Strengthening Professional Skills in Engineering Internships: A University-Industry Approach from Uganda with Global Relevance

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Abstract

This empirical research paper is a full paper that explores the effectiveness of a pre-internship training program in developing essential professional skills, including communication, technical report writing, and problem-solving, for engineering students at Mbarara University of Science and Technology located in the western region of Uganda in Africa. A one-week training program focusing on communication, technical report writing, and problem-solving was implemented with an intervention group, while a control group did not receive the training. Quantitative analysis involved Shapiro-Wilk and Levene's tests for normality and homogeneity of variance respectively, followed by paired and independent t-tests to evaluate the impact of the intervention on students' professional skills. The results demonstrated significant improvements in communication and report writing skills, while problem-solving skills showed modest gains. Qualitative feedback highlighted the importance of further refining the training content, extending industrial internship durations, and encouraging companies to increase the number of internship placements for students to ensure greater exposure to real-world professional environments. This study provides valuable insights for enhancing engineering education, particularly in resource-limited contexts, and offers actionable recommendations for improving professional skill development among engineering students.

Key words

Professional skills, Student assessment, Internships, Workplace, Competence

Introduction

Engineering internships serve as a critical platform for experiential learning, enabling students to bridge the gap between academic knowledge and professional practice [1]. While technical proficiency forms the core of engineering education, the absence of robust professional competencies often hampers graduates' effectiveness in real-world contexts, particularly in resource-limited settings like Africa [2]. The significance of professional skills such as communication, problem-solving, and report writing is well-documented in engineering practice [3], [4]. These skills are crucial for aligning education with industry demands, fostering innovation, and addressing societal challenges. Despite their recognized importance, studies consistently highlight significant gaps in students' professional skills development during their academic training, leaving them underprepared for the workforce [5]. Addressing these gaps is particularly critical in resource-constrained regions where improving industry readiness can yield transformative socio-economic benefits [6]. Internships, as experiential learning opportunities, provide an avenue to address this disconnect; however, many students struggle to integrate technical and professional skills effectively due to insufficient preparation, shorter industrial internship durations, and limited institutional resources [7], [8].

Feedback from company supervisors frequently highlights gaps in students' professional skills, including communication, teamwork, and problem-solving—critical areas for workplace readiness [9]. To address these gaps, we adopted the SoSTeM Model (Soft Skills Teaching Method), developed by [10], which aligns well with our focus on enhancing soft skills in engineering students. The SoSTeM Model emphasizes integrating key skills such as communication, problem-solving, and teamwork into engineering education. In our study, we focused on enhancing these professional skills through an intervention of a one-week pre-internship training program of the intervention group focusing on communication, report writing, and problem-solving. By adopting this model, we built upon proven methods to help students develop the essential skills needed for their future careers. By evaluating the impact of this intervention, we hope to provide valuable insights for educators, policymakers, and industry leaders, ultimately strengthening the development of professional skills and aligning engineering education with the evolving demands of the workforce.

Literature review

The integration of professional skills, often referred to as soft skills, into engineering education is increasingly recognized as essential for bridging the gap between academic training and industry expectations [11]. These competencies, including communication, teamwork, and problem-solving, complement technical expertise and are critical for fostering workforce readiness and adaptability in professional environments [4], [12].

Internships are widely recognized as critical experiential learning opportunities, allowing students to apply theoretical knowledge in real-world settings while developing both technical and professional skills [13], [8]. However, in resource-constrained environments, students face significant challenges, including limited access to quality internship opportunities and inadequate preparation for integrating soft skills with technical knowledge. Studies highlight persistent gaps in students' professional skills upon entering internships, emphasizing the need for purposeful, structured pre-internship training to address these deficiencies [5].

Kolb's Experiential Learning Theory (ELT) provides a foundational framework, emphasizing learning as a cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation [14]. This theory supports structured interventions such as the SoSTeM model, which integrates professional skill development into engineering curricula through targeted pre-internship training [10].

Structured models such as SoSTeM have demonstrated their potential to enhance student readiness by fostering essential skills through collaboration between universities and industry. These interventions not only increase workplace contributions and employer satisfaction but also provide evidence-based strategies for integrating soft skills into engineering education, making them vital for addressing the complexities of modern engineering practice [15], [16]. The growing recognition of these competencies highlights the urgency of aligning curriculum with industry needs, particularly in resource-constrained contexts, to ensure graduates are prepared for the dynamic demands of engineering professions.

