respectively, of students respond neutrally when asked about cultural differences and the importance of Human Centered Design.

Question 25 focuses on the relationship between the different student populations and how it contributed to their cultural understanding. **Figure 8** shows that 20% of students disagreed that the course completed the goal. **Figure 9** also shows this indifference with there being a significant difference between the student responses in the pre-course survey versus post-course for question 25. Further statistical analysis was conducted to gain a better understanding for this variance. **Figure 10** illustrates the statistical analysis for all US students' responses and displays the statistical differences for question 25. Here, students responded with a lower mean score indicating a negative experience in this category. A 360-Feedback survey was conducted to get better insight on the students' experience and their recommendations for the future is discussed in the 'Future Directions' section.
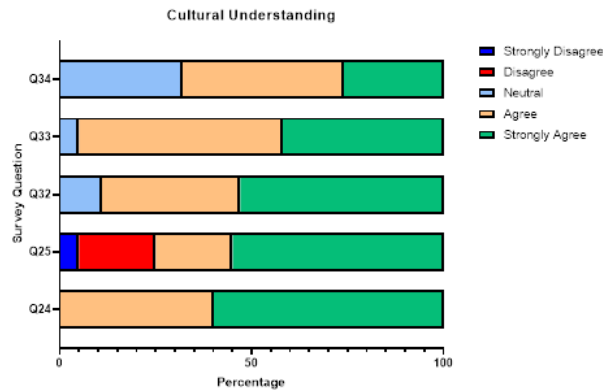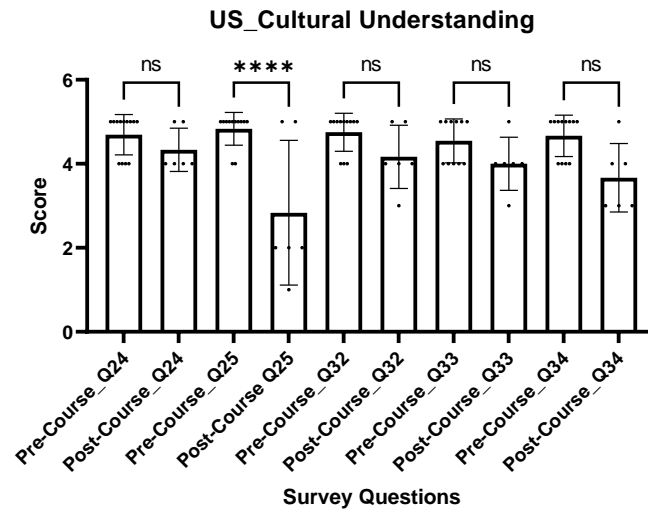
Figure 8. Student responses to the questions regarding cultural understanding, reported as a percentage.

Table 4 - Category 4: Cultural Understanding - Likert Scale

Pre-Course Survey question in black. Post-Course questions in blue	
Questions	**What is Being Measured?**
24. Do you believe that cultural awareness has an important role to play in helping solve global health issues? 24. I believe that cultural awareness has an important role to play in helping solve global health issues.	Cultural Understanding
25. Do you anticipate that studying and working with international students will increase your cultural understanding? 25. Did studying and working with international students increase cultural understanding??	Cultural Understanding
32. I have an appreciation of cultural differences 32. I have an appreciation of cultural differences	Cultural Understanding
33. Human Centered Design is an important methodology to promote innovative healthcare solutions 33. Human Centered Design is an important methodology to promote innovative healthcare solutions	Cultural Understanding
34. I believe working in teams from various nationalities/cultures will result in exceptional quality products/services that meet the needs of both local and global economies 34. I believe working in teams from various nationalities/cultures will result in exceptional quality products/services that meet the needs of both local and global economies	Cultural Understanding

