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BOARD # 33: Work in Progress: Understanding the Biomedical Engineering Student: Using Maslow's Hierarchy of Needs

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Work in Progress - Understanding the Biomedical Engineering Student: Using Maslow's Hierarchy of Needs

Modern engineering classes have struggled to engage students since the pandemic began[1-5]. Changes in teaching methods during this time have burdened students. Online classes, a lack of college experience, and reduced faculty interaction can impact learning outcomes and departmental goals[2, 3, 5-10]. Recently, our university implemented pedagogical changes in Biomedical Engineering classes to address these challenges[6, 11]. During one-on-one discussions about course changes, the faculty team recognized a significant gap in understanding our students[12-15].

In this ongoing research, motivated to address this issue, we employ Maslow's Hierarchy of Needs as a framework to explore the experiences of senior BME students.[16-19]. Maslow's Hierarchy of Needs offers a human-centered approach to engaging with and understanding fundamental motivations, ranging from basic needs to higher aspirations. We surveyed senior students graduating in 2024 and 2025 who are enrolled in two courses at Meinig School of Biomedical Engineering, Cornell University: Course 1: BME 4010 Biomedical Engineering Analysis of Metabolic and Structural Systems (Fall '23 and '24) and Course 2: BME 4020 Electrical and Chemical Physiology (Spring '24 and '25). This report presents data from Fall '23 and Spring '24, with ongoing collection planned for Fall '24 and Spring '25. Students scored their physiological, safety, love and belonging, esteem, and self-actualization needs based on their experiences. The IRB at Cornell University approved this study for voluntary participation. (IRB Approval #0146842).

The primary research questions we pursued during the study include:

RQ1. RQ1. What is the level of satisfaction among senior Biomedical Engineering students regarding their safety, physiological, belonging, self-esteem, and self-actualization needs?

RQ2. RQ2. How effective are departmental policies and practices in fostering community and inclusivity among students, as senior students perceive?

RQ3. RQ3. Can targeted interventions enhance student engagement and motivation (e.g., more group work, peer feedback) and foster feelings of safety and belonging among BME students?

RQ4. RQ4. Can understanding these needs guide departmental decisions regarding course design, faculty training, or student support services to enhance overall student success?

Methodology: Survey

All enrolled students receive questions covering Maslow's 5 hierarchical needs (Physiological, Safety, Belonging, Self-Esteem, Self-Actualization). The initial survey consists of 15 ratings on a scale of -3 to 3 (See Appendix). These questions are based on prior research, particularly following COVID-19 pandemic[20-23]. There is evidence of a lack of understanding of such needs; therefore, having an initial set of data before further in-depth questioning is our approach study[24, 25]. The survey questions aim to cover various aspects of five basic needs as follows:

- Physiological Needs: “Is the scheduling of sessions allowing for food breaks, sleep, and other social activities?”
- Safety Needs: “How safe are you in the [course/department/program]?”
- Self-Esteem Needs: “Does the [course/department/program] motivate your learning objectives as a BME student?”
- Belonging Needs: “Does the [course/department/program] make you feel like you are a part of a community and/or a biomedical engineer?”
- Self-Actualization Needs: “Does the [course/department/program] empower your pursuit of a successful future?”

The developed statements present these themes through various formulations, and the ratings, ranging from extremely dissatisfied (-3) to extremely satisfied (3), given by the students are evaluated based on a fuzzy cognitive map. [26]. In addressing the research questions, these survey questions provide data to analyze RQ1. For RQ2 to RQ4, we are currently conducting semi-structured one-on-one interviews with students (See Future Work) who volunteer to ask additional questions alongside the survey questions. As the scope of this WIP is to present data from Fall ’23 and Spring ’24, the interviews are not included here.

