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Student-Centred Reform in Engineering Laboratory Education: A Thematic Analysis of Improvement Suggestions

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Abstract

Engineering education continues to grapple with challenges of student engagement and retention, particularly in relation to practical work. While hands-on experiences are central to professional preparation, students often report a mismatch between their expectations and actual practice. This study addresses the issue by conducting a thematic analysis of 274 student suggestions for improvement. Six themes emerged: practical relevance and authentic learning (28.8%), resources and infrastructure (27.0%), teaching quality and pedagogical support (15.3%), time allocation and scheduling (10.9%), assessment and feedback (5.5%), and learning environment and atmosphere (5.1%). The results point to a continuing mismatch between classroom learning and the realities of professional practice. Students consistently emphasised the importance of practical experiences that are not only authentic and well-supported with resources but also underpinned by sound pedagogy. By placing student perspectives at the centre, this study offers an empirically grounded basis for rethinking the design of practical work in engineering education, with the aim of bringing it into closer alignment with the expectations of industry.

Keywords: Engineering education, Student voice, Laboratory learning, Educational reform, Thematic analysis, Student feedback

1. Introduction

Even with the changes that have been in place, issues regarding enrolment, student engagement and equipping students to work in professional settings remain a major factor in the current engineering education (National Academy of Engineering, 2018). The main issue is that the conventional frameworks of engineering education, especially those that are based on the intensive use of laboratories and practical elements, might not serve the requirements and hopes of the present generation of learners as comprehensively as they did previously (Graham, 2018). In this case, the notion of student voice that comprises of real experience, student advice, but also student attitudes and views may be deemed as the major aspects of the evidence-based educational change (Bovill et al., 2011).

The student voice concept has revealed the paradigm shift between the conventional idea where students are viewed as passive consumers of the learning process and where students are key stakeholders whose

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contribution can make a significant difference in the learning process (Maloshonok & Shcheglova, 2021). Of special interest are the student attitudes to create effective and informative learning experiences in engineering practise because, in teaching engineering, the discipline has a strong focus on practical work as a significant transitional core between theory and practise (Gullberg et al., 2025). It has been revealed through extensive research that students have an advanced sense of their environments in learning and can provide quality insights that can be used to supplement the traditional methods of assessing the results of education (Quaye et al., 2020). The given methodology proposes a deeper insight into the factors in academic performance, demonstrating that the represented perspectives transcend the rigor frames of the traditional scope. This methodological approach will allow learners to describe their opportunities to enter a more practice-driven and authentic learning environment and explain what they interpret their barriers to learning at the same time. The systematic research of the suggested improvements provides the results of the current issues and opportunities regarding the practical work concerning the directly involved people, which are students.

2. Literature Review

2.1. The Role of Student Voice in Engineering Education Reform

The student voice concept has gained increasing popularity in higher education as the idea of student as a passive receiver of educational content has been gradually replaced by the vision of a student as an active constructor of education (Brooman et al., 2015). The paradigm in question assumes various forms of participations, such as giving feedback on both teaching practises and learning strategies and participating in currency development and institutional governance (Haupt & Erasmus, 2018). Engineering education reinforces the perspective as it demonstrated that students can fully reflect on their learning processes and provide as much insight as far beyond the constraints posed by traditional assessment systems (Boelt et al., 2023).

The controversy is particularly acute in the engineering field, where the issue of the learner engagement and programme retention remains one of the primary concerns to this day. Students have been observed to remain more committed to their education and acquire more positive professional identities when they believe their views are heard (Tinto, 2017). New Engineering Education Transformation (NEET) along with various other modern movements at the Massachusetts Institute of Technology focus on the importance of integrating student perspectives into the design of inclusive and adaptable learning experiences sensitive to the transforming demands of business and teaching (Graham, 2017).

2.2. Challenges in Practical Work and Laboratory-Based Learning

Practical work, which is both lab and design work, is an inseparable part of education as an engineer, focused on extending the role of theoretical knowledge, developing practical skills, and a professional set of competencies (Krivickas & Krivickas, 2007). However, a variety of obstacles are plaguing the design and implementation of effective practical work. One of the outstanding problems is the lack of correspondence between the academic experiences and the reality of professional practise. Many traditional activities in labs are prescriptive and have a cookbook form, thus they are lacking in the ability to develop the open-ended problem-solving skills that would be needed by practising engineers (Rokos & Zavodska, 2020).