Table 4. Five-Point Likert scale questions specifically asked in the pre- and post-course surveys to measure Cultural Understanding
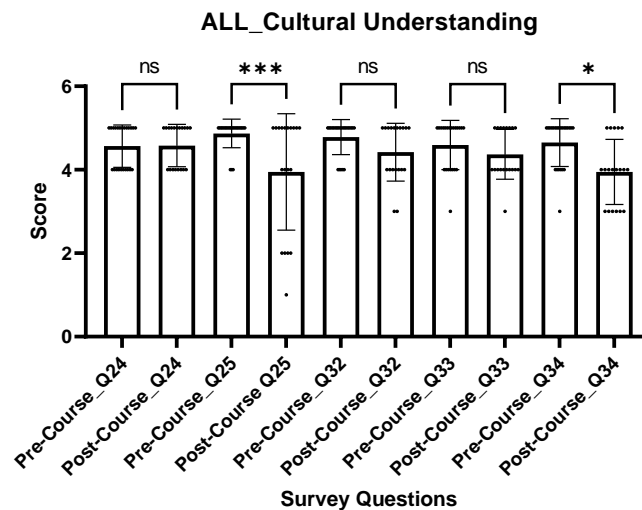
Figure 9. Summary of student response scores to all the survey questions (Table 2) the cultural understanding category. Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was significant difference in responses for question 25 and 34 from the pre-course and post-course survey (ns- not significant; *** - significant difference; *- slight significant difference).

Question 34 focuses on working on interdisciplinary and diverse teams to build better quality products to meet global needs. Figure 8 shows that 32% of students were neutral on this matter in the post course survey. To investigate in detail, **Figures 9 and 11** display the statistical analysis performed by a one-way ANOVA test. Figure 11 specifically shows the answer distribution within the Panamanian student population. This displays the statistically significant difference between the pre-course and post-course survey questions. Here, students responded with a lower mean score indicating a negative experience in this category. A 360-Feedback survey was

conducted to get better insight on the students' experience and their recommendations for the future is discussed in the 'Future Directions' section.

US_Cultural Understanding

Figure 10. Summary of US student response scores to all the survey questions (Table 4) in the cultural understanding category. Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was significant difference in responses for question 25 from the pre-course and post-course survey (ns- not significant; *** - significant difference; *- slight significant difference).

Panama_Cultural Understanding
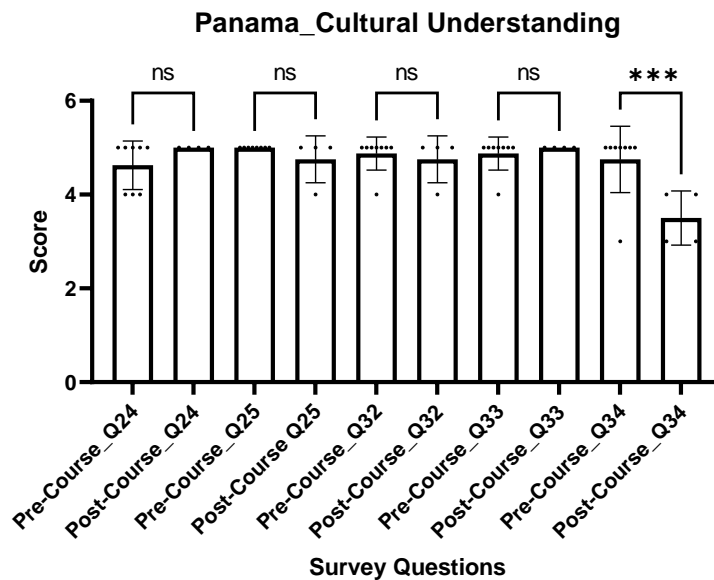
Figure 11. Summary of Panamanian student response scores to all the survey questions (Table 4) in the cultural understanding category. Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was significant difference in responses for question 34 from the pre-course and post-course survey (ns- not significant; *** - significant difference).

Discussions

When looking at all components of the survey, we noted that majority of the categories indicated positive experiences for all students. The educational experience and professional development categories had 50-60% "Strongly Agree" and "Agree" as answers on the Likert-scale. Statistical analysis was also calculated for each category and there was no significant difference for any of the questions. This indicates that each of the course objectives were met based on the responses in the pre-course survey. Most students agreed that their knowledge in the educational experience and professional development categories grew because of the course.

