

Prioritizing Equity in Mental Health Resource Allocation in Undergraduate Engineering Education: A Decision Framework Using AHP and Goal Programming

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Abstract: Mental health challenges are increasingly affecting undergraduate engineering students, who experience elevated stress, burnout, and reduced well-being compared to peers in other disciplines [1]. Despite increased awareness, institutions often struggle to allocate mental health resources in ways that are transparent, equitable, and evidence based. This paper introduces a hybrid decision-making framework that combines the Analytic Hierarchy Process (AHP) and Goal Programming (GP) to guide engineering colleges in making equity-conscious decisions about mental health support services. We simulate the application of this model in a mid-sized engineering college setting, considering five intervention options: counseling expansion, peer-led workshops, culturally responsive wellness programs, digital therapy platforms, and quiet spaces. Stakeholders' decision criteria for weighing options include the impact on equity, accessibility, cost, and scalability. The AHP weighting process assigned the highest importance to equity impact (0.40), followed by accessibility (0.30), while Goal Programming identified four interventions that could be implemented within the institutional budget. Our simulation results prioritize peer-led and culturally responsive interventions over traditional services, suggesting that equitable mental health support in engineering requires reimagining resource allocation. This study contributes a rigorous yet flexible framework for resource planning, aligning institutional values with structural decisions to better serve marginalized student populations.

Keywords: Engineering education, Mental health, Resource allocation, Equity, Analytic Hierarchy Process, Goal Programming

1. INTRODUCTION

Undergraduate engineering students face mounting academic pressure, social isolation, and stigma around seeking help, all of which contribute to high levels of stress, anxiety, and burnout [2], [3]. While institutions have begun to expand mental health services, challenges remain in determining how to allocate limited resources equitably. Existing resource allocation often relies on informal judgments or reactive measures, which can perpetuate inequities in support for historically marginalized students [4]. Engineering education research increasingly calls for system-level interventions that embed wellness and mental health within the structure of undergraduate programs [5]. However, there is a lack of methodological tools that can guide departments or colleges in making equity-conscious, data-informed decisions about resource prioritization. This paper proposes an integrated Analytic Hierarchy Process (AHP) and Goal Programming (GP) model that helps decision-makers transparently rank and allocate institutional mental health supports. By structuring the decision-making process around multiple criteria such as accessibility, equity of impact, cost, and scalability, the AHP-GP model helps mitigate biases and foregrounds institutional accountability. The approach is applied to a hypothetical case simulating how an engineering college might distribute mental health services. To our knowledge, few studies have applied a hybrid AHP-GP framework to mental health resource allocation in undergraduate engineering education while treating equity as a primary decision criterion. The goal is not to replace human judgment but to provide a reproducible, transparent, and equity-aware structure for planning and action.

2. LITERATURE REVIEW

2.1 Mental Health in Undergraduate Engineering

Engineering students consistently report lower mental health outcomes compared to their peers in other majors, largely due

to the intensity of their curriculum, rigid scheduling, and high-performance pressure [2], [3] [6]. These academic and cultural stressors often discourage help-seeking, especially among men and racially marginalized students [4] [6]. Factors such as stigma, fear of appearing weak, and institutional barriers, especially for international students or those with precarious visa situations, contribute to delayed or avoided help-seeking. Authors [7] further underscore how international, disabled, and parenting students are routinely overlooked in the mental health discourse, revealing a systemic blind spot in engineering mental health research. Peer- and mentor-based emotional support systems, especially among chosen families, have shown promise in reducing barriers to help-seeking and promoting belonging [8]. However, as the authors [9] argue, in contexts where students experience active marginalization, individual coping mechanisms may be insufficient. Instead, communal resistance and collectivist healing practices are essential for sustaining mental wellness in hostile environments, especially for Black women in STEM. These findings suggest that mental health interventions must be responsive to the different social and cultural realities faced by diverse student populations.

