Student and Clinician Feedback from a BME Clinical Immersion and Design Program: A Five-Year Evaluation

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Abstract

Clinical immersion programs in biomedical engineering (BME) education have emerged as transformative experiences that bridge classroom learning with real-world healthcare environments. These programs aim to enhance student understanding of clinical workflows, foster empathy, and improve their ability to identify unmet medical needs – skills that are essential for effective medical device design and innovation [1], [2]. Our summer immersion program spans six weeks and integrates instructional sessions (week 1), clinical observations (weeks 2-5), and collaborative design work (week 6) to strengthen students' engineering design capabilities and deepen their understanding of health disparities [3]. A total of 52 undergraduate BME students participated in our program across a five-year period (2021-2025). This paper presents an evaluation of our clinical immersion and design program over this period, using data from three complementary surveys: the Program Survey, administered to students at the conclusion of their experience in our program; the Ambassador Survey, which captures longitudinal feedback from program alumni; and the Clinician Survey, which gathers insights from healthcare professionals who hosted students during clinical rotations. Together, these instruments provide a holistic view of the program's impact on student learning, professional development, and clinical collaboration.

Program Survey results consistently demonstrate high levels of student satisfaction and perceived preparedness. Participants reported strong agreement with statements related to program organization (mean = 5.50/6), communication with organizers (5.85), and availability of resources (5.80). Students also ranked the design experience highly, reporting a strong understanding of the engineering design process (5.52) and that the program helped them think differently about needs identification (5.80) and prepared them for future design courses (5.96). Students also expressed increased confidence in identifying and refining clinical needs and applying design principles, with all respondents recommending the program to peers. Open-ended responses emphasized the value of diverse clinical exposure, the importance of social consciousness in design, and the transformative nature of real-world healthcare engagement. The Ambassador Survey, which received responses from both current students and recent graduates, revealed sustained benefits beyond the initial immersion period. Program alumni frequently cited the influence of their clinical immersion and design experience on their career direction, continued involvement in design projects, and leadership development. These findings suggest that the program fosters long-term professional identity formation and reinforces design competencies over time.

Clinician feedback was overwhelmingly positive, with most respondents rating their experience with the program and its student participants highly across multiple dimensions. On a 6-point Likert scale, clinicians consistently rated the program's organization, communication, and student engagement between 5 and 6. Specifically, clinicians felt that students were well-prepared in terms of medical terminology, comfortable asking questions, and demonstrated professionalism and curiosity during their rotations. Several clinicians noted that students were eager to learn and actively contributed to discussions about clinical processes and technology use. Some clinicians observed that students offered ideas for improving clinical workflows, indicating a meaningful level of engagement and design thinking. While most clinicians felt the program was well-structured and worthwhile, a few suggested improvements such as better alignment between

student interests and clinical placements. Overall, clinician responses reflect strong support for the program's continuation and growth, with many expressing enthusiasm about hosting future cohorts.

In summary, participants, program alumni, and clinician partners highly rank our clinical immersion and design program. These survey results complement recent qualitative analyses of student reflections during our program, which described high levels of design learning alongside identified themes of healthcare access, insurance challenges, and socioeconomic disparities [4]. By triangulating student and clinician perspectives across time, this study contributes to a growing body of evidence supporting experiential learning in biomedical engineering [5].

Introduction

Clinical immersion programs in biomedical engineering education have emerged as transformative experiences that bridge classroom learning with real-world healthcare environments. These programs enable students to observe clinical workflows, interact with medical professionals, and understand the varied contexts in which biomedical technologies are used. The growth of these opportunities for BME students reflects a broader historical evolution of experiential engineering training, as clinical immersion programs emerged from decades of innovation in bridging engineering curricula with real-world medical practice toward professional preparation [1]. The literature consistently highlights the educational impact of BME clinical immersion programs [6], [7], [8], [9]. A recent multi-year assessment of a summer clinical immersion program demonstrated significant gains across ABET learning outcomes, BME-specific competencies, and program-specific objectives, confirming advances in students' technical skills, confidence, and professional readiness [10]. These findings align with the broader pedagogical principle that experiential learning fosters deeper, integrated understanding of engineering concepts.

A national survey of CI experiences conducted by Guilford, Kotche, and Schmedlen in 2023 documented 52 distinct programs across the United States, revealing wide variance in duration, structure, and learning objectives but uniformly positive perceptions of educational impact. The survey reported program lengths ranging from 3 to 400 hours and annual participation ranging from 2 to 160 students, while emphasizing the need for stronger alignment between desired outcomes and assessment strategies [2]. Program design continues to evolve, with institutions integrating multidisciplinary and innovation-focused frameworks. A recent example involves implementation of a 10-week summer course focused on the biomedical innovation lifecycle in parallel with 8 weeks of clinical rotations, with strong ties to the academic year curriculum [11]. This example shows increasing ambition on the breadth and scope of BME clinical immersion programs, as educators aim to provide students with essential mentorship and guided opportunities for needs identification, ideation, prototyping, and iterative design, all of which are central to professional engineering practice.

Beyond formal immersion programs, integration of co-curricular experiential learning has been shown to advance student success. Hueck *et al.* report that embedding experiential components – such as design challenges, mentorship experiences, and authentic clinical problem-solving – within BME curricula enhances student engagement, supports skill transfer, and improves academic persistence [5]. This work reinforces findings from the broader clinical immersion literature that meaningful experiential exposure enhances not only technical competence but also holistic professional development. Together, these studies collectively demonstrate that clinical immersion

programs play a critical role in preparing biomedical engineering students for careers in healthcare innovation. By providing authentic clinical context, fostering interdisciplinary communication, and enabling hands-on engagement with real-world challenges, these programs strengthen students' engineering identity, broaden their professional perspectives, and build the competencies necessary for translating engineering solutions into clinical practice.