In the cultural understanding category, there was a larger percentage of response variation for some of the questions and the statistical analysis indicated significant difference between the pre-course and post-course surveys. When taking a closer look at the data, **Figure 10** displays that the significant difference in the data was contributed by the US student population. These students had a lower mean score for the post-course survey for question 25. This question asks about working with students from different countries and how it impacted their cultural understanding. When we study the team dynamics between students (**Figure 12**), we can observe that half of the student responses ranged from poor to neutral. This can indicate that there was some trouble within team communication and understanding when collaborating to create a solution to a global health need. Things such as time differences, and language barriers, could contribute to misunderstanding on a team. Figure 11 also displays a significant difference in pre-course and post-course survey responses for the Panamanian student community within the course. Question 34 asks about working in an international team to complete a common goal for improving product quality. When looking closer at the data, there was a small percentage of students going from "Strongly Agree" to "Agree" as the mean answer in the surveys. The analysis in the cultural understanding can indicate a majority positive experience for all students, but also leaves room for improvement for the future to better the experience for all students.

In the personal growth category, only 20% of the student population responded with "Disagree" and "Neither Agree or Disagree" for question 23. This response variation was indicated in the statistical analysis of the US student population; there was a slight significant difference between the pre-course and post-course survey responses. Question 23 asks if the course contributed to an increased understanding of common global health issues. This variance could be attributed to the course's focus on product development and market assessment, versus focusing solely on healthcare challenges globally.

We also had all students rank their ideal career choice in a list from 1 to 5, most likely to least likely. Most students chose industry for #1. This response could be due to specific mentorship they received in the course and the fact that most of the course material focused on companies, start-up culture, and entrepreneurship. Students were exposed mostly to these types of careers in the course and the professors focused heavily on product viability. Government/Policy was ranked #5 the most out of all the options. This could be a result of not knowing how engineering and product development relate to government and policy. During the course, there weren't many guest speakers from this field and most of the material didn't focus on this subject and this could contribute to the ranking list.

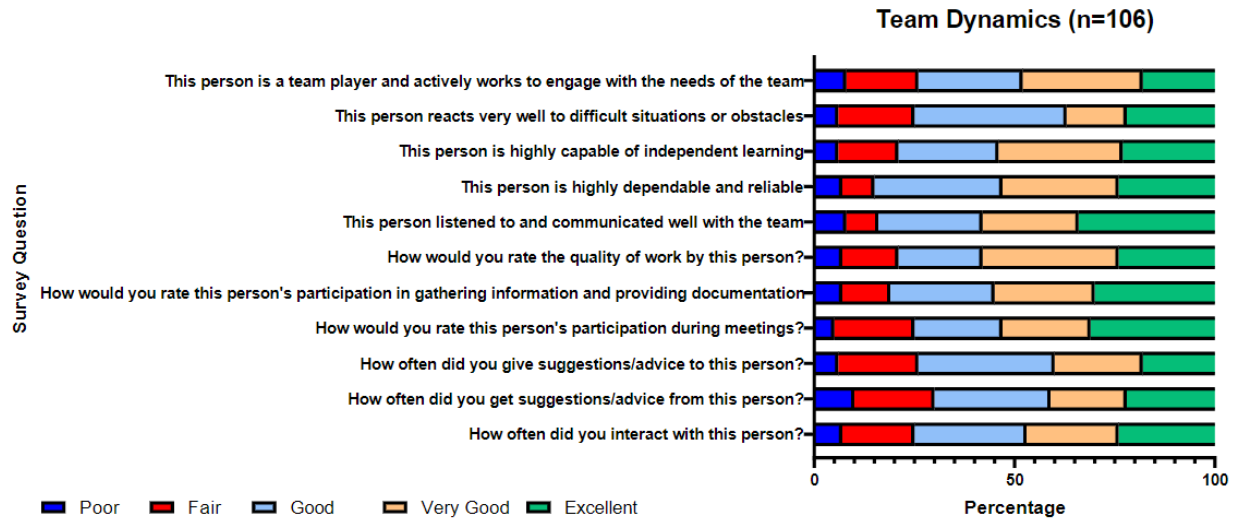## Future Directions & Improvements

Figure 12: Students' responses to questions related to team dynamics and collaboration. Each question is displayed to the left of the percentage graph.