Also, a significant barrier to high-quality and experience learning provision is the issue of resource constraints, including outdated equipment and facilities insufficiency (Nwuke, 2024). Pedagogical issues, as illustrated by the lack of training to administer laboratories among professionals, and poor combination of practise and theory in the curriculum, can also lead to disintegrating and alienating learning experiences in students (Darling-Hammond et al., 2020).

3. Methods

This study used a qualitative research design and utilised a thematic analysis to examine written suggestions given by students on how to improve practical instruction. A constructivist epistemological framework was used to conduct the research as it recognises the fact that knowledge is socially constructed and mediated by individual experiential prism (Krahenbuhl, 2016). The study was framed persuasively in the principles of the critical pedagogy approach and prefigured the importance of student voice in triggering the educational change and more democratic and responsive learning environments (Dwikamayuda et al., 2024).

3.1. Participants and Data Collection

The data consisted of 274 written improvement suggestions provided by engineering students at a large, research-intensive tertiary institution. The following suggestions were collected as part of a larger cross-sectional survey with regards to student experiences with practical work, and consisted of 338 participants, with an 81.1% response rate on the open-ended question.

3.2. Data Analysis

The thematic analysis was conducted inductively as suggested by Braun and Clarke (2006) in a six-step framework. Such a methodological decision allowed the development of themes that directly

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appeared on the basis of the data, which means that the results obtained are deeply ingrained in the views of students. These stages included: (1) data familiarity, (2) initial code generation, (3) theme search, (4) theme review, (5) define and name themes and (6) create report. To enhance the validity of the analysis, a second coder coded a 20 per cent of the data and the discrepancies were resolved by means of discussion.

4. Results

The thematic analysis of 274 student recommendations revealed six main themes, summarised in Figure 1; the combination of these themes provides a complete picture of student priorities on how the practical work can be improved in the context of engineering education.

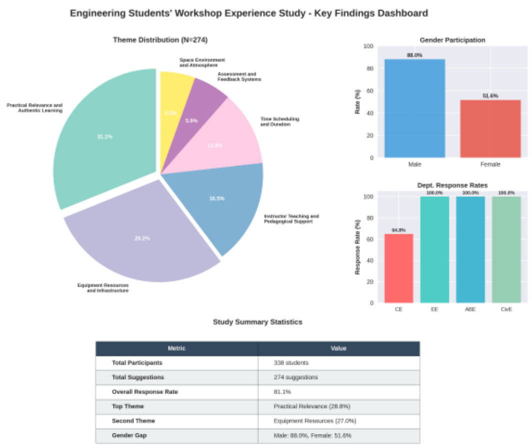

Figure 1: Comprehensive dashboard summarizing the key findings of the study.

4.1. Thematic Analysis of Student Suggestions

The identified six themes, by increasing frequency are:

1. **Practical Relevance and Authentic Learning (28.8 %)**: Students expressed a strong desire towards more lab-views that more closely resemble the real-world engineering issues and practise.
2. **Equipment Resources and Infrastructure (27.0 %)**: It was apparent that a significant percentage of the recommendations was that modern, well-equipped, and properly provisioned equipment and laboratory facilities were required.
3. **Instructor Teaching and Pedagogical Support (15.3%)**: Students highlighted the importance of a well-organised instruction and guidance of the instructors and teaching assistants in the laboratory environment.
4. **Time Scheduling and Duration (10.9%)**: The issue of the time scheduling and length of practical working sessions were another repeated theme.
5. **Assessment and Feedback Systems (5.5%)**: Students requested better assessment processes and provision of timely and accurate feedback.
6. **Space Environment and Atmosphere (5.1%)**: The physical setting of the laboratory, ventilation

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and workspace design were defined as one of the areas that need improvement.

The Table 1 below gives a detailed breakdown of these themes, with examples of student comments given.