We developed the Indiana Summer Clinical Residency in Innovation for Biomedical Engineers, or (IN)SCRIBE Program, in 2021. Throughout the five-year history of the program, we have continually disseminated our progress and insights. These publications include a description of the program structure and first-year outcomes [3], a comparison to a collaborator's program in a nearby state [12], a qualitative research study on student critical reflections from the program [13], and a description of the debriefing activity we employ at the end of the clinical immersion period [14]. In this paper, we present findings that span five summer offerings of the (IN)SCRIBE Program (2021 - 2025), focusing on program evaluation by three key groups of stakeholders: students who just completed the program, student ambassadors of the program (i.e., past participants), and clinicians who hosted students for clinical immersion rotations

Methods

Program Structure: The (IN)SCRIBE Program (**Figure 1**) is a paid, six-week clinical immersion and team-based design internship for BME undergraduates, supported with funding from the NIH (NIBIB). Its structure was designed to develop students' design capabilities, clinical awareness, and understanding of healthcare disparities and challenges. Each spring, students apply to program by writing cover letters that describe their interest and goals, and participants (8-12 per year) are selected by a committee led by the Program Directors. The (IN)SCRIBE program is built around four sequential phases, combining design instruction, immersive clinical observation, and collaborative problem-solving. Participants, known as (IN)SCRIBE Scholars, begin with pre-program training (Phase 01) followed by a week of structured design training with the Program Directors and invited speakers (Phase 02). Phase 02 introduces foundational skills in identifying unmet medical needs and approaching engineering innovation in a clinical context, highlights topics related to innovation and entrepreneurship, and summarizes the structure and disparities in the US healthcare system. In Phase 03 of the program, students engage in meaningful clinical immersion, as they spend four full-time weeks embedded in varied hospital environments. These rotations expose them to diverse patient populations and clinical workflows, helping them understand how medical technologies are used and where opportunities for improvement exist. Further, the program intentionally emphasizes awareness of social and cultural factors that influence healthcare delivery, particularly within urban clinical settings. In the final week (Phase 04), students participate in team-based design, synthesizing their observations into defined problems and early solution concepts. The structured sequence of training, immersion, and collaborative design ensures that students build engineering skills while confronting authentic healthcare needs across Indianapolis communities.

Program Survey: Each year, on the final day of the (IN)SCRIBE Program, student participants complete the Program Survey to provide feedback on their experiences and learning. The Program Survey contains 28 Likert-style statements (**Appendix, Figure 8**) for which students rank their level of agreement (1 = Completely Disagree, 6 = Completely Agree) and six open-ended qualitative questions (**Table 1**) that students write responses to. To organize our analysis, we

identified four categories of Likert-style questions to group our presentation of results around common themes. These categories are: 1) Overall Satisfaction with Program, 2) Program Logistics & Clinical Experience, 3) Design & Needs Identification, and 4) Healthcare & Socioeconomics.

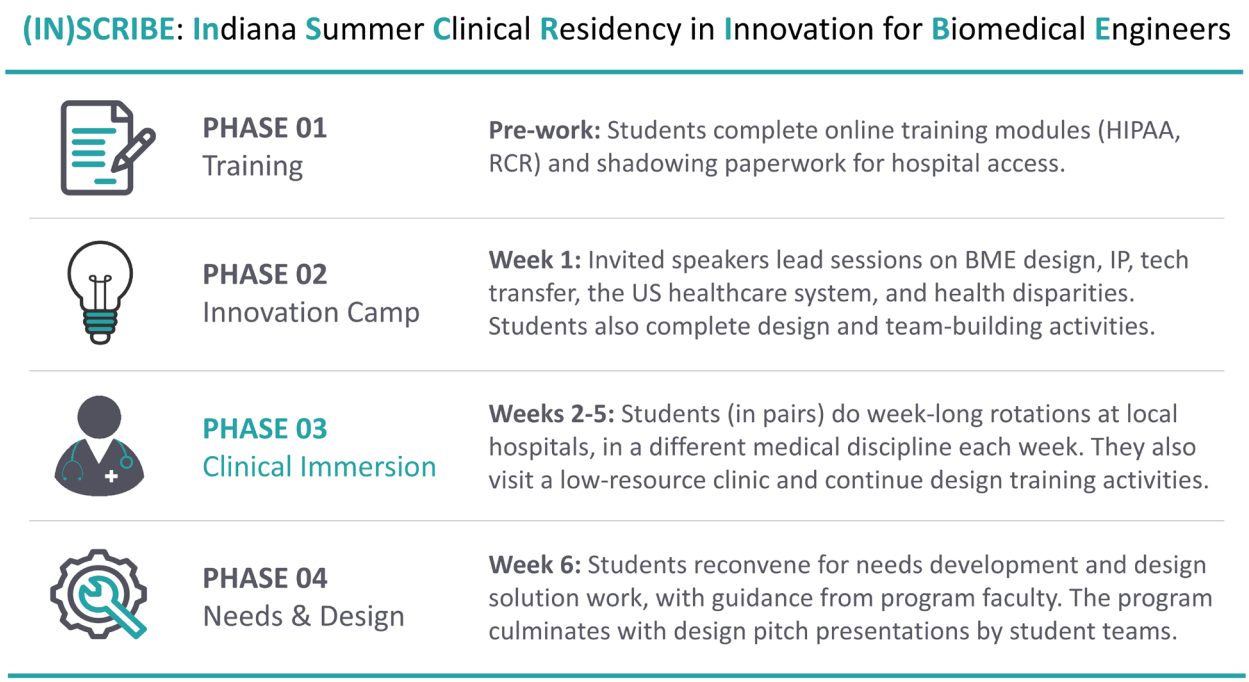

Figure 1: The (IN)SCRIBE Program. The six-week program includes four one-week clinical immersion rotations (Weeks 2-5) between two weeks of classroom and design time (Weeks 1 & 6).

Ambassador and Clinician Surveys: In addition to the Program Survey, we use two other brief questionnaires to collect feedback about the (IN)SCRIBE Program. First, every 1-2 years, we send out the Ambassador Survey to all former (IN)SCRIBE Scholars. This survey, which includes four Likert-style prompts (**Appendix, Figure 9**) and four open-ended questions (**Table 1**), collects data from past participants on how they contextualize their (IN)SCRIBE participation within their broader BME experience. Second, every 2-3 years, we send out the Clinician Survey to physicians who have hosted pairs of (IN)SCRIBE Scholars for one or more clinical immersion rotations. This survey, which includes eight Likert-style prompts (**Appendix, Figure 10**) and two open-ended questions (**Table 1**) collects clinicians' opinions on the readiness and professionalism of our students and the organization of our program, among other things.