Methods

Research question

Does pre-internship training intervention improve engineering students' professional skills in communication, technical report writing, and problem-solving, as measured by post-internship evaluations from both university and company supervisors?

Study design

Figure 1 illustrates the stages involved in the implementation of this study. The quantitative component followed a quasi-experimental design with control and intervention groups. The research activities included;

- *Baseline student assessment:* All participating undergraduate engineering students underwent baseline skill assessments to determine grouping into control and intervention cohorts; students were assigned so that each group had nearly identical baseline performance.

- *Pre-training for intervention group:* The intervention group participated in structured activities focused on communication skills, report writing, and problem-solving.

- *Internship implementation:* Students from both groups proceeded to internships in companies of their choice. Company and university supervisors assessed students' performance using the university's standardized assessment rubric.

- *Post-internship student assessment:* University supervisors visited students during industrial internships and conducted evaluations on all students. Also, industrial supervisors assessed the students since they worked closely with them for the entire internship duration of three weeks as opposed to the standard three months due COVID-19 disruptions.

- *Post-internship feedback:* Interviews were conducted with 10 students from the intervention group, 5 industry and 10 university supervisors to assess the intervention's impact after the internship training.

Student participants

A total of 70 students, 35 in each group (control and intervention), were selected for the study from multiple undergraduate engineering programs, including Biomedical Engineering, Computer Engineering, Petroleum and Environmental Management Engineering, and Electrical and Electronic Engineering. Students were grouped based on their baseline performance in the pre-training evaluation, following a sorting approach where participants were ranked by their scores. This ensured balanced representation of performance levels across both groups.

Intervention

The intervention consisted of one-week pre-internship training program targeting three core professional skills: communication, report writing, and problem-solving. The training incorporated theoretical sessions and practical activities facilitated by the research team comprised of three faculty, one laboratory technician and one industry professional. The pre-training lasted one-week, 8-hours per day. Part of the activities in the one-week training involved enhancing communication, report writing, and problem-solving skills. Students practiced writing application letters and resumes, developed presentation techniques, and worked on illustrating reports with data. They also participated in team-based problem-solving exercises and learned troubleshooting for communication equipment and software. One key exercise involved analyzing and optimizing a three-phase motor control system for energy efficiency, using tools like Programmable Logic Controllers (PLCs) and Variable Frequency Drives (VFDs), allowing students to apply engineering principles and communicate solutions professionally.

All students, those with and without the pre-training, participated in industrial internships at the same time at the companies of their own choice. Both the university and industry supervisors were unaware of which students belonged to the control and intervention groups, ensuring that the evaluation process remained unbiased and the assessment criteria were applied uniformly across all participants. The study design is summarized in Figure 1, which depicts the allocation of students, professional skills training, and evaluation processes.