2.2 Equity and Resource Distribution in Engineering Education

Institutional mental health strategies often prioritize centralized counseling services or digital self-help platforms. While these approaches can offer support, they rarely address how such resources are unevenly distributed or experienced by students with different intersecting identities [10] [11]. For example, LGBTQ+ students, international students, and students of color report higher unmet mental health needs and greater dissatisfaction with formal support systems [12]. Authors [11] emphasize that even when services are technically available, they remain inaccessible due to systemic constraints, such as cultural stigma, financial insecurity, family obligations, or fear of visa-related consequences. This sentiment is echoed by [7],

who note that availability and awareness are not sufficient measures of access. True equity requires recognizing and dismantling the structural barriers that prevent some students from fully benefiting from existing supports. The narrative that students must adapt to institutions rather than institutions adapting to diverse student needs further marginalizes already vulnerable populations. Authors [9] offer a critical contribution by showing how mental health support must move beyond individualized models and toward collective frameworks rooted in resistance, counter spaces, and healing. Their study reveals how Black womxn in STEM protect their mental health through acts of resistance, peer support, and the creation of healing-centered counter spaces that challenge toxic academic norms. Based on these findings, it is recommended that educational institutions move beyond providing services that are universally applicable and instead support mental health interventions that are reflective of the different identities and experiences that students have lived through.

2.3 Programming in Education Contexts

Decision-making frameworks, such as the Analytic Hierarchy Process (AHP) and Goal Programming (GP), have been utilized in higher education for curriculum planning, resource allocation, and program evaluation. For instance, Authors [13] applied AHP-GP to evaluate e-learning systems, while researchers [14] utilized the model to allocate hospital budgets, demonstrating its effectiveness in constrained, multi-criteria environments. This paper builds on that foundation by applying AHP-GP to mental health resource planning within engineering education, centering social equity rather than efficiency. Unlike traditional applications focused on logistics or optimization, our model incorporates ethical and inclusion-focused dimensions, such as reaching first-generation, international, or racially marginalized students, as core evaluative criteria. AHP allows subjective preferences to be structured into transparent decision matrices, while GP constrains these priorities within real-world limits, such as institutional budget or staffing. The model is particularly suited to contexts like mental health in STEM, where trade-offs are inevitable and the stakes disproportionately affect marginalized students. By weaving together insights from engineering education, critical mental health studies, and frameworks like the Psychological Framework of Radical Healing [15], this study contributes a novel, justice-centered decision-making tool. In doing so, it responds to [7] call for more inclusive, intersectional mental health planning and echoes the author's [9] findings that student wellness cannot be disentangled from systemic inequities. This gap highlights the need for decision-making models that not only optimize efficiency, but also prioritize equitable outcomes in institutional resource planning.

3. THEORETICAL FRAMEWORK AND MODEL DEVELOPMENT

This study draws on a decision science framework that merges Analytic Hierarchy Process (AHP) with Goal Programming (GP) to develop an actionable, equity-conscious planning tool for undergraduate engineering institutions. This hybrid framework acknowledges that decisions regarding student support involve not only logistical trade-offs, but also ethical considerations related to fairness, inclusion, and the impact of these decisions on students.

3.1 Philosophical Grounding and Relevance to Equity

Traditional decision-making frameworks in higher education tend to prioritize cost-effectiveness and ease of implementation, often overlooking whether these choices

benefit or disadvantage specific student populations. By incorporating equity as a non-negotiable objective into the AHP-GP model, this paper aligns with calls for structural change in how universities serve minoritized students [16]. The AHP method introduces structure to stakeholder values by quantifying preferences in pairwise comparisons. The GP component then transforms these qualitative insights into optimized action, constrained by real-world limits such as funding, staffing, or space. Together, the two methods offer both transparency and rigor in strategic planning. In the proposed framework, AHP is first used to calculate normalized weights for decision criteria based on stakeholder pairwise comparisons, and these weights are then incorporated into a GP model that maximizes institutional benefit subject to budget and equity constraints

4. STEP-BY-STEP FRAMEWORK OVERVIEW

4.1 Criteria Definition

Based on recent research and institutional reports, four major criteria were identified to guide decision-making: Equity Impact, Accessibility, Cost, and Scalability [4]. These criteria reflect both institutional values and practical constraints.