Data Analysis: We calculated means and standard deviations for all Quantitative (Likert-style) items across the three surveys. We also plotted full distributions of responses for select items from the Program Survey and all items from the Ambassador Survey and Clinician Survey. For the qualitative data, responses to the three surveys were analyzed thematically and collectively. Common themes were identified, and supporting quotes were pulled from student participants, student ambassadors, and clinicians.

IRB Approval: Work presented in the paper is approved by the Purdue University IRB (Protocol number 2024-619).

Table 1. Qualitative (Open-ended) Questions from the Program, Ambassador, and Clinician Surveys

Program Survey	- Tell me what didn't work well during the (IN)SCRIBE Program. - Tell me about one of your best experiences. (Anecdotes?) - What would you tell other students about this experience? - Was the structure of the (IN)SCRIBE Program (week one: bootcamp, weeks two-six: immersion, week seven: design) well suited to build your confidence in needs identification? - Which BME program courses (e.g., Freshman Engineering, BME, Mathematics, Science) helped you feel prepared for your (IN)SCRIBE experience? - Is there anything you want us to know to continue improving this program?
Ambassador Survey	- Which BME program courses (e.g., Freshman Engineering, BME, Mathematics, Science) would have helped you feel better prepared for your (IN)SCRIBE experience? - How has your participation as an (IN)SCRIBE Program ambassador been beneficial to your BME experience? - Tell me about any BME course experiences that have benefitted from your (IN)SCRIBE Program participation. - Is there anything you want us to know to continue improving this program?
Clinician Survey	- Is there anything you want us to know to continue improving this program? - Please share any highlights from your experience with our (IN)SCRIBE Scholars.

Results and Discussion

Program Survey Results. Of the 52 students (28 women and 24 men; 27 rising seniors and 25 underclassmen) who participated in the (IN)SCRIBE Program over the five-year period, 46 completed the Program Survey. Student ratings were consistently positive across the 28 items on the Program Survey, with response distributions clustering in the highest Likert categories for most questions (**Figures 2 - 5**). The strongest endorsements were for recommending the program to other students (Mean = 5.98, Standard Deviation = 0.15) and perceived preparation for future design courses (M = 5.96, SD = 0.21). Students also rated overall program organization highly (M = 5.50, SD = 0.51). The lowest mean ratings were for student preparedness in medical terminology (M = 4.67, SD = 1.17) and whether sufficient time was allotted to identifying a need and developing a solution (M = 4.93, SD = 1.16). Items related to reflecting on socioeconomic disparities were rated positively on average (M = 5.28) but showed greater variability (SD = 1.07).

Ambassador Survey Results. Ambassadors (past program participants) reported sustained positive perceptions of program impact (**Figure 6**). Respondents included both current students and recent graduates who had previously completed the (IN)SCRIBE Program. All respondents indicated they would recommend the program (M = 5.82, SD = 0.39; Top-2 box = 100%). Ambassadors also reported that the program provided additional perspective on the BME profession (M = 5.64, SD = 0.56), influenced career goals (M = 5.57, SD = 0.69), and improved preparation for BME design coursework (M = 5.50, SD = 0.69).

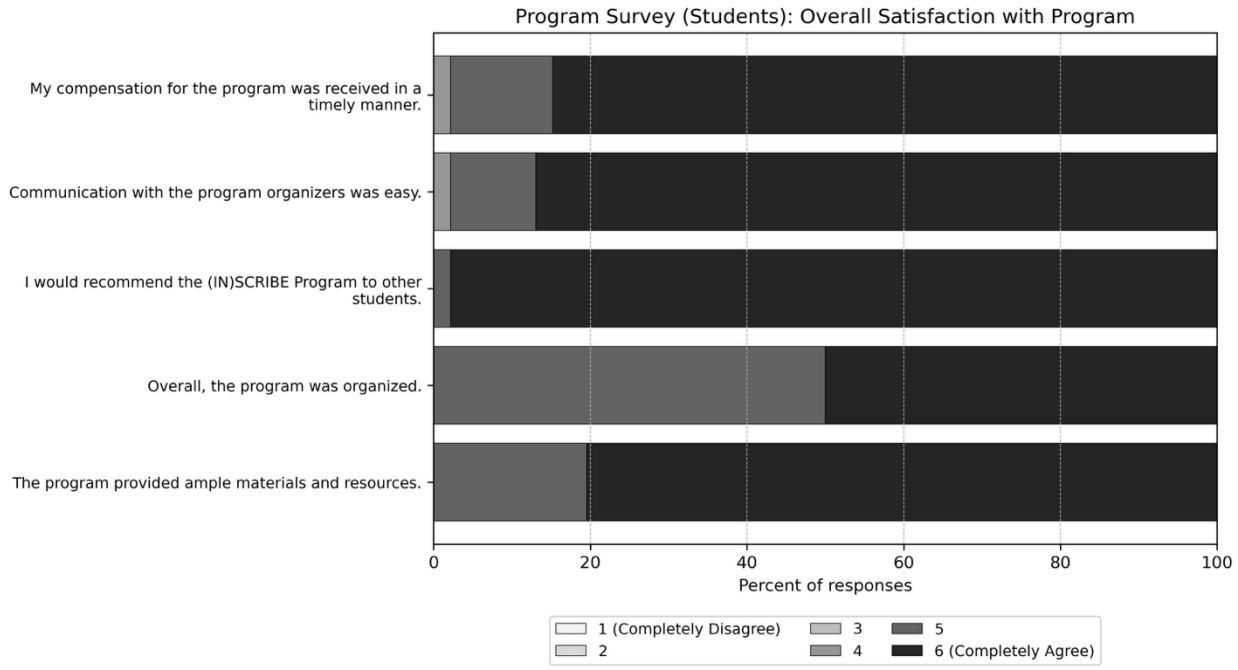

Figure 2: Program Survey (Overall Satisfaction). Response distributions by category. 100% stacked horizontal bar charts showing the percentage distribution of student responses (n = 46) for selected Program Survey items on a 6-point Likert scale (1–6). Each bar represents one survey question, and stacked segments indicate the proportion of responses in each category (1–6), summing to 100%.