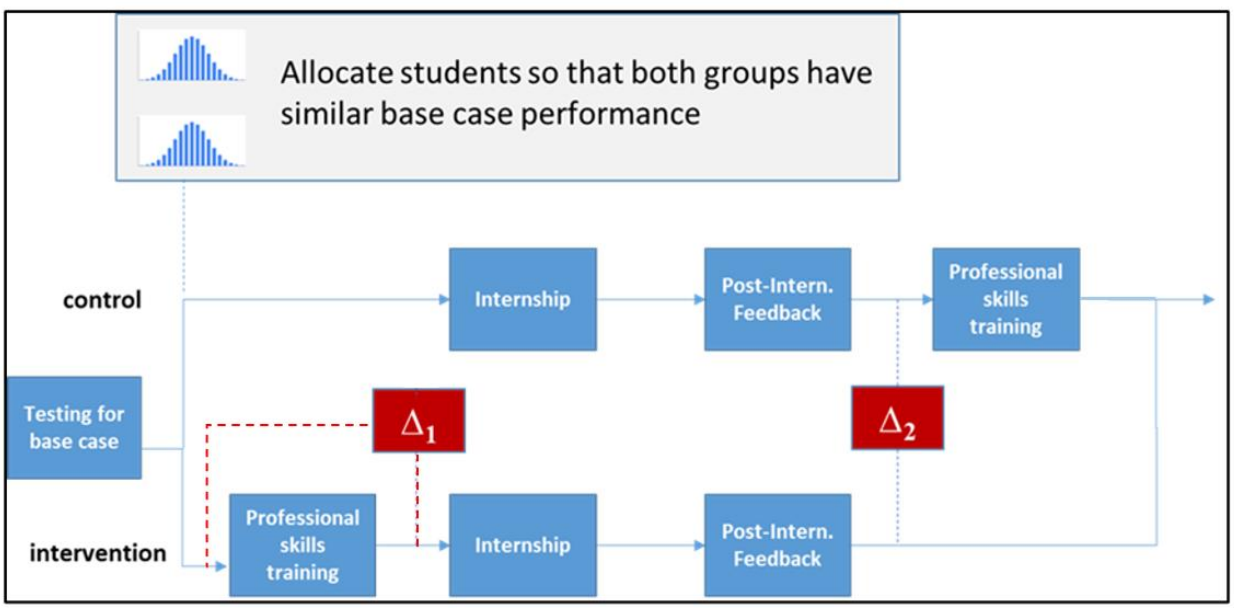

Figure 1: Study design phases

Instruction to supervisors of the one-week training

These supervisors were instructed on the research methods to ensure uniformity in evaluations. Training included;

- *Rubric familiarization*: A detailed briefing on the standardized rubric used for assessing communication, technical report writing, and problem-solving. For example, the problem-solving section of the rubric evaluated students on their ability to identify problems, propose viable solutions, and implement them effectively in an electric circuit.

- *Pre-intervention training goals and procedures*: The goals of the intervention, such as improving clarity in communication and precision in report writing, were discussed. The supervisors involved in the one-week intervention training were provided with sample evaluations to help them provide consistent evaluations and constructive feedback after the intervention training.

- *Standardization of post-internship student assessment process:* Regarding the post-internship assessment, the university supervisors were briefed during a faculty internship meeting whereas the 10 industry supervisors were briefed individually by the research team at their respective companies to ensure consistency in the assessment criteria and to maintain uniformity in the evaluation process across all participants. This step was critical for minimizing biases and ensuring that the supervisors applied the same standards when assessing the students' performance.

Data collection

Data was collected at four key stages to comprehensively evaluate the intervention's impact.

- *Pre-intervention assessment:* Baseline performance was evaluated through three assignments graded by a rubric. The three assignments were: CV writing, application letter drafting to a company seeking industrial internship and writing one page of a previous group project explaining the procedure of problem-solving.

- *Pre- and post-intervention group assessment:* Assessment was done by the supervisors who conducted the one-week intervention training. This exercise focused on the same three assignments as described in the baseline assessment activities.

- *Post internship student assessments:* Performance evaluations were conducted by university and company supervisors based on the students' performance and submitted technical reports. The rubric used focused on aspects of communication and problem-solving. Report writing skills were assessed by the university supervisors specifically when the students submitted their final report book. The company rubric had an element of assessing how well students used their logbooks during the internship period since it was a mandatory part of the training. It is important to note that 10 companies that had signed a memorandum of understanding with the university participated in this study.

- *Post-internship feedback:* Oral interviews were conducted with students and university supervisors. Four project team members interviewed 10 university supervisors, 5 industry supervisors and 10 students from the intervention group. They were randomly selected based on their willingness to participate in this survey. The aim was to have a general sense of how to improve the internship intervention training model.

Data analysis

This study used both quantitative and qualitative data analysis. The quantitative part focused on assessing the impact of the intervention on students' professional skills using R software. Shapiro-Wilk tests were conducted to check the normality of the data before and after the intervention, Levene's test was used to assess homogeneity of variances, and paired samples t-tests were performed to compare the performance of the intervention group after the one-week training. Independent t-tests, both parametric and non-parametric, were also used to compare the control and intervention groups. The company supervisor data used a non-parametric test because the data violated normality assumptions, while the university supervisor and the technical report assessments used parametric t-tests due to their normal distribution and equal variances. Thematic analysis was used to gain insights in the qualitative data from the oral interviews conducted with students and university supervisors for improvement of the intervention model in the future.