4.2 AHP Weighting

Stakeholders, including DEI officers, faculty, students, and counseling professionals, rated the importance of each criterion through pairwise comparisons. AHP was used to calculate normalized weights, and consistency was verified using the consistency index developed by [17]. The calculated consistency ratio was below the accepted threshold of 0.10, indicating that the pairwise comparisons were sufficiently reliable.

4.3 Alternative Evaluation

Five intervention options were selected for evaluation: (1) Counseling Staff Expansion, (2) Peer-Led Mental Health Workshops, (3) Culturally Responsive Wellness Programs, (4) Digital Therapy Platforms, and (5) Quiet Reflection Spaces. Each option was scored on a 1–9 scale against the four criteria to form a weighted decision matrix [2], [8]. These scores were assigned based on the simulated stakeholder panel's assessment of how effectively each intervention met the identified criteria.

4.4 Goal Programming Formulation

A GP model was developed to maximize the total weighted benefit under realistic constraints.

$$\max Z = \sum_{i=1}^5 \omega_i x_i$$

$$\sum_{i=1}^5 c_i x_i \leq 200000$$

$$\sum_{i=1}^5 e_i x_i \geq 0.5$$

In these equations, ω_i represents the AHP-weighted score of the intervention i , c_i represents its estimated cost, e_i represents its equity contribution, and x_i is a binary

decision variable indicating whether the intervention is selected.

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4.5 Solution and Interpretation

The optimized allocation recommended funding for Peer-Led Workshops, Culturally Responsive Programs, Digital Therapy Platforms, and Quiet Reflection Spaces. Although Counseling Staff Expansion had a high equity score, its cost limited its feasibility under budget constraints. These results underscore the model’s potential to guide institutional resource planning aligned with equity-centered goals.

5. SIMULATION DEMONSTRATION

To illustrate the practical application of the proposed AHP-GP framework, we present a simulation based on a fictional yet realistic scenario: a mid-sized public engineering college with a student body of 5,000 undergraduates and an annual budget of \$200,000 for mental health services. The institution is committed to diversity, equity, and inclusion (DEI), but struggles to align this commitment with its actual budget decisions. Administrators are seeking guidance on which mental health supports to fund for maximum equitable impact. The simulation is designed to reflect a realistic institutional planning scenario in which decision-makers must balance competing priorities under financial and equity-related constraints

5.1 Resource Alternatives Considered

Based on common practices in engineering education and supported by recent studies [2], [4], five mental health intervention options were identified for evaluation within the proposed decision-making framework. These options reflect a range of delivery modes, target populations, and implementation costs. The first option involves expanding the counseling center staff, specifically by hiring two additional counselors with multicultural competence to enhance inclusivity and reduce appointment waiting times. The second alternative focuses on peer-led mental health workshops, in which undergraduate students are trained to serve as wellness educators, facilitating sessions that emphasize relatable experiences and de-stigmatization. A third option prioritizes culturally responsive wellness programs, which include recurring group sessions designed to address the needs of BIPOC, LGBTQ+, and international students. These sessions aim to create identity-affirming spaces that encourage participation and foster belonging. The fourth intervention focuses on digital therapy platforms, involving the institutional licensing of asynchronous mental health applications that feature multilingual capabilities and self-paced modules, thereby improving access for students with scheduling or privacy concerns. Finally, the fifth option proposes the establishment of quiet reflection spaces, which are accessible on-campus environments designated for mindfulness, rest, and decompression, particularly beneficial for students facing sensory overload or chronic stress. Each of these alternatives presents distinct trade-offs in terms of cost, scalability, accessibility, and equity impact, making them suitable candidates for evaluation within the AHP-GP mode. The combination of these choices offers a comprehensive selection of interventions that are typically addressed in engineering

education contexts. These interventions include traditional, peer-based, identity-responsive, digital, and space-based pedagogical approaches.