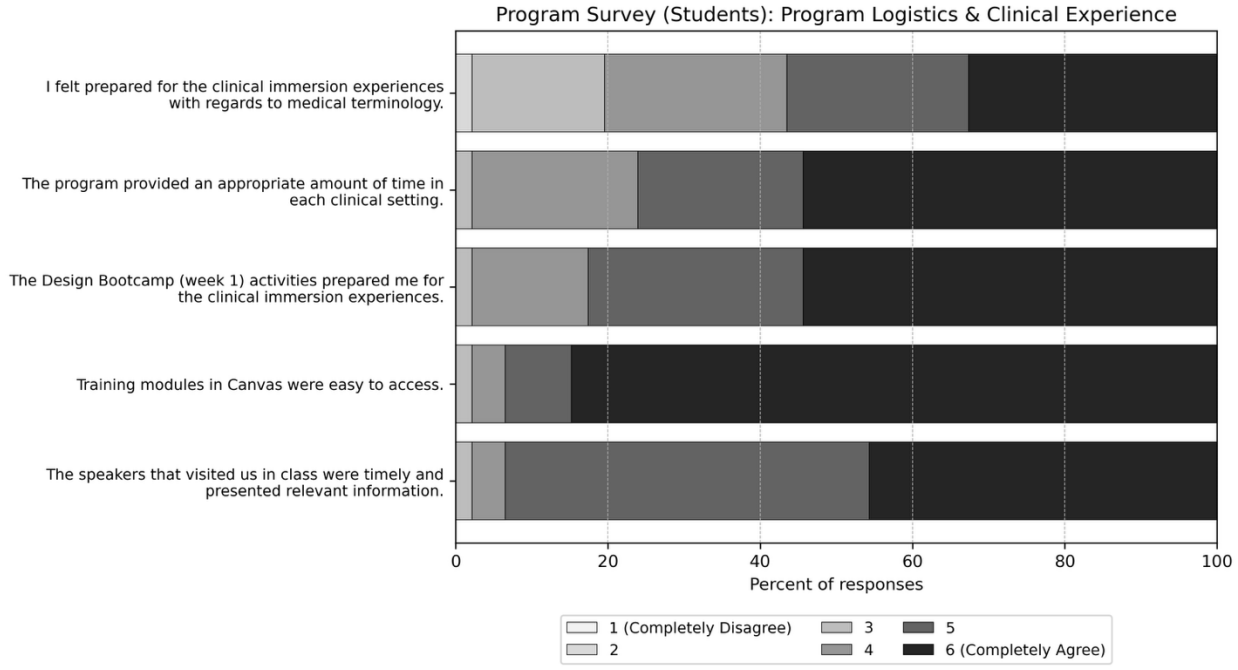

Figure 3: Program Survey (Logistics & Clinical Experience). Response distributions by category. 100% stacked horizontal bar charts showing the percentage distribution of student responses (n = 46) for selected Program Survey items on a 6-point Likert scale (1–6). Each bar represents one survey question, and stacked segments indicate the proportion of responses in each category (1–6), summing to 100%.

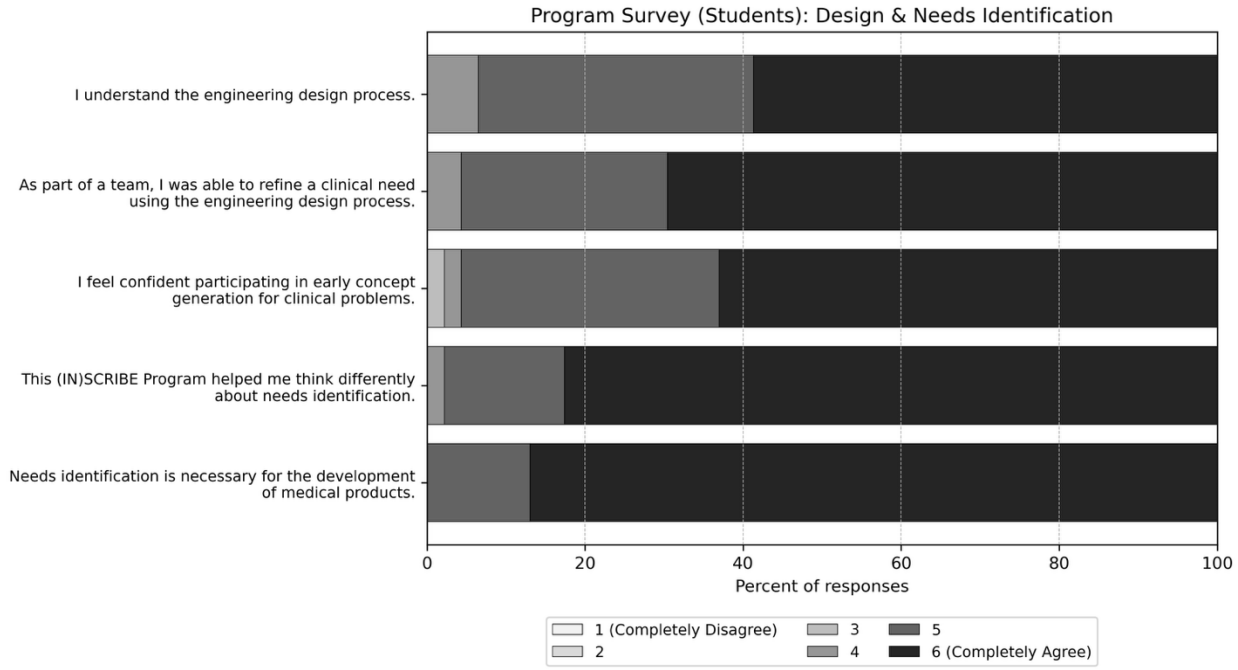

Figure 4: Program Survey (Design & Needs Identification). Response distributions by category. 100% stacked horizontal bar charts showing the percentage distribution of student responses (n = 46) for selected Program Survey items on a 6-point Likert scale (1–6). Each bar represents one survey question, and stacked segments indicate the proportion of responses in each category (1–6), summing to 100%.

