WIP: Improving Engineering Point of View in an Immunoengineering Lab Course

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Nyna, born and raised in Durham, North Carolina, obtained her Bachelor's degree in General Engineering with a concentration in Biomedical Engineering in 2022 from Wake Forest University. Following her undergraduate degree, she received her Master's degree in Biomedical Engineering with a focus in Immunoengineering from Johns Hopkins University. Nyna has a strong interest in increasing diversity in biomedical engineering spaces and she intends to research this by focusing on inclusive classroom spaces and diversifying research models.

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Introduction and Background

Immunoengineering is an emerging interdisciplinary area that combines engineering and medical principles to develop therapies for immune related disorders [1]. This disorder category disproportionately impacts marginalized populations, yet immunoengineering curriculum lacks components that teach students about demographics that need these therapies the most [2], [3], [4], [5], [6], [7], [8]. This study seeks to understand how students increase their sociotechnical understanding of immunoengineering concepts by assessing their experience engaging in a curriculum intervention. The intervention is composed of three online discussion posts in which a multi-case study explanatory mixed-methods assessment will seek to answer the overarching research question, "*What impact does immunoengineering curriculum design have on students' approach to real-world immunoengineering problems that contribute to health inequities in marginalized communities?*"

This work is being observed through the lens of Transformative Learning Theory (TLT), a phenomenon developed by Jack Mezirow (1978), where he observed how adult students changed their worldviews when being introduced to the higher education space [9], [10], [11]. This study resulted in 10 phases that indicate transformed learning: (1) Disorienting Dilemma, (2) Self-Examination, (3) Critical Assessment, (4) Recognition of Shared Experiences, (5) Exploring Options for New Behavior, (6) Planning a Course of Action, (7) Acquisition of Knowledge, (8) Trying New Roles, (9) Building Confidence, and (10) Reintegration. Using themes from TLT we have developed a curriculum intervention that includes content related to health inequities and disparities. This work has been assessed quantitatively using a grading rubric to determine each student's trajectory throughout the lab course. Quantitative data analysis has shown that majority of students are either high performing (n=5) or are classified as having substantial growth and maintenance (n=7). Future work includes explaining these findings using qualitative methods inspired by Joslyn and Hynes, who introduced a study that explored the integration of TLT [12]. Joslyn and Hynes used qualitative coding as the primary tool for analyzing reflection assignments that students were required to complete as part of multiple transformative learning activities (TLA). The three deductive coding schemes used for their work and this one are: DPOV (Dominant Engineering Point of View), EPOV (Extended Point of View), and SPOV (Sociotechnical Point of View). Codes will be assigned to student written discussion responses and interview transcripts to see how they support the quantitative findings.

Methods

Using TLT as our theoretical framework, we have developed a curriculum intervention that contains content related to health equity and disparities for an upper level immunoengineering laboratory course. Components of the intervention appeal to overarching themes of TLT to include disorienting dilemma, critical reflection, and rational discourse.

Course Description

The immunoengineering laboratory course used for the intervention is centered around students learning about toll-like receptor 2 (TLR2). This receptor protein lives on the cell surface and is responsible for triggering an intracellular immune response. The course objectives include:

1. Become familiar with the functions of TLR2
2. Learn basic cell-culture techniques
3. Practice scientific writing

To encompass the intervention, the additional objective of, "*understand real-world applications as it relates to marginalized communities"*, was added to the course syllabus. To achieve these objectives students, complete four different modules where they engage with TLR2 in a different way and learn the skills necessary for being in a laboratory setting.

Intervention Description

The intervention is designed to take place during modules 2, 3, and 4 as described in Table 1. Refer to **Appendix A** for the informational text in the Lab 2 discussion prompt.

Table 1. Intervention discussion prompts

Lab 2: Characterizing Immune Cell Receptor
Reflect on the reading for this module, "TLR2 activation promotes tumour growth and associates with patient survival and chemotherapy response in pancreatic ductal adenocarcinoma" and respond to one of the following questions. Cite any additional references you decide to use. Chronic inflammation, which can be caused by stress, environmental factors, and poor diet, has been proven to increase TLR2 levels. These elements are more prevalent in marginalized communities. 1. How can research consider these aspects in developing more equitable therapies for cancer? 2. How does TLR2 influence immune responses in cancer, and why might it vary among different populations? 3. If you were designing a TLR2-targeted cancer immunotherapy, how would you ensure it benefits all patients equally?
Lab 3: Modulating Immune Cell Receptor Activity
[Information text described in **Appendix A**] Reflect on your reaction to disparities in immunoengineering. Then using this information as a starting point, research and identify a limitation of current immunoengineering approaches in addressing health disparities. Describe that limitation here, being sure to include your own reactions to this disparity in your response.
Lab 4: Activating Innate Immunity Response
Research an immunological disorder that disproportionately impacts a marginalized group (examples of groups you might consider are provided below). Describe how you would change the experimental setup of one of the labs to consider your researched disorder and approaches for applications to benefit broader populations. Cite any references you used to form this experiment. Examples of this type of experimental description is found at the top of the lab protocols shared so far. "Marginalized populations are defined as groups that experience health inequities due to factors such as race, ethnicity, and socioeconomic status (SES), often resulting from historical preclusion from social mobility. These populations face barriers to access healthcare and may experience poorer health outcomes compared to more privileged groups." (Adnan et al., 2022) Example groups: Girls and Women; People of Color (Black or African Americans, Latin Americans, Asian Americans, Native Americans, Pacific Islander Americans, and multiracial Americans); LGBTQIA+ (Lesbian, Gay, Bisexual, Transgender, Queer/Questioning, Intersex, and Asexual); Immigrants, Refugees, and Migrants; People with Disabilities; People of Low Socioeconomic Status