Preliminary Results

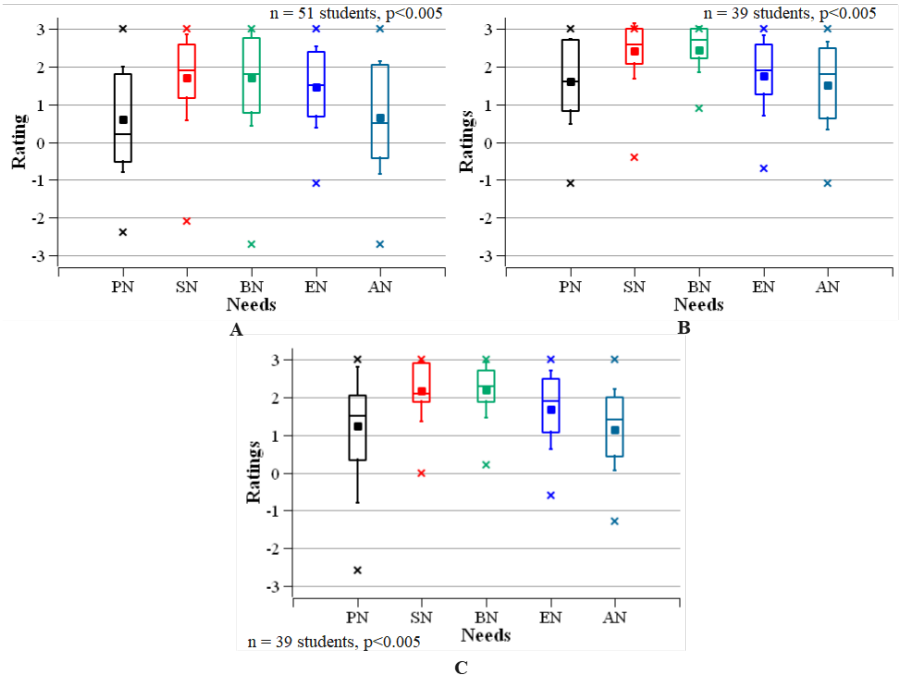

Figure 1: Plot of Student Ratings for the different Needs in the Hierarchy of Needs, namely Physiological (PN), Safety (SN), Belonging (BN), Self-Esteem (EN), and Self-Actualization Needs (AN). (A) Course in Fall 2023, (B) Course in Spring 2024, and (C)BME as a major. The box represents the mean of the data, ‘X’ marks the maximum and minimum values, and the whiskers flank the standard deviation.

The study is ongoing; therefore, the results we have are very preliminary, with more data expected to be available over the next few months. Figure 1 summarizes the ratings the students provided for the survey questions. The score for each need was averaged based on the number of statements associated with each need. For example, the physiological need has three statements, and the value for each of these is averaged for every student to determine their score for that need. Similarly, the other needs are also calculated. Plot 1A presents a summary of the data from the Fall 2023 course, Plot 1B shows the data from the Spring 2024 course, and Plot 1C displays the data from the same group of students for the same survey question now focused on BME as a

major, excluding the individual course aspect. These surveys typically occur at the end of the semester. The data across 1A–1C reveal a consistent trend: students are generally moderately satisfied with the course and department in terms of fulfilling their physiological, self-esteem, and self-actualization needs, while they report higher satisfaction with their sense of safety and belonging within the course or department.

*Table 1: Correlation between Needs based on Data from Course in Fall 2023 (*p<0.001, ^p<0.005)*

	PN	SN	BN	EN	AN
PN		0.555*	0.419^	0.510*	0.593*
SN			0.652*	0.549*	0.727*
BN				0.488*	0.552*
EN					0.631*
AN					

We proceed to study Pearson's correlation coefficient (r) between the different needs, and Table 1 summarizes the correlation analysis for the data in Figure 1A. A high correlation coefficient between two needs indicates that students who feel satisfied with one need will likely be more confident with the second need in the pair. For instance, the data suggest that students who feel safe can feel a sense of belonging and have more confidence to explore BME's options.