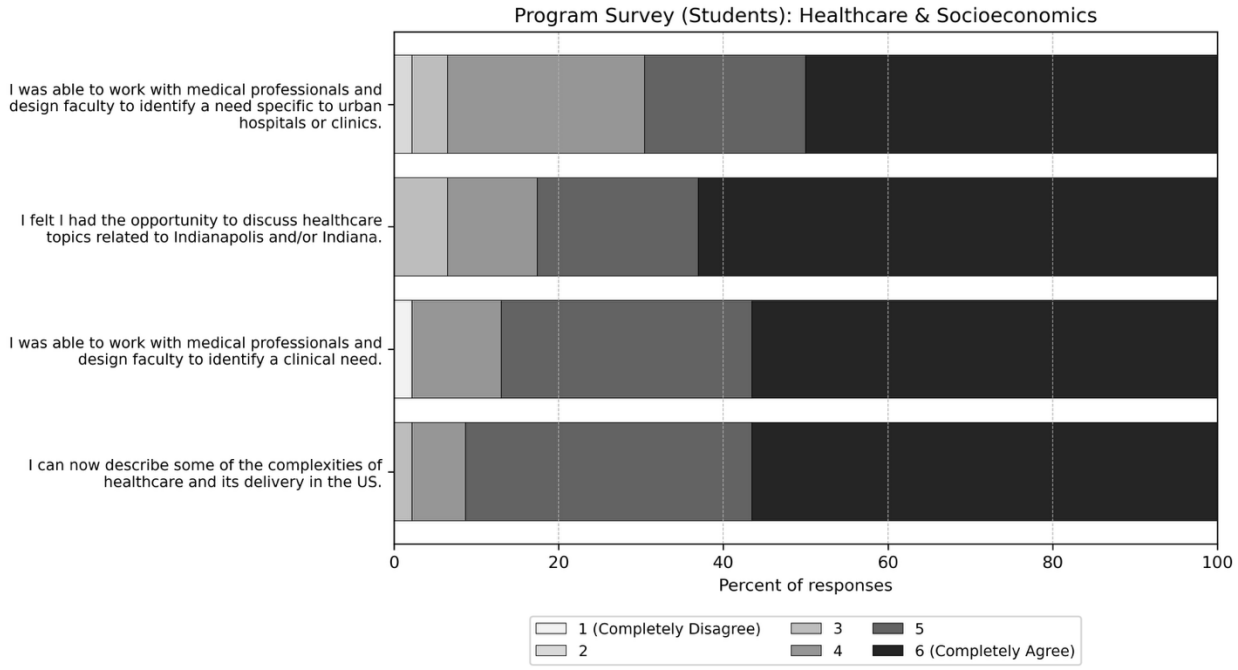

Figure 5: Program Survey (Healthcare & Socioeconomics). Response distributions by category. 100% stacked horizontal bar charts showing the percentage distribution of student responses (n = 46) for selected Program Survey items on a 6-point Likert scale (1–6). Each bar represents one survey question, and stacked segments indicate the proportion of responses in each category (1–6), summing to 100%.

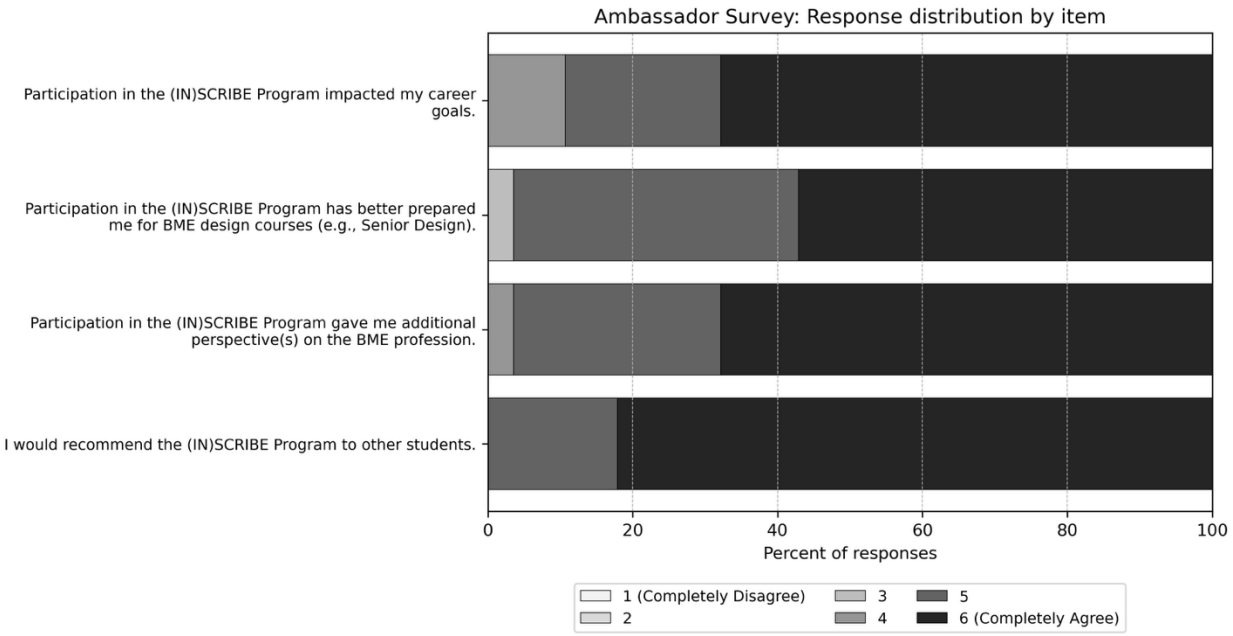

Figure 6: Ambassador Survey. Response distributions depicted as 100% stacked horizontal bar chart showing the percentages of ambassador responses **(**n = 28**)** across four Ambassador Survey items using a 6-point Likert scale (1–6)**.**

Clinician Survey Results. Clinicians (n = 6) reported highly positive hosting experiences and strong endorsement of program implementation (**Figure 7**). The respondents represent six different medical disciplines: orthopaedic surgery, cardiology, neurosurgery, sleep medicine, obstetrics and gynecology, and general surgery. The highest ratings were for program organization and clinicians' experience with students (both M = 5.83, SD = 0.41). Communication with organizers, perceived value of participation, adequacy of materials/resources, and time in clinical settings were also rated highly (all M = 5.67, SD = 0.82, 0.52, 0.52, 0.82 respectively). Clinicians rated students' comfort asking questions (M = 5.50, SD = 0.84) and preparedness in medical terminology (M = 5.33, SD = 0.52) positively.