Students are provided with the opportunity to consent in to sharing their responses with the researcher. The consent period for this intervention is during the first lab module, "Cell Culture". This is done to maximize the number of participants as the intervention does not begin until after the course add/drop period. Students are tasked with completing the intervention via online discussion posts in which they respond to the discussion prompts and to two other students.

Quantitative Assessment

Discussion posts were assessed using the American Association for Colleges and Universities (AAC&U) Value rubrics [13]. Through consultation with the course instructor and aligning to the course's goals, the rubric dimensions that students were assessed on were Intercultural Knowledge and Competence, Inquiry and Analysis, and Information Literacy. To determine the significance of how students changed throughout the intervention, a linear mixed-effects model was employed in JMP to analyze student trajectory over the course of each lab module and within each dimension of the rubric. Performance levels are described in Table 2.

Table 2. Intervention rubric performance levels

Capstone	Milestone	Emerging Milestone	Benchmark	Missing
100%	75%≥	50%≥	25%≥	0

This work was determined to be exempt from further review by the University of Georgia IRB.

Preliminary Results and Future Directions

Fourteen (N=14) out of 32 students consented to participating in the intervention. The data from this intervention revealed trends that indicated increased sociotechnical understanding. The analysis showed that students' scores differed across lab discussions, $p < .0001^*$, as well as across the different rubric dimensions, $p = .019$. Statistical significance was evaluated at $\alpha = 0.05$, corresponding to 95% confidence intervals. Individual percent scores were classified across cases: High Performing (n=5), Substantial Growth and Maintenance (n=7), Moderate Growth with Plateau (n=1), and Decline (n=1). High performing students scored at Milestone or Capstone for all three labs. Students that have substantial growth and maintenance grew at least one performance level, students with moderate growth grew at least half a performance level, and decline indicates students decreased a performance level. Results showed that on average students grew the most between Lab 2 (M = 74.07), and Lab 3 (M = 89.03), while maintaining their average performance level for Lab 4 (M = 88.95). Similar growth patterns were observed at the rubric dimension level. Students performed best in the Inquiry and Analysis dimension (M = 88.71), followed by Information Literacy (M = 82.14). While students performed the lowest in Intercultural Knowledge and Competence (M = 80.85), they still performed at a Milestone level. The next step for this project includes assessing student responses using the EPOV codebook and recruiting students for individual semi-structure interviews. Through qualitative analysis, we aim to gain insight on the effectiveness of the intervention and if student maintained their assigned EPOV.

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Appendix A: Lab 2 discussion prompt informational text

In 2023, the National Center for Health Statistics reported that cancer was the second leading cause of death claiming over 600,000 lives in the United States. Immunotherapies have been the source of cutting-edge treatment for this issue, however, there have been noted variations in response. The National Cancer Institute has reason to believe that there are differences in the genetics, tumor biology, and immune environment of several cancers that arise in Black/African Americans compared with those that arise in people of other racial/ethnic groups. For example, despite having a lower incidence rate in breast cancer than White women, Black/African American women are more likely than White women to die of the disease. A similar disparity is also seen in Black/African American men who are still more than twice as likely as White men to die of prostate cancer although prostate cancer deaths have dropped significantly in the United States.

Recent studies have shown that TLR2 plays a critical role in modulating immune responses to tumors, which influence the response to immunotherapies. Genetic variations in TLR2 expression may affect the success of immunotherapy, meaning that current treatments may be more effective for some ethnic groups than others. The TLR2 receptor helps regulate immune responses by detecting pathogens and abnormal cells. When NK cells express TLR2, it can boost NK cell cytotoxicity and cytokine production. However, in cancer patients, TLR2 activation can either stimulate the immune system to fight tumors or suppress it, which can facilitate tumor progression. While some immunotherapies aim to enhance TLR2 signaling to boost anti-tumor immunity, these treatments may not work equally well in all populations. If immunotherapy research and trials fail to consider these differences, they risk excluding marginalized communities from life-saving treatments.

Despite the advances in immunotherapies, racial, ethnic, and socioeconomic disparities persist in cancer outcomes, Black/African American people have higher death rates than all other racial/ethnic groups for most cancer types.