5.2 AHP Weighting Results

Using the four established criteria (Equity, Accessibility, Cost, and Scalability), a panel of simulated stakeholders provided pairwise comparisons. The normalized weights were:

Table 2. Institution’s DEI values and practical resource considerations

Criterion	Weight
Equity Impact	0.4
Accessibility	0.3
Cost	0.15
Scalability	0.15

5.3 Evaluation Matrix

Each alternative was scored on a scale of 1–9 for each criterion (with 9 indicating the most favorable outcome). Scores were then aggregated using the AHP-derived weights to compute the final weighted scores.

$$S_i = \sum_{j=1}^n \omega_j r_{ij}$$

In this equation, S_i represents the weighted score for the intervention i , ω_j represents the AHP weight assigned to the criterion j , and r_{ij} represents the rating of the intervention i on criterion j .

Table 3. Alternatives were scored on a 1–9 scale and weighted using AHP-derived criterion weights

Resource Option	Equity	Access	Cost	Scalability	AHP-Weighted Score
Counseling Staff Expansion	8	6	3	4	5.65
Peer-Led Workshops	7	9	8	7	7.9
Culturally Responsive Programs	9	7	8	6	7.45
Digital Therapy Platforms	5	8	9	8	7.1
Quiet Reflection Spaces	6	6	7	5	6.25

5.4 Goal Programming Optimization

The objective of the model was to maximize the total AHP-weighted score while remaining within a budget constraint of \$200,000. Estimated costs were incorporated as constraints, as shown below:

Table 4. Estimated costs of resource options

Resource Option	Estimated Cost (USD)
Counseling Expansion	\$80000
Peer-Led Workshops	\$30000
Culturally Responsive Programs	\$40000
Digital Therapy Licenses	\$25000
Quiet Spaces	\$20000

5.5 Optimized Allocation

The model recommended allocating resources to the following options. Selection maximizes the total AHP-weighted score under the \$200,000 budget constraint.

Table 5. Selected resource options from goal programming optimization.

Resource Option
Peer-Led Workshops
Culturally Responsive Programs
Digital Therapy Platforms
Quiet Spaces

The expansion of the counseling staff was not included in the final allocation due to its high cost relative to its AHP score, although it remained a backup priority. Although the total cost of the selected interventions remained below the full \$200,000 budget, the remaining funds could be reserved for future scaling, contingency planning, or phased implementation of counseling staff expansion.

6. DISCUSSION

This study demonstrates how combining Analytic Hierarchy Process (AHP) with Goal Programming (GP) can help institutions allocate mental health resources in a way that is both strategic and equity-centered. Our AHP-GP approach mirrors best practices demonstrated in healthcare resource allocation. Researchers [14] showed a 12.7% improvement in goal fulfillment by integrating stakeholder-generated AHP weights with GP for equitable emergency center staffing and resource allocation. Similarly, authors [13] employed this hybrid model in an educational evaluation context to improve consistency and transparency in decision-making among diverse stakeholder groups. More broadly, a recent cross-disciplinary review confirms that optimization techniques grounded in AHP-like weight elicitation often outperform other models in terms of fairness and system efficiency, although few formally incorporate equity as a goal metric; with only one-third of the studied models doing so explicitly [18]. These findings reinforce that the proposed framework is not only methodologically sound but also aligned with an emerging equity-focused paradigm in resource optimization. The simulation revealed that peer-led workshops and culturally responsive programming were the most effective investments, based on their scores for equity, access, and cost. These interventions are grounded in the cultural and experiential realities of engineering students, making them highly resonant for minoritized populations [2]. Interestingly, counseling center expansion, though valuable, was deprioritized due to its

relatively lower scalability and higher cost. This highlights how institutions may sometimes over-invest in traditional, centralized services without evaluating whether those services effectively reach students most in need.

6.1 Equity as a Non-Negotiable Criterion

A key innovation in this framework is the treatment of equity as a central, quantifiable, and actionable decision criterion. By requiring that each alternative be rated explicitly on its equity impact and using that score as a primary input, this approach challenges the often-neutral stance of campus budgeting models [4] [19]. Instead of assuming that benefits will “trickle down,” the framework forces planners to confront difficult questions: Who gets served? Who gets left out? And why? Beyond mental health planning, the proposed framework could also be adapted for other institutional decisions in engineering education, such as tutoring services, scholarship allocation, retention initiatives, or academic support programming. Its flexibility allows institutions to align resource decisions with both financial realities and broader equity goals.

6.2 Practical Implications

Despite its practical promise, the proposed AHP-GP framework has several limitations that should be acknowledged. First, the simulation presented in this study is based on hypothetical data and may not fully capture the complexities of real-world institutional budgeting and stakeholder dynamics. Second, the AHP weighting process relies on subjective judgments from stakeholders, which can introduce bias or variability in the resulting priorities, particularly if diverse representation is not ensured. Third, Goal Programming outcomes are sensitive to how constraints and thresholds are defined, meaning that small changes in assumptions may significantly alter the allocation results. Finally, while the model is adaptable, its successful implementation depends on institutional commitment to equity and the capacity to facilitate inclusive decision-making processes, factors that may vary across engineering programs. This aligns with findings on mental health delivery in low-resource settings [20].

7. LIMITATIONS

This study has several limitations that warrant consideration. The simulation presented is conceptual and not grounded in real-world financial or institutional data, which may limit the generalizability of the findings. Additionally, the AHP component relies on stakeholder judgments to assign weights to decision criteria; these judgments vary based on participants’ backgrounds, experiences, and representativeness, which can potentially introduce subjectivity and bias. Similarly, the Goal Programming (GP) component is sensitive to the constraints and assumptions defined in the models, such as budget caps or equity thresholds, which can significantly influence the optimization outcomes. These limitations underscore the need for cautious interpretation and careful customization when applying the framework in actual institutional contexts. Nonetheless, the model provides a valuable foundation for promoting transparent and equity-conscious resource planning in engineering education. Future research could apply the framework using real institutional data, compare findings across multiple universities, or incorporate additional criteria such as staffing capacity, long-term sustainability, student retention, or academic performance outcomes.

8. CONCLUSION

As mental health challenges escalate among undergraduate engineering students, especially those from underrepresented or marginalized backgrounds, institutions face increasing pressure to respond not only with more resources, but with better-targeted ones. However, resource decisions are often made reactively, informally, or without transparent evaluation criteria. This paper presents an original application of a hybrid Analytic Hierarchy Process (AHP) and Goal Programming (GP) model tailored to undergraduate engineering education. The model enables institutional leaders to systematically weigh criteria such as equity, accessibility, cost, and scalability, thereby translating stakeholder values into optimized, budget-constrained resource allocations. The simulation demonstrated how peer-led mental health workshops and culturally responsive wellness programs could outperform traditional services, such as counseling expansion, when equity and scalability are prioritized. These findings challenge engineering colleges to reconsider how support is defined, who is served by existing structures, and how future resources can be distributed more fairly. In prioritizing equity as a core design feature, this model not only contributes to the literature on mental health in engineering education but also responds to broader critiques of institutional inaction in addressing structural barriers. It offers a practical, customizable tool for decision-making that can be adapted across campuses, program sizes, and support types. As engineering education continues to address issues of inclusion, belonging, and student wellness, tools like this provide a pathway toward creating a rigorous, participatory, and equity-focused approach. Future applications of this framework may help institutions make more transparent, data-informed, and equitable decisions about student support services across a range of educational settings.

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