Discussion of Quantitative Results. When considered together, the three surveys show that individuals see the (IN)SCRIBE program as clear, meaningful, and making a difference in how students learn and grow professionally. What stands out most is how everyone - students, ambassadors, and clinicians - spoke highly of the experience. Clinicians especially noted the value of having students participate. This shared perspective backs up the idea behind the program: blending hands-on clinical exposure with creative problem-solving helps prepare undergraduates in BME for future careers. Looking at student scores related to socioeconomic issues, results differ across groups. How much learners notice and grasp these differences might hinge on where they are rotating and who leads their sessions. When keeping clear invitations to talk and organized group chats, consistency in learning could improve, yet real clinic experience stays intact.

What needs constant upgrades stands out clearly, matching both number-based and real-world findings. Notably, learners gave their lowest marks to medical terminology preparation, while often asking for practice with real cases. This points to better prep helping them feel more certain

before clinical encounters. Notably, our undergraduate BME curriculum includes a quantitative physiology course in the senior year, after any student might participate in our summer program. Doctors said that students knew terminology well enough; so, it seems students assume they're not ready, despite doing well by professional standards. Students and ambassadors often mentioned too little time moving from spotting needs to developing first solutions. Since doctors judged workloads reasonable, it likely stems from tight schedules built into the system at the start. One way forward might be more space given straight to design tasks. Another option lies in moving design efforts sooner, rather than waiting until later stages of the program. A different path could involve clear review points, specifically designed to sharpen needs during the rotation phase.

Qualitative Results. Table 2 summarizes the common themes that were identified across written responses to the open-ended items on the Program Survey, Ambassador Survey, and Clinician Survey. Representative quotes were selected from the three populations of stakeholders to support these overarching themes.

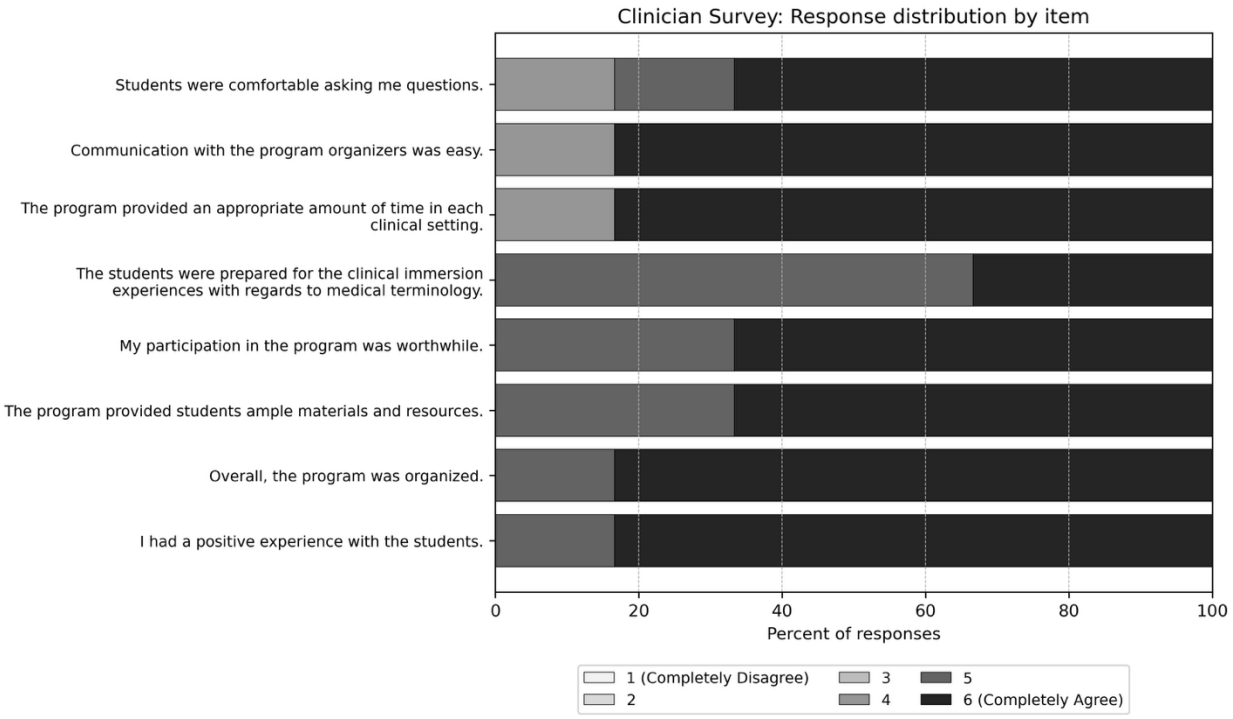

Figure 7: Clinician Survey. Response distributions depicted as 100% stacked horizontal bar chart showing the percentages of clinician responses **(**n = 6**)** across eight Clinician Survey items using a 6-point Likert scale (1–6)**.**

Discussion of Qualitative Results. From every student, ambassador, and clinician account, one thing stands out: the experience felt genuinely real, sparking deeper involvement while opening doors to patient views and daily systemic hurdles. This authenticity translated to the changes that made it through, as students and ambassadors saw better addressed user needs, more defined gaps and issues, and steadier footing stepping into major design projects. Still, plenty of students felt the timeline squeezed too tight, particularly during the final design week, leaving little room for trial or refinement. That pressure wasn't about single events; it revealed a deeper imbalance in

how space and schedule fit together. Some responses pointed out gaps in preparation tied to clinical settings, trouble with medical jargon, unclear understanding of surgical cases, or difficulty spotting needs when situations moved quickly. This hints that briefings focused on specific clinical needs could sharpen understanding faster. Getting schedules, contact details, timing, parking, and entry points organized from the center often reduced hurdles even when participants still praised the effort overall. Not every site showed the same challenges. A few noted details like insurance rules, unequal care access, or social economic backgrounds shaping outcomes. These weren't universal, as they shifted based on where in the health system someone was placed. Feedback pointed to uneven comfort levels during placements, a few students felt interests weren't well represented and struggled with the idea of speaking up, yet clinicians described students as sharp, polite, and attentive. These differences might signal varying confidence based on role, offering room to clarify expectations and build safer dialogue through clear guidelines and planned questioning sessions.