In addition to the pre-course and post-course survey, we asked students to fill out a feedback survey that focused on group dynamics. All students were required to work in interdisciplinary and international teams to complete a common goal. Most students expressed concerns and problems they experienced with team communication and collaboration through the duration of the course. At the end of the course, we distributed a brief survey to get a better understanding of team dynamics and this aspect of the course could be improved in the future. In Figure 12, it lists out each question we asked and their corresponding responses. For the second question, "How often did you get suggestions/advice from [your group member]", ~55% of the students responded with an answer lower than "Sometimes". This indicates that there was a strain in team communication and participation. In the future, we could implement different communication platforms to make international communication easier for all team members. Collaboration and interaction between team members is essential to ensure all common goals are completed and a quality product is created for the project portion of the course.

In the future, we plan on engaging with non-governmental organizations like 'Physicians for Peace' to provide valuable insights and perspectives on real-world challenges that are experienced in clinical settings across the globe. This would help broaden students' understanding of healthcare disparities and help develop skills for working in interdisciplinary teams to solve global healthcare challenges. We also hope to enter student teams into innovation and product competitions such as 'Science and Tech-based Innovations to Advance the SDGs' sponsored by the UN. These competitions will expose students to different avenues of product development and entrepreneurial skills to help with team collaboration. Introducing seed money for each team will give them the opportunity to prototype their device to further develop the course as interactive and involved.

Conclusions

The results of this study provide evidence on how effective project-based learning approaches are at addressing global healthcare needs through biomedical innovation and contribute to student learning. In our analysis of educational experience through Likert-scale survey questions, we noticed that all students, irrespective of their location, had similar responses for each survey question with no significant difference between the pre-course and post-course responses. This consistency indicates that the course objectives were fulfilled, and student expectations were met. The questions in the educational experience category gauged students' understanding of product development, implementation, viability, and scalability. Many of the students commented on learning about the financial and business models for product development as an important component of the course, indicating the usefulness of this component in helping students better develop low-cost sustainable solutions with potential for broad impact across diverse populations. With the guidance of this study, we will enrich the biomedical engineering curriculum and develop courses that promote empathy, solidarity, and transnational, multidisciplinary, multi-sector collaboration, making sure common problems are solved with common solutions.

The implementation of the Biomedical Innovations for Global Impact course is an example of how universities can collaborate across the globe for the benefit of learners in both universities and their respective communities. Both engineering and business students gained valuable understanding about their unique roles and built a network of peer learners and community support. Ultimately, different communities benefit from the collaborative efforts that empower social entrepreneurs to work together to design real-world solutions to pressing healthcare challenges. Overall, our study demonstrated the significant potential of collaborations across countries (India and the USA) to analyze opportunities to bring innovations to market, and possibly coordinate transnational efforts to implement and scale the development and impact of innovations to address pressing social issues.

UARK); Prashanth Ravishankar (Research and Development Scientist – Namida Lab); Dr Sudeendra Koushik (IEEE TEMS); Sina Dadger (Now Diagnostics); David Hinton (Director Technoly Ventures UARK); Naiby Salazar (Universidad Latina); Gisela del Carmen (Universidad Latina); Deb Williams (Universidad Latina); Alexandra Gutierrez Vega (university of Arkansas Teaching Assistant); Christopher Thompson (CEO Sober Sidekick); James Morgan and Kathleen Casey (Physicians for Peace); Ryan Sheets (Business Communication Lab UARK)

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Post-Course Survey Responses