Future Work

The results reported here summarize the raw data from a batch of students who have graduated, while the current year's data collection is ongoing. We will continue data collection during the Spring and Fall semesters of 2025 and 2026. In addition to the survey, we have initiated one-on-one interview sessions with a subset of students. The questions are conversational and align with the same themes as the surveys, maintaining a basic framework for all students. The one-on-one interviews are expected to highlight the factors that need consideration while developing this model, and therefore we will continue conducting these interviews in the upcoming semester.

Upon collating all the data, the next step is to devise a predictive model of student motivation. The larger goal of this study is to develop a theoretical framework for the predictive model along with student assessments, surveys, etc., that will provide both individual feedback about a student and insights into the class for the instructor. The model can facilitate targeted interventions by the instructor in a timely manner, introduce pedagogical changes (we will introduce some in Fall '25), and advocate for changes to departmental policies. These changes aim to enhance engagement and motivation by ensuring that the instructor is connected to the students and tracking their progress in a way that promotes a sense of belonging to the wider BME community.

Conclusion

The scope of this work-in-progress paper is to initiate conversations with the BME community at large. Preliminary results that address RQ1 of this ongoing research study suggest that understanding students' needs and their relationship to effective learning requires a rigorous study. By prioritizing student-centered learning and creating a more inclusive and supportive environment, we can address specific challenges identified by students, improve student success, and promote a more inclusive BME community.

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Appendix

How satisfied were the following scenarios met by the courses you took in the BME department and in general BME as a major? Assign a score from -3 (Extremely Dissatisfied) to 3 (Extremely Satisfied) by moving the slider to provide your assessment of the different scenarios requested.

Physiological Needs (PN)

1. The schedule of [course/department/program] allowed me to meet my basic needs (food, breaks, etc.).
2. The support provided by the [course/department/program] faculty allowed me to enroll in the courses I wanted to take as I developed towards a career in BME.
3. In an emergency, the [course/department/program] instructors responded to requests for valid reasons to be partly or wholly excused from missing sessions, specifically exams.

The schedule of sessions here includes, but is not limited to:

- The timing of lectures, labs, and other components associated with the course requirements.
- classroom allocation and the time needed to travel between classrooms between sessions
- Timing of office hours for TAs, instructors, and other instructional staff associated with a course.
- the timing of preliminary exams, final exams, and final projects (if any)
- the gap between homework assignments and the time allotted for each assignment
- Time allocated for laboratory reports after the lab session.
- the spacing of each assessment component (homework, lab reports, etc.) in a course.

Safety Needs (SN)

4. The learning spaces (classes, labs, etc.) in [course/department/program] provided a safe environment for me to learn.
5. I felt safe voicing my input and opinions to my group in the [course/department/program].
6. I felt secure sharing my thoughts and opinions with my peers, [course/department/program] instructors, TAs, and during group work.

Belonging Needs (BN)

7. I performed better in a group of my choice rather than in an assigned one, whenever the [course/department/program] instructor permitted me to.
8. Among my peers in the cohort, I often express my ideas and opinions, informed by the knowledge I have accumulated from the [course/department/program] study materials.
9. Among my peers in the cohort, I often express ideas and opinions informed by the knowledge I accumulated from [course/department/program] instructors.

Self-Esteem Needs (EN)

10. Throughout my time in the [course/department/program], I believe my work and contributions have been recognized and appreciated by my peers, particularly in a group setting.
11. Throughout my time in the [course/department/program], I acknowledge and appreciate the work of my peers.

12. During my time in the [course/department/program], I know my work and contributions to the [course/department/program] were noticed and appreciated by the instructors and BME faculty.

Self-Actualization Needs (AN)

13. The BME [course/department/program] and its curriculum enable me to pursue my dream career.
14. Courses and course materials were divided effectively to allow me to learn at a comfortable pace through all the different courses in BME.
15. Working in groups in [course/department/program] enhances my ability to learn more effectively from peers who may be stronger in specific topics than I am, compared to a traditional classroom.