Unique context at Mbarara University of Science and Technology

Challenges influenced the design and execution of this project, namely, included unpaid internships, COVID-19 disruptions, shortened internship periods, and limited resources for faculty researchers. Although these challenges limited the internship experience for students, they did not impact the conclusions of this research.

Evaluation criteria

Performance was assessed using inputs from three supervisors, combined into a single measure with the following weightings:

- University supervisor assessment (45%) focusing on practical skills, communication, and record-keeping (use of the internship log books).

- Company supervisor assessment (25%) focusing on team dynamics which involved assessing how each student communicated within the team and task management which focused on problem-solving, use of the internship log books and technical report writing.

- Written report evaluation (30%) graded based on formatting, writing mechanics, and content relevance.

This evaluation framework was adopted based on the internship evaluation rubric at the home university's engineering faculty for consistency and fairness purposes.

Results

Table 1: Baseline performance after grouping

Group	Mean baseline performance	Shapiro-Wilk p-value	Levene's test p-value
Intervention	25.63	0.3378	0.7116
Control	25.34	0.6434	0.7116

To ensure that the two groups (intervention and control) were comparable at the start of the study, a normality test was performed using the Shapiro-Wilk test to assess whether the baseline scores for each group followed a normal distribution. The results indicated that both groups had normal distributions, with p-values greater than 0.05. Additionally, a Levene's test was conducted to check for homogeneity of variance between the groups. The test confirmed that the variances were equal (p-value = 0.7116); we conclude that the baseline performance was consistent across both groups. These analyses confirmed that the groups were fairly matched at baseline, providing a solid foundation for evaluating the effects of the intervention.

Pre- and post-intervention group training assessment

The first quantitative evaluation was performed to determine whether the effect of the pre-internship training had on the students who obtained the training before the beginning of the internship. For emphasis, only students from the intervention group who received the training were involved. Table 2 shows results from a paired-samples t-test that was conducted after the one-week training to ascertain whether the intervention had a significant impact on the students' performance in the three key professional skills: communication skills, technical report writing, and problem-solving.

Table 2: Paired t-test results of pre- and post-intervention group training assessment

Assignment	t-statistic	df	p-value	95% Confidence interval	Mean difference	Cohen's d
Application letter	5.4429	34	4.566e-06	(1.31, 2.86)	2.0857	0.92
Curriculum vitae (CV)	5.3128	34	6.743e-06	(1.31, 2.53)	1.8286	0.90
Problem-solving task	1.2124	34	0.233	(-0.15, 0.61)	0.2286	0.21

For the Application assignment, the paired t-test yielded a t-statistic of 5.4429, with df = 34 and a p-value of 4.566e-06, indicating a highly significant improvement in student performance after the training. The 95% confidence interval for the mean difference ranged from 1.31 to 2.86, with a mean difference of 2.0857. The Cohen's d value of 0.92 suggests a large effect size, indicating that the intervention had a strong impact on the students' application skills.

For the CV assignment, the paired t-test showed a t-statistic of 5.3128, df = 34, and a p-value of 6.743e-06, also indicating a statistically significant improvement. The 95% confidence interval for the mean difference was between 1.13 and 2.53, with a mean difference of 1.8286. The Cohen's d value of 0.90 suggests a large effect size, reflecting the significant improvement in students' CV writing skills after the intervention.

For the Problem-solving task, the paired t-test yielded a t-statistic of 1.2142, df = 34, and a p-value of 0.233, indicating that the improvement in problem-solving skills, although positive, was not statistically significant at the 0.05 level. The 95% confidence interval for the mean difference was between -0.15 and 0.61, with a mean difference of 0.2286. The Cohen's d value of 0.21 suggests a small effect size, indicating that the intervention had a modest impact on problem-solving skills.

These results suggest that short-term training can have a strong impact on certain professional skills, while other skills may require longer or more focused interventions.

Post-internship assessment

To assess the impact of the one-week training on the professional skills of engineering students after their industrial internship, the second quantitative evaluation involved statistical tests to compare the performance of the control and intervention groups across three assignments: the university supervisor, report assessment, and company supervisor. Recall that the scores for these three features were combined into one weighted evaluation score per supervisor, as explained above. For data preparation, normality and homogeneity of variance tests were conducted first to determine which t-tests would be appropriate for the post-internship assessment as shown in Table 3. These tests helped ensure the data met the necessary assumptions for selecting either parametric or non-parametric t-tests to accurately assess the impact of the intervention.