Table 2: Identified Themes and Representative Quotes from Responses to Qualitative Survey Items

Theme	Quotes
Authentic clinical immersion builds relevance	Clinician: "They were inquisitive… and… had ideas how to improve some of our clinical process." Clinician: "they all have been very engaged and eager to learn" Student: "Talking with patients in PM&R… the only opportunity I had to get true patient perspective… conversations about their wheelchair needs… pain points… and costs of their care."
Clinical experience builds capstone skills and confidence	Ambassador: "My capstone benefited… going through the whole design process… made the experience less scary…" Ambassador: "User needs and problem statement development… during senior design this was very beneficial… INSCRIBE helped greatly…" Student: "The program is helpful in learning how to identify and refine user needs…"
More allotted time is needed for the final design sprint	Student: "The last week… not enough time to identify a need and develop a great solution." Student: "The final week… most challenging… time to get a very clean project…" Student: "The last design week felt very jam-packed…"
Students want better preparation (for medical terminology)	Ambassador: "A course in medical terminology… would have been really cool…" Student: "Prepared us for what we would see in surgery… scrubs/bunny suits… where to stand… intubations…" Student: "We don't know which case is being performed until the minute we walk into the OR…"

Scheduling logistics affects the clinical experience	Student: “Zoom links… schedule… organized… not… the announcements tab” Student: “Trying to get in contact with doctors during the final week… not able to get a hold of anyone…” Student: “Free Parking was hard to find… parking passes…”
Systems-level learning was meaningful	Student: “Learned about the healthcare system and health disparities in Indy.” Student: “OBGYN… best… socioeconomic background…” Ambassador: “Better understanding of the insurance structure and its limitations…” Ambassador: “I liked learning about insurance and how healthcare works.”
Placement alignment variability	Clinician: “Please match students with the clinical programs that most interests them.” Student: “Sometimes I didn't fell [sic] very comfortable asking the doctors questions…” Clinician: “They have been professional and engaged…”

Conclusions

The overwhelmingly positive feedback on the (IN)SCRIBE Program, both from students and clinicians, validates the effort that has gone into developing, organizing, and running the program. Nonetheless, there remain clear areas for improvement as we envision how the program will move forward past its first five-year run.

Acknowledgments

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Appendix – Means and Standard Deviations for All Quantitative Items

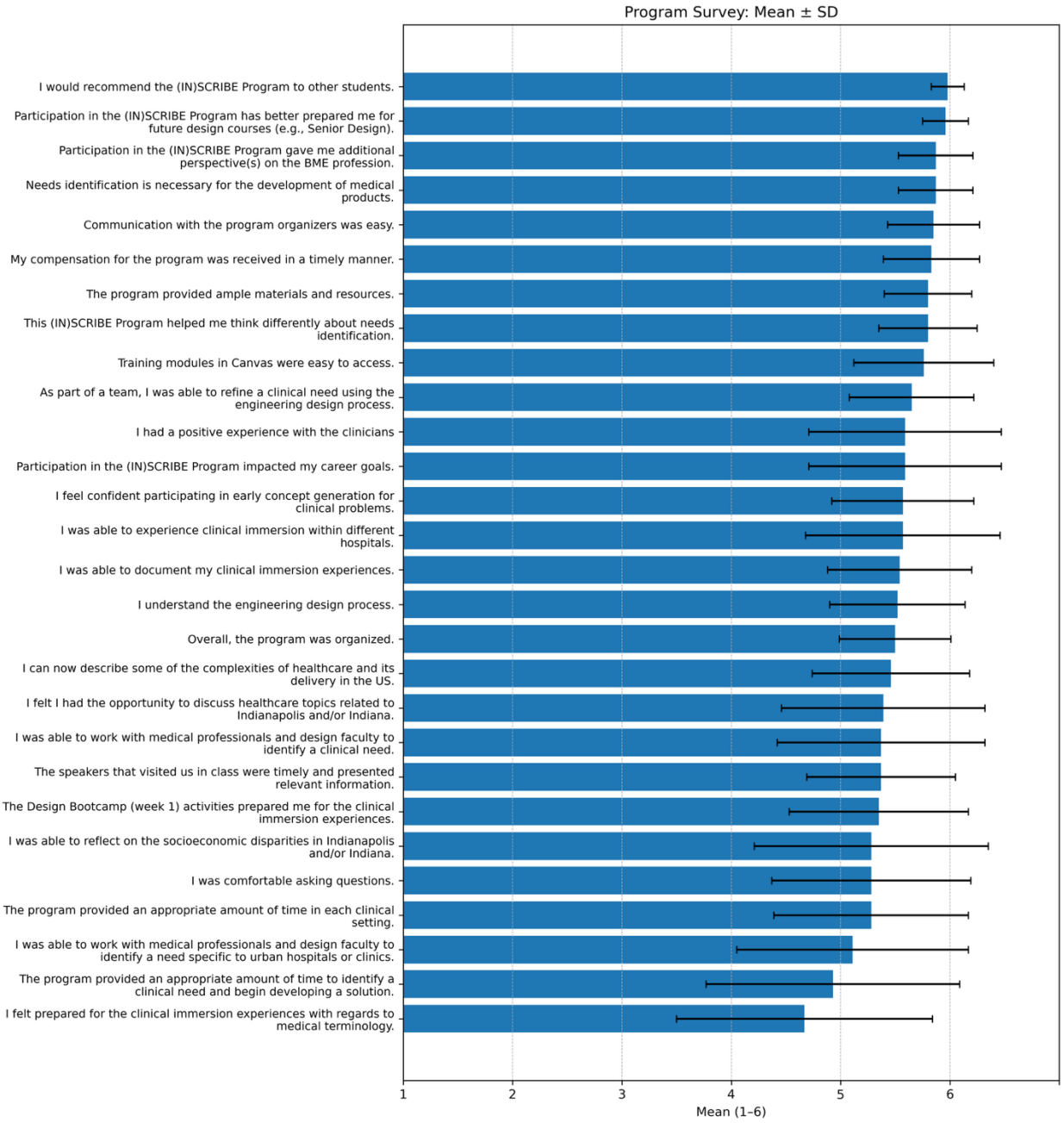

Figure 8: Program Survey Results (Students). Mean student ratings (n = 46) for Program Survey items (6-point scale), displayed as horizontal bars with error bars representing ±1 SD. Items are ordered from highest to lowest mean.