This appendix will include all additional figures for the post-course survey responses for all student populations for all 4 categories. Most figures were included in the bulk of the paper, but additional resources are here for more information.
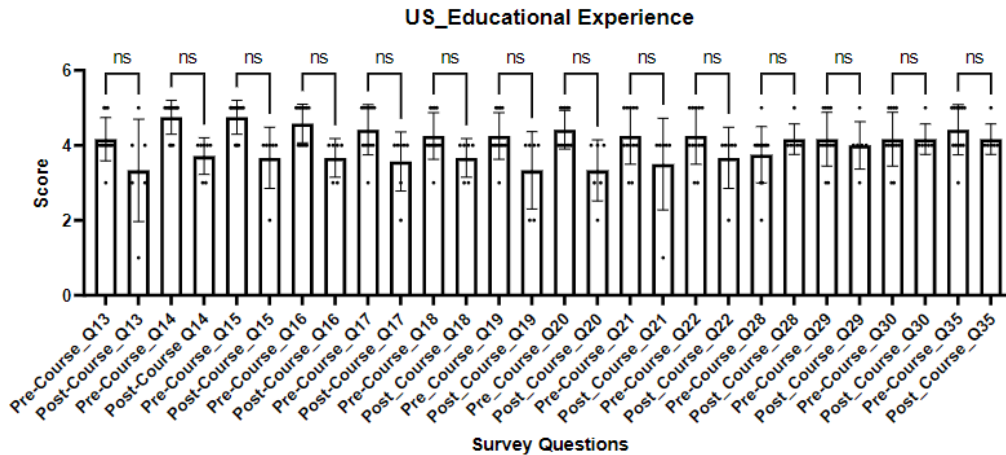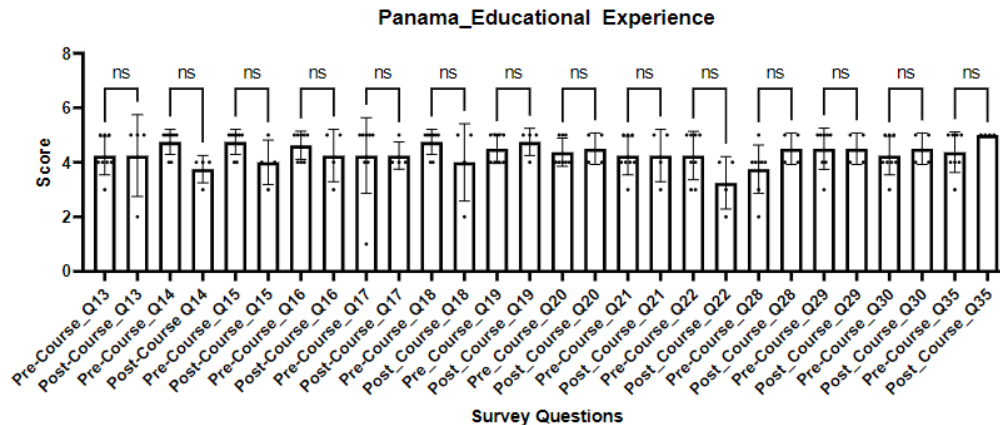
Educational Experience

Figure A1. Summary of US student response scores to all the survey questions (Table 1) related to educational experiences. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).
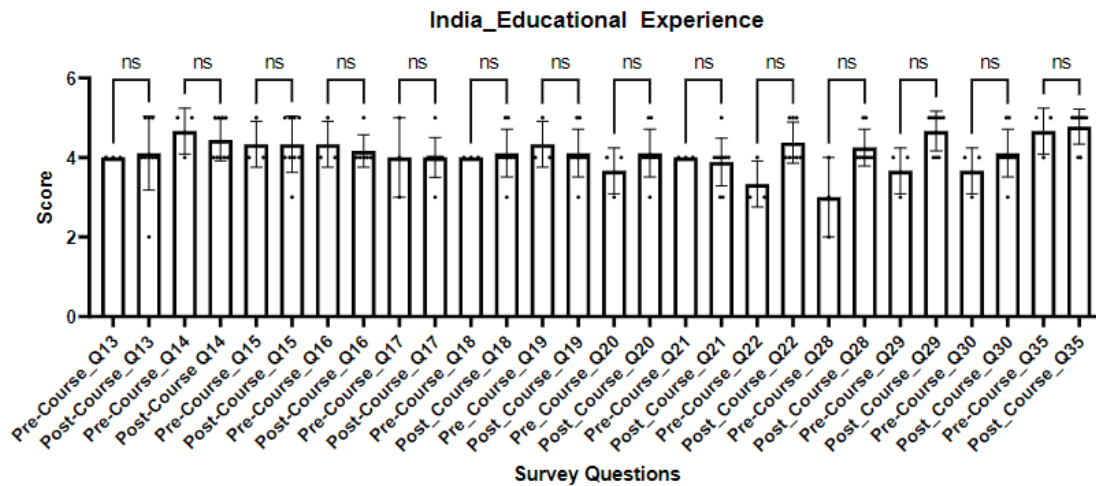