Table 1: Thematic Analysis of Student Improvement Suggestions (N=274)

Theme	Number of Suggestions	Percentage	Representative Examples
Practical Relevance and Authentic Learning	79	28.8%	"Connect lab work to real industry projects"; "Use current technology that we'll encounter in the workplace"; "Include case studies from actual engineering problems"
Equipment Resources and Infrastructure	74	27.0%	"Update outdated equipment"; "Provide more modern software"; "Ensure all equipment is functional"; "Increase availability of tools and materials"
Instructor Teaching and Pedagogical Support	42	15.3%	"Provide clearer instructions"; "More hands-on guidance during experiments"; "Better preparation and training for lab instructors"
Time Scheduling and Duration	30	10.9%	"Extend lab session duration"; "Better scheduling to avoid conflicts"; "More flexible timing options"
Assessment and Feedback Systems	15	5.5%	"Provide timely feedback on lab reports"; "Clearer grading criteria"; "More formative assessment opportunities"
Space Environment and Atmosphere	14	5.1%	"Improve laboratory ventilation"; "Better lighting conditions"; "More comfortable workspace design"

4.2. Demographic Factors

There was a high disparity in the rate of providing suggestions depending on the gender. The rate at which male students gave suggestions was significantly high (88.0%), then among female students (51.6%). This disparity in participation is an important finding that warrants further investigation.

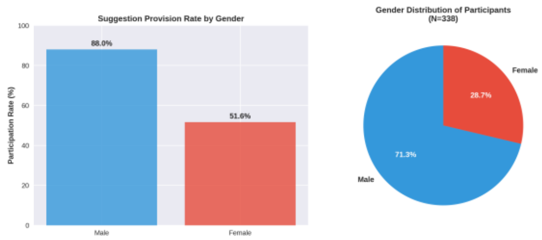

Figure 2: Gender differences in suggestion provision rates.

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5. Discussion

Empirical results of this paper provide strong evidence on the effectiveness of student voice in setting out significant areas of improvement in the engineering lab practise. The investigation of the emergent motifs based on the recommendations proposed by the participants are displayed in the architecture which shows strong correspondence to the issues described in modern engineering education scholarship and, thus, introduces a student-oriented perspective of the well-established pedagogical issues.

The strong focus on Practical Relevance and Authentic Learning (28.8%), and Equipment Resources and Infrastructure (27.0%) reveals the perceived mismatch between what learners are taught and the requirements of the real life of professional engineering practise. This fact supports the findings of some previous studies emphasising the limitations of traditional cookbook laboratory formats and being a plea in favour of more realistic and constructive instructional modalities. The disconnection is further highlighted with the acute concerned acknowledgement students have of the rapid pace of technological change, and their stated wish of having up-to-date equipment and facilities that reflect the current trends and standards in the industry.

The Instructor Teaching and Pedagogical Support category (15.3) is an important indicator of the central significance of educators in the laboratory-based learning. According to the previous studies, a significant number of teachers are not formally trained in laboratory pedagogy, which becomes an obstacle in the ability of students to participate in the full range of experimental activities. Such issues may be connected with student feedback in this research since students were constantly willing to see better instructions and more realistic help. These kinds of requests highlight the two-fold importance of subject-matter knowledge and pedagogical skill in the crafting of substantive laboratory experiences.

Among the more remarkable conclusions that the analysis has made is the unequal distribution of the proportion of respondents providing feedback based on gender: 88.0% of male participants had given feedback but only 51.6% of female participants did the same. This is an indication of a lack of power and/or lack of motivation among female students to participate in the feedback process which the larger research on equity and inclusion in STEM education also indicated. To foster diversity and equity, institutions should adopt pedagogical and technical innovations since feedback mechanisms are ineffective when they are based on practices that are not inclusive and cannot allow all students to express their views.

6. Conclusion

The analysis shows that students' reflections on their practical work provide a useful road map for significant educational reform in addition to a critique of current practice. The results emphasise the need to design learning environments which are authentic, resource rich, and pedagogically effective. Students provide insights of their needs, and through listening to the voices of the workshop, engineering programmes can be more inclined to satisfy the needs of the students and be more useful to prepare them to the challenges of professional practise.

The extreme gender difference in feedback delivery emphasises the need to exercise more accommodative practises where the voices of all the students are reiterated with resounding figures. The causes of this disparity, and the methods of cultivating a more inclusive and just feedback culture are the issues that need to be analysed in future studies.

Finally, this study restates the primary importance of student voice as the key to evidence-based changes in the field of engineering education. When establishing institutions as co-owners of the learning process, more experiential, superior, and relevant learning experiences would be developed that would, in the final analysis, reinforce the future of the engineering profession.

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