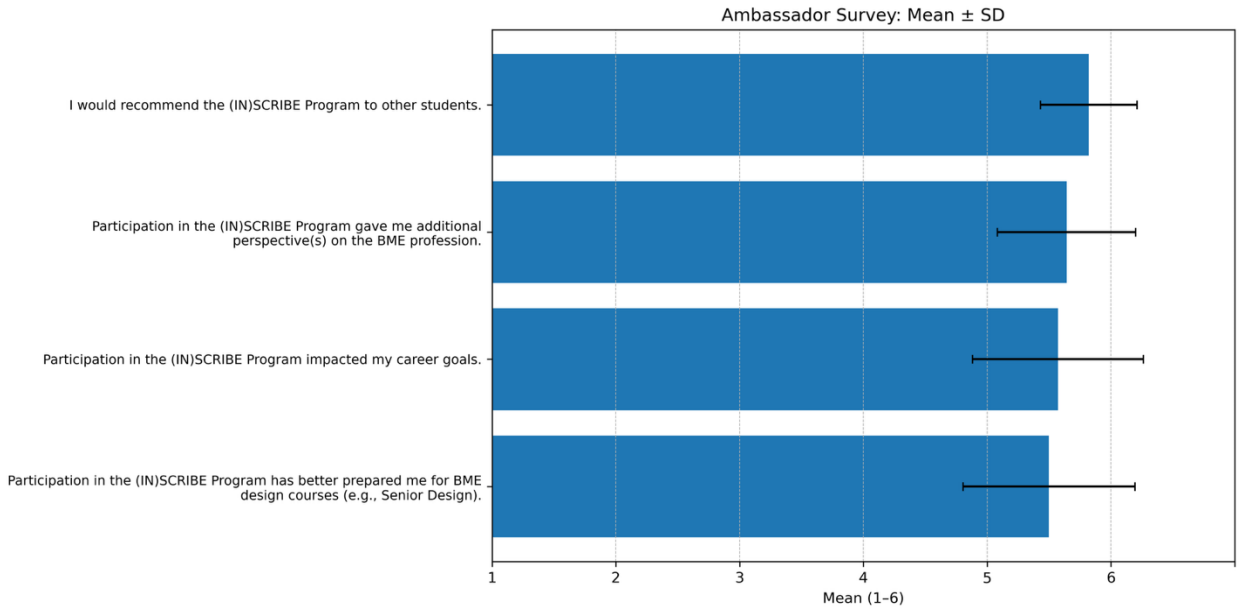

Figure 9: Ambassador Survey (Program Alumni/Ambassadors). Mean ambassador ratings (n = 28) for Ambassador Survey items (6-point scale), displayed as horizontal bars with error bars representing ±1 SD. Items are ordered from highest to lowest mean.

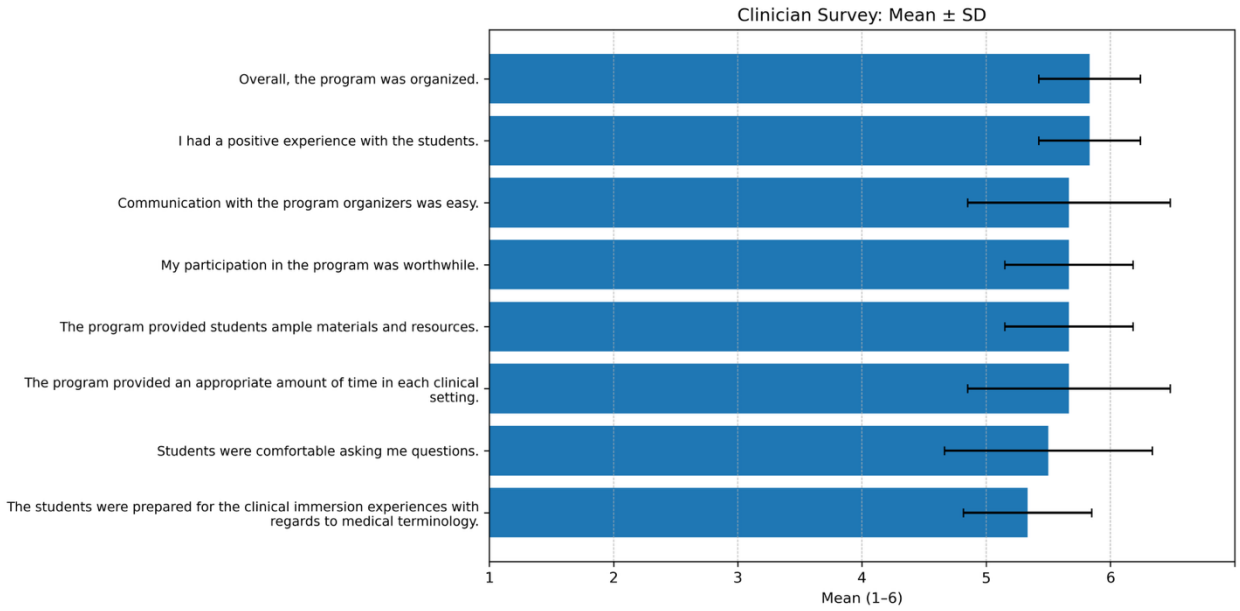

Figure 10: Clinician Survey (Clinical Hosts). Mean clinician ratings (n = 6) for Clinician Survey items (6-point scale), displayed as horizontal bars with error bars representing ±1 SD. Items are ordered from highest to lowest mean.