Figure A2. Summary of Panama student response scores to all the survey questions (Table 1) related to educational experiences. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).

Figure A3. Summary of Indian student response scores to all the survey questions (Table 1) related to educational experiences. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant):
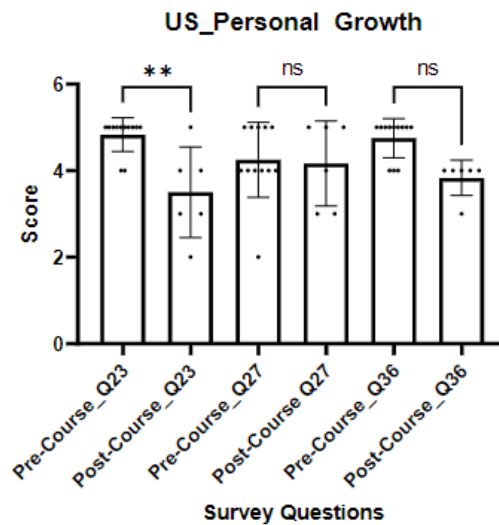
Personal Growth

Figure A4. Summary of US student response scores to all the survey questions (Table 2) related personal growth. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was significant difference in question 23 from the pre-course and post-course survey (ns- not significant); *** - significant difference; *- slight significant difference).
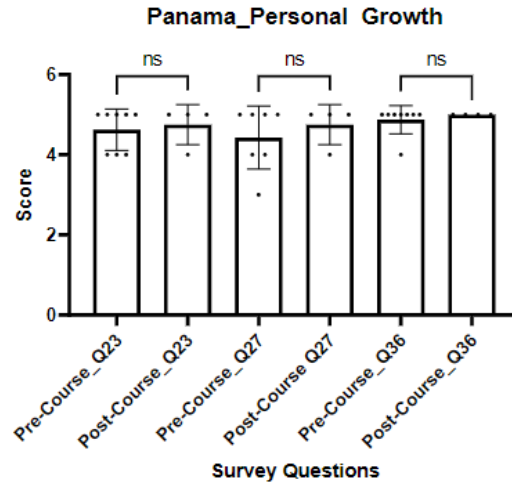
Figure A5. Summary of Panama student response scores to all the survey questions (Table 2) related personal growth. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference between pre-course and post-course survey response (ns- no significant difference)
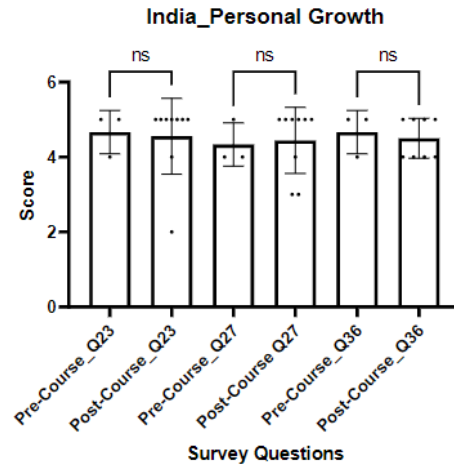

Figure A6. Summary of Indian student response scores to all the survey questions (Table 2) related personal growth. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference between pre-course and post-course survey response (ns- no significant difference)
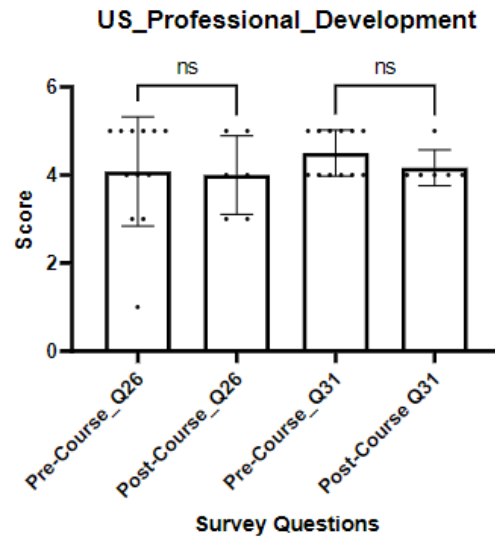
Professional Development

Figure A7. Summary of US student response scores to all the survey questions (Table 2) related professional development. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).
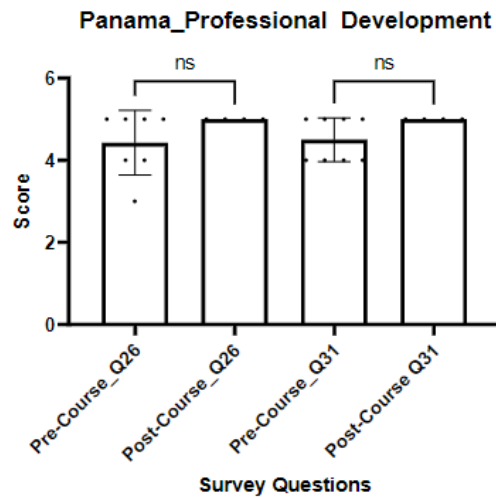

Figure A8. Summary of Panama student response scores to all the survey questions (Table 2) related professional development. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).
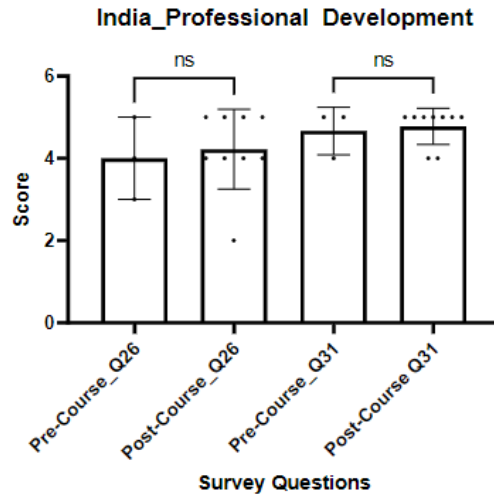
Figure A9. Summary of Panama student response scores to all the survey questions (Table 2) related professional development. (Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses for each question from the pre-course and post-course survey (ns- not significant).
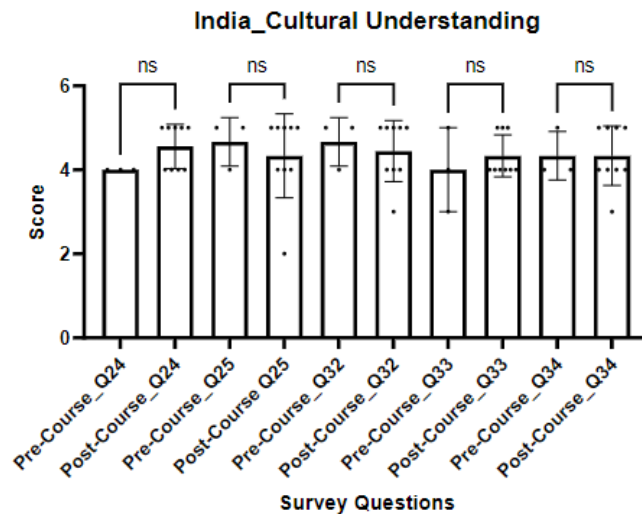
Cultural Understanding

Figure A10. Summary of Indian student response scores to all the survey questions (Table 4) in the cultural understanding category. Pre-course response (n= 23); Post-course response (n= 19). Statistical analysis indicated that there was no significant difference in responses from the pre-course and post-course survey (ns- not significant; *** - significant difference).