Table 3: Post-internship normality and homogeneity of variance tests

Assignment	Group	Shapiro-Wilk p-value	Normality (Pass/Fail)	Levene's test p-value	Homogeneity of variance (Pass/Fail)
University supervisor	Control	0.7164	Pass	0.7848	Pass
	Intervention	0.1353	Pass		
Company supervisor	Control	0.0004088	Fail	0.009684	Fail
	Intervention	0.04813	Fail		
Report assessment	Control	0.237	Pass	0.5517	Pass
	Intervention	0.06962	Pass		

Based on the outcomes from the tests as shown in Table 3, the university supervisor assessment and report assessment data passed the normality and homogeneity of variance tests, indicating that parametric t-tests were appropriate for these assignments. However, the company supervisor assessment data failed the normality test for both the control and intervention groups, which led to the use of a non-parametric test (Mann-Whitney U test) for this assignment to assess group differences. Tables 4a and 4b show the results of the independent t-test and Mann-Whitney U test.

Table 4a: Post internship assessment between intervention and control groups

Assessment	Test	t-statistic/ W	df/N	p-value	95% Confidence interval
University supervisor	Independent t-test	-2.2943	68	0.02487	(-2.70, -0.19)
Report assessment	Independent t-test	-0.93228	68	0.3545	(-3.28, 1.19)
Company supervisor	Mann-Whitney U test	984.5	N/A	7.847e-06	N/A

Table 4b: Post internship assessment between intervention and control groups

Assessment	Test	Mean (Control)	Mean (Intervention)	Cohen's d (Effect Size)	Effect Size (r)
University supervisor	Independent t-test	36.33	37.77	-0.5484	N/A
Report assessment	Independent t-test	18.03	19.07	-0.2229	N/A
Company supervisor	Mann-Whitney U test	N/A	N/A	N/A	0.5223

For the university supervisor assessment, the independent t-test revealed a significant difference between the two groups. The intervention group had a higher mean score (37.77) compared to the control group (36.33) (See Table 4b), with a p-value of 0.02487 (See Table 4a), which is less than the significance threshold of 0.05. This suggests that the intervention positively influenced students' performance as evaluated by the university supervisors, making the intervention group the better-performing group.

In contrast, the report assessment showed no significant difference between the two groups. The p-value was 0.3545 (See Table 4a), which is greater than 0.05, indicating that both the control and intervention groups performed similarly on the report writing task. With a mean of 18.03 for the control group and 19.07 for the intervention group, this suggests that the intervention did not have a notable effect on students' performance in report writing.

A Mann-Whitney U test was conducted to assess the differences between the control and intervention groups due to the non-normal distribution of the company supervisor assessment scores. The W statistic of 984.5 was obtained, and the p-value was found to be 7.847e-06 (See Table 4a), which is highly significant and well below the typical threshold of 0.05. This indicates a statistically significant difference between the two groups. The intervention group outperformed the control group, as reflected in the significant difference in the company supervisor assessment scores. The effect size (r) of 0.5223 suggests a medium effect, indicating that the intervention had a noticeable positive impact on the students' performance in the company supervisor evaluative task.

Qualitative feedback from interviews with supervisors from the university and industry and students from the intervention group provided deeper insights into the intervention's impact. The five general themes that emerged from the qualitative analysis include:

- *Emphasis on practical skills and problem-solving:* Participants highlighted the need for more emphasis on practical skills and problem-solving during training. Industry supervisors noted that these skills are critical for students' professional growth. One supervisor stated, "These areas addressed critical gaps commonly observed in internship programs." Students from the intervention group echoed this sentiment, expressing that the training helped them become more adaptable and confident in professional settings. Many suggested the inclusion of more technical problem-solving scenarios that are aligned with industry expectations. One student remarked*, "I think we need to rethink the internship period so that we can spend more time in the companies to learn better."*

- *Allocation of more time for intervention training and internship:* Another common theme was the need to allocate more time for both the pre-internship training and the internship experience itself. Both students and university supervisors recommended extending the intervention to enhance its impact. A university supervisor commented, *"I like the initiative for a deliberate effort to address skills development during internship, and I am available to support when needed."* A student mentioned "*During the semester, we could have an extended period of a similar training like the one-week training we had through our extracurricular clubs to benefit more*".

- *Facilitating internship placements for students:* There was also a suggestion for the university to assist students in finding internship placements, especially for those who struggle to secure placements independently. One of the suggestions was for the university and companies to collaborate more actively in providing these opportunities, with students noting*, "It would help if the university could find placements for students who struggle to find their own."*

- *Increase in internship placements by companies:* University supervisors emphasized the need for companies to increase internship placements, offering more students the chance to gain real-world experience and develop practical skills. They suggested that companies expand their capacity to meet the growing demand. As one supervisor noted, "*It's important for companies to think about how they can offer more opportunities for students, especially as more students are looking for placements."* This underscores the role companies play in supporting students' professional development.

- *Ongoing refresher training for university supervisors*: The need for refresher training for university supervisors was another key recommendation. Many participants felt that continuous professional development for supervisors, particularly regarding internship supervision, would improve the overall quality of the internship experience. One supervisor emphasized, "*Continuous engagements and collaborations with industry will help us find more value in this initiative, especially with improving on the evaluation tools we use in this exercise."*

Discussion of the results

The findings demonstrate the value of structured pre-internship training in enhancing essential professional skills among engineering students. Communication and report writing skills showed the most improvement, likely due to the targeted nature of the SoSTeM intervention. These results are consistent with prior studies emphasizing the critical role of soft skills in bridging the gap between academia and industry [4], [16]. The modest gains in problem-solving skills suggest the need for a more comprehensive approach, such as integrating Problem-Based Learning (PBL) modules within the pre-training program. These modules could simulate real-world technical challenges, providing students with opportunities to practice critical thinking and decision-making in industry-relevant contexts. Industry feedback highlighted the intervention's effectiveness in fostering workplace readiness, a critical outcome for resource-constrained settings.

However, the study also revealed challenges related to internship duration and resource limitations, which constrained students' ability to fully apply and refine their skills. Addressing these systemic issues through stronger academia-industry partnerships and extended internship programs could further amplify the benefits of pre-internship training. This study provides evidence-based recommendations for integrating soft skills training into engineering curricula, particularly in resource-limited environments. By tailoring interventions like SoSTeM to address specific skill gaps, institutions can better prepare students for the evolving demands of the global engineering workforce. Future research should explore scalable models for sustaining such training programs and investigate their long-term impact on graduate employability and career success.

The qualitative findings suggest that while the training was well-received and addressed participants' concerns, there remains room to integrate more novel concepts to further enhance knowledge acquisition. Conducting refresher training for university supervisors regarding internship supervision was reported by [17] as a major factor that will improve the overall quality of the internship experience and better support students in their professional development.

Conclusion

This research has significantly influenced engineering internship practices at the home university. The findings demonstrated that structured pre-internship training enhances students' professional skills, including communication, technical report writing, and problem-solving, as validated by both university and company evaluations. Following the success of the SoSTeM intervention, the engineering faculty has adopted pre-training sessions as a standard practice for all engineering students before internships. This institutional shift ensures that students gain experiential learning more effectively during their placements. The study's contribution lies in providing a replicable framework for aligning academic training with industry expectations, setting a precedent for future improvements in engineering education and workforce readiness in resource-constrained settings.

Future work

Future work will focus on refining internship frameworks by integrating structured mentorship, reflective practices, and problem-based learning. Additionally, plans include developing scalable, sustainable models tailored to the unique challenges faced by institutions in developing nations and exploring innovative, cost-effective collaborations with industry partners to enhance professional skill development. These efforts will contribute to advancing engineering education practices, aligning academic training with evolving industry needs, and ensuring impactful, evidence-based improvements in internship programs. By expanding on the insights gained from this study, future research endeavors will contribute to evidence-based approaches for transforming engineering education, particularly in resource-constrained settings.

Ethical considerations

Student data were anonymized, and assessments were conducted collaboratively with academic and industry partners to ensure fairness. To ensure that all students ultimately received comparable instruction, the control group was given a similar one-week training after the project